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Sociotechnical Co-production of Planning Information: Opportunities and Limits of Crowdsourcing for the Geography and Planning of Bicycle Transportation

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Sociotechnical Co-production of Planning Information: Opportunities and Limits of Crowdsourcing for the Geography and Planning of Bicycle Transportation

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Dedication

To Zachary and Caleb.

Acknowledgments

Most acknowledgements sections in dissertations begin with pragmatic recognitions, and end with gratitude of those most dear and true. That mold does not fit my situation: one person was the center of the dreams and practice of this work. Katherine L. Griffin, my wife of eighteen years, is why this dissertation was possible, from the practical to emotional support, and everywhere in between. She is the one who sacrificed the most with the least to gain, while putting her own life transitions in limbo while prioritizing my and our sons' needs. I can only hope this dissertation will be a good foundation for the next stage of our life together.

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Sociotechnical Co-production of Planning Information: Opportunities and Limits of Crowdsourcing for the Geography and Planning of Bicycle Transportation

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Urban planners deploy civic technologies to engage publics with digital tools in a relative vacuum of theory, understanding of challenges, or benefits. The issue, Lewis Mumford might have framed, could be of authoritarian and democratic technics—whether the technology contributes more to top-down control or bottom-up understanding. Building from collaborative planning theory, co-production suggests ways people can leverage technologies to build urban solutions with or without professional planners. Empirical research shows that crowdsourcing to address planning questions with digital civic platforms can help fill or mitigate information gaps, including support for bicycling as a safe and comfortable travel mode. However, no research has addressed how crowdsourced information for bicycle planning offers new insights for safety, the geography of participation, or how its social construction impacts its representation of bicycling in a community. A new framework for evaluating co-productive planning is proposed, considering legitimacy, accessibility, social learning, transparency, and representation (LASTR). This dissertation addresses these concerns of safety, geography, and social construction through the LASTR framework using mixed-methods case studies in Portland, Oregon, and Austin, Texas. Bicycle volumes and street ratings through the crowdsourcing platform, along with geographic information system environmental data, and interviews with thirty-three informants form the basis for evaluating these issues. Viewed from pragmatism and social construction of technology, the social processes of planning and technological developments are intertwined and traced in tandem. The first three chapters frame the problems, build a background in theory, and describe the research questions, planning contexts, and data for analysis. The next three chapters are empirical, evaluating the use of crowdsourced information for bicycle safety, comparing the geography of crowdsourced participation with in-person meetings from both cities' most recent bicycle planning process, and tracing the sociotechnical representation of crowdsourcing bicyclist information through interviews and case materials. The final chapter summarizes the findings and implications for practice and research. This dissertation shows that the biased representation of bicycling in these two crowdsourcing cases pose opportunities to identify safer bicycling routes and expand public participation geographies, but could exacerbate problems with aligning public improvements with the users of a specific technological approach. Further, the construct of crowdsourcing for urban planning remains flexible and therefore merits further study and knowledge transfer for practitioners and students.

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Chapter 1: Introduction

Observers of urban planning in the post-Millennium United States are likely to agree on two points: hosts of problems exist between the triad of professional practice, public opinion, and politics in planning, and that the role of how communication technologies facilitate or degrade these relationships is far from settled. Planning scholarship from John Forester, Margo Huxley, Tore Sager, and others highlighted the opportunity and struggle for the role of communication in planning. More recently, scholars such as Daren Brabham, Jennifer Evans-Cowley, and Lisa Schweitzer explore the role of technology in changing how planners, publics, and politicians work together—or not.

Through case studies of bicycle transportation planning with information and communication technology (ICT) in Austin, Texas, and Portland, Oregon, this dissertation assesses opportunities and limits for the role of communication technology in urban planning. I view ICT in planning as more than tools to facilitate the transfer of knowledge or opinions in the traditional sense of public participation as visioning or commenting but regarding respecting local knowledge as an opportunity to co-produce any or all phases of the planning process (Watson 2014). The physical definition of power relates energy and work production to time. If a physical notion of power is transferable to urban planning, this would suggest that more energy (through more participants) has the potential to create more powerful planning. However, this assumes that all actors pull in the same direction, which practice suggests is seldom the case. Might crowdsourcing—an online co-production method to facilitate bottom-up contributions to top-down ideas (Brabham 2013)—offer a venue for the exploration of processes and outcomes that might support empowerment? This dissertation considers crowdsourcing as a set of digitally-mediated practices to support co-production of information for urban planning, differing from definitions centered on mass creativity to solve a problem (Brabham 2009; Afzalan and Muller 2018).

This study traces a lineage of theory for co-production, situating it as a participatory method in Chapter 2, but I do not evaluate co-production quantitatively as in earlier work (Griffin and Jiao 2019a). Co-production is one potential outcome of planning, but this study does not explicitly evaluate the use of crowdsourcing for co-production in this manner—either through location data or policy impacts. Since this dissertation focuses on ongoing applications of crowdsourcing, it cannot yet reveal impacts through *ex post* analysis (Guyadeen and Seasons 2018).

John Forester makes the analogy that to study the best innovations in cooking requires following accomplished cooks (Forester 2015). Conversely, a broad survey of all chefs—or planners—would merely describe the practice without focusing on improvement. Accordingly, this dissertation does not seek to describe the practice of emerging crowdsourcing practices in planning, but to learn from innovators in the field through instructive and detailed cases. As described further in Chapter 3, the sub-field of bicycle transportation planning provides a critical venue for understanding emerging uses of crowdsourcing, since it supports the acquisition of previously unattainable information to measure and improve safety outcomes. Therefore, this dissertation explores crowdsourcing in bicycle transportation planning in two cities with early investments in crowdsourcing: Austin, Texas, and Portland, Oregon. The next section provides an overview of communicative planning and an introduction to some of the problems with public participation in planning.

Problems of Traditional Participation

What I call "traditional participation" might also be referred to as off-line, including all of the broadly-accepted participation practices including, but not limited to public meetings, hearings, postal notifications, paper surveys, workshops, and mediation. These are merely the tools of much more substantial concerns of communicative planning. John Forester was the first to translate Habermas' critical theory for application in planning, resulting in four practical questions for planning practice, which I have edited for brevity (Forester 1980, 239):

> 1. Is the planner's communication *comprehensible*, so others can understand what in fact is happening around them or to them?
>
> 2. Is the planner's communication offered *sincerely* and uttered in good faith, or are the listeners being manipulated, misled, fooled or misguided?
>
> 3. Is the planner's communication *legitimate*, given the planner's role and the participation of other interested parties, or is the planner taking advantage of professional status unfairly?
>
> 4. Is the planner's communication *true*? Can we believe it, bet on it? Is there evidence supporting it?

In Forester's view, and others to follow (e.g. Innes 1995; Hoch 2007), each of these questions hold both the potential for planners to support communicative planning and distortions that can also undermine the practice. Comprehensiveness, sincerity, legitimacy, and truthfulness can serve as lenses to understand potential problems for traditional participation, but there are practical constraints to achieving the aims of communicative planning.

In the United States, specific public participation methods are required by law, which tends to set a narrow conception of traditional techniques (Innes and Booher 2004). Community meetings, public hearings, and the like have been encoded by law since the 1960s through the National Environmental Policy Act (United States Council on

Environmental Quality 2005) and Civil Rights Act (United States Department of Justice 1964). States and local governments adopted the concepts of these laws in their statutes and guidance for transportation planning, and often include supplemental involvement methods such as comment cards and paper-based questionnaires. This section deals directly with the problems of traditional participation from the perspective of participants, planners, and decision makers such as government department heads or elected officials in turn.

Problems for Participants

"Meaningful public involvement is a necessary condition for achieving transportation equity, but standard approaches for engaging the public are simply not working well" (Karner and Marcantonio 2018, 8). This statement suggests that transportation decisions can and do get made with inadequate public processes and that they will not likely result in equitable outcomes. Participants struggle with public meetings, whether because of location, timing, self-study time and investment, or concerns with public speaking (Grossardt, Bailey, and Brumm 2003; Showers, Tindall, and Davies 2015; Karner and Marcantonio 2018).

Members of the public—which I define in the broadest sense beyond that of *citizens* or *stakeholders*—have to balance the use of their time and resources with their interests in improving public planning outcomes. Many participants take time from their schedules to learn about the issues at hand before attending meetings. The locations of meetings have to meet public accessibility requirements per the Americans with Disabilities Act, but may not necessarily be available to all. For instance, a meeting could be held more than a walkable distance from a transit stop, favoring participation by those with motorized vehicle access (Kramer et al. 2013; Karner and Marcantonio 2018).

Additionally, meetings may not be held at convenient times. Inevitably, those working shifts, caring for children or elders, are less likely to attend a meeting fitting a nine to five work schedule. When people can attend, they may also be frustrated by one-way interactions through "listening sessions" or public hearings that do not support dialogue or even clarifying questions (Innes and Booher 2004). Some meetings may offer discussion, but the physical layout of the room can reinforce a power hierarchy by placing officials behind large desks in a classroom arrangement. Each of these barriers—location, time, one-way communication, and physical layout—are challenges for participation specific to traditional public meeting formats. These barriers prevent basic access to participation, and therefore notions of comprehensibility, sincerity, and truthfulness can only be evaluated through the eyes of attendees. These issues, in particular, the one-way communication approach dominant in public hearings, calls into question the legitimacy of the process.

Problems for Planners

Professionals such as transportation planners have a different set of challenges than members of the public in fostering participation. Planners may be among the most informed on the direction of a given planning project, and their challenges lie in communicating key issues to both the public and decision-makers in the process. Institutional barriers, such as a workplace culture or traditions with little regard for the value of public involvement is a chief concern (Grossardt and Bailey 2018). Planners struggle to counter the challenges facing the public in getting involved, including convenience, knowledge, and apathy. To ensure a broad spectrum of participants, they attempt to tailor approaches ranging from cultural leaders such as churches to new communication technologies and mass media (Lewis and Lane 2007; Evans-Cowley and

Griffin 2012). Public engagement inherently requires dealing with complexity, integrating a growing group of participants' perspectives with bureaucratic procedures and often-conflicting organizational goals (Innes and Booher 2000; Grossardt and Bailey 2018). The complexity of planning projects also involves an extended time, creating a quandary for planners. Planners can attempt to sustain public interest in the project, sometimes extending from months to years, or they can focus engagement in defined participation periods. The sustained approach may foster apathy and be perceived as a waste of public time and resources with no immediate outcomes, whereas the periodic approach could lead some to feel left out of key decisions that set the path of the process. The lack of accepted standards for measuring performance leaves planners with little agreement on how to measure success, whether in the interim to support changing course when needed, or overall to demonstrate the value of public engagement to a planning process (Kramer et al. 2013; Griffin, Radtke, et al. 2018; Callahan and Kloby 2007). Finally, training for public engagement is uneven in planning academic programs and professional education, though organizations such as the International Association of Public Participation are advancing the practice (Fredericks and Foth 2013). In sum, the challenges for public participation from the planner's perspective are vast, including institutional barriers, ensuring a broad audience, complexity, extended time periods, a lack of standardization, and uneven training opportunities. Despite the challenges faced by the public and planners in planning process, agency heads and elected officials must nonetheless finalize a decision.

Again, these issues pose challenges to planners regarding whether the ideas are comprehensible—issues involving economics and forecasting involve complicated methods, that may nonetheless impact real-life outcomes. Planners struggle to assure participants that their statements are sincere, coupled with the level of uncertainty involved in any estimate of future conditions. Furthermore, despite their best efforts, the actual time and resources available for a planning project can make a planner feel it may be mostly illegitimate, especially if they suspect the critical decision makers may have already decided on a given outcome. Planners work with two levels of transparency—public meetings and posted materials may conflict with inner workings of staff and elected officials.

Problems for Decision Makers

Regardless of the process, elected or appointed officials have the responsibility of making a disposing decision on planning issues, determining which of the recommendations by the public or staff becomes encoded as policy (Brooks 2002). To do this, they implicitly make judgments based on their perceptions of the process and likely outcomes. In an ideal approach to communicative rationality, this would include consideration of "openness to the public, inclusiveness, equal rights to participation, immunization against external or inherent compulsion, as well as the participants' orientation toward reaching understanding (that is, the sincere expression of utterances)" (Habermas and Cooke 1998, 367). In reality, decision-makers such as city council members must make judgments of planners' communication, again regarding comprehensibility, sincerity, legitimacy, and truthfulness, often in a high-paced public meeting with real people and money at stake. Decision makers, planners, and the public have transformed participation to incorporate online methods in recent years in an attempt to mitigate these problems, or at least make them more accessible and transparent, but online approaches have problems of their own.

PROBLEMS OF ONLINE PARTICIPATION

No studies suggest that online engagement can or should serve as a complete substitute for personal interactions. Despite contemporary improvements that increase the richness of experience for participants and enhanced data structures for use by planners, online participation has serious challenges when considered outside of a comprehensive participation process including in-person engagement. Writing in 2010, Innes and Booher recognized the increasing role of remote participation, but they stress the need to personally engage in challenging collaborative issues. "The face to face aspect of collaborative dialogue is critical, not just so everyone can hear and question each other's statements, but also so everyone has the opportunity to judge each others' sincerity" (Innes and Booher 2010, 98). Beyond their assessment, studies support concerns over digital inequality, loss of contact, and the loss of civility in online engagement.

Digital Inequality

As early as 2001, researchers of the Internet in the United States distinguished the "digital divide" concept as merely identifying access issues, rather than serious differences in people's ability to use and benefit from the Internet—termed "digital inequality" (DiMaggio and Hargittai 2001). For instance, most Americans now have access to the Internet in one form or another, but lower-income and older persons more likely only use mobile devices, which limit their ability to use the Internet for "capital enhancing" activities (Pearce and Rice 2013, 721). Though these inequalities do vary over space, with clusters of high and low use, a recent study from the United Kingdom revealed digital inequality to be explained by demographic differences that happen to be associated with specific geographies (Blank, Graham, and Calvino 2018). I suggest public participation in planning as such a "capital enhancing" activity, to the extent that individuals and communities can help direct future environmental changes to a varying extent that could be impacted by online engagement practices. Whether dictated by place, income, age, or education, digital inequality poses a serious challenge to public participation seeking inclusiveness or equity.

Loss of Contact

Personal, rich, interactions between people can increase trust, reduce prejudice, help address ambiguous problems, and are often preferred by participants (Pettigrew and Tropp 2006; Wee, Geurs, and Chorus 2013). An experiment of online interaction showed text-only communication scored lowest regarding four components of affiliation: "enjoyment of interaction," "liking," "closeness," and "perceived partner responsiveness" (Sprecher 2014, 194). However, these perceptions essentially equalized after a second encounter, with online video scoring slightly lower than audio, face-to-face, and even text-only (Sprecher 2014). These recent findings corroborate with previous studies, suggesting the choice of communication channel might be necessary for initial interactions, but not for follow-up communication. Planners' current emphasis on online engagement might not promote positive interactions as well as face-to-face encounters, at least initially. Social media and online methods are likely to be a useful way to recruit participants, but might be most successful if focused on first achieving an in-person interaction. Online technologies increasingly offer richer, personal experiences, with the use of augmented and virtual reality increasing in practice. However, this strain of loss of contact from online interactions, particularly in the urban planning field, deserves more attention from researchers.

Loss of Civility

Some people are willing to share more online than in person, but this does not mean that their behavior is more factual, and may more often be unkind. Increasing evidence shows that people avoid interacting with people online who hold different views—and clashes are often unproductive (Kriplean et al. 2014; L. G. Stewart, Arif, and Starbird 2018). However, planning practice-oriented research suggests that approaches which tend to mirror traditional meetings can foster more civil participation. Setting expectations of civil behavior at the beginning of an interaction is vital in an online tool, just as in an in-person public meeting (Evans-Cowley and Kitchen 2011). Using a real identity online may improve civility. Forums that allow participants to use an online avatar or "handle," rather than their own identity, may encourage uncivil behaviors (Noveck 2003). Other methods that mirror real-life interactions, such as meeting at the same time—*synchronously*—supports purposive interaction "without the inefficiencies of travel" (Noveck 2003, 62–63). A moderator's role is vital online as well, providing a check of civil behavior, and verbal re-direction when required.

Evidence suggests that more investment in resources and online staffing could improve interaction with and among publics. Beth Noveck takes this perspective, in that "observing the etiquette of interaction, it is possible to create an environment in which everyone can speak and be heard, conflicting viewpoints can be aired with civility" (2003, 29). A study of online communication about transit showed that participants were more civil on social media when staff could take the time to offer personalized attention—a finding consistent with previous findings from customer service research (Schweitzer 2014). Though online participation does not solve problems of uncivil participation—in fact, it may exacerbate them—planning organizations can take affirmative steps to improve civility online.

However, evidence from insurgent communities in threatened or emergent democracies shows a place for "incivility" focused toward liberation. Uprisings in Egypt, Saudi Arabia, Brazil, Chile, and India have all shown the power of online collaboration as counter to the state, but civil in the sense of seeking to improve democratic communication (Castells 2013; Hoskins 2013). Online moderators, including planners, have to be attentive to whether participation that may appear to some to be uncivil could be working towards positive ends.

Determining whether agencies are making progress on improving online participation is undoubtedly a challenge, and few frameworks exist to apply performance measures. The next section describes why legitimacy, accessibility, social learning, transparency, and representativeness provide focus on the issues that matter for public participation that incorporates online engagement.

Organizational Control

Online participation creates new problems concerning not only how people participate, but even who owns the information and manages the process. Unlike a traditional public meeting staged by a planning agency, online platforms combine devices owned by members of the public, guidance that might be led by the agency or a third party, and often software developed by yet another organization. By fostering online participation, agencies may unwittingly require public sharing of information with software developers or hardware makers, and these digital intermediaries not only become the 'venue' of participation but may also function as archivists or resellers of the information (Gabrys 2014). In offering online participation for public participation, agencies are negotiating a "dialectic of control" with stakeholders, working through top-down decision processes based on contributions through equipment owned by participants from the bottom-up (Stephens 2018). At the same time, these "stakeholders…located beyond the organizations where people work often have some pull on how people communicate, especially with personal mobile devices" (Stephens

2018, 222). Providing online access to public participation through personal devices thus blurs the boundaries of participation—personal and professional, inside or outside the agency, generalized information or targeted towards a specific planning decision. These opportunities and problems for participation with online tools suggest a need to (re)define what good participation looks like, and how it may lead to improvements in planning and outcomes in everyday lives.

This review of traditional and online approaches to participation, including methods to evaluate the process and results suggests gaps in existing frameworks for participatory planning. Specifically, research on contemporary participation suggests that Forester's framework may be insufficient to evaluate impacts on public decision-making that incorporate digital techniques, particularly concerning accessibility, social learning, transparency, and representativeness. Accessibility to digital engagement practices differs from traditional media, necessitating new approaches to evaluate access to online public participation (Jankowski et al. 2017). Social learning occurs both through online discussion groups (Black 2012; Afzalan, Sanchez, and Evans-Cowley 2017), and with in-person meetings using digital media (Goodspeed 2016a), therefore a valuable part of online public participation. Similarly, transparency is a public expectation of online government, both through open data and planning process (Schweitzer and Afzalan 2017; Griffin and Jiao 2019a). Further, representation issues stem from uneven online participation linked to accessibility and structural biases (Goodspeed 2016b; Clark and Brudney 2018). Therefore, access, social learning, transparency, and representation are additional concepts needed in an evaluation framework suitable for contemporary online participation. Human contact, civility, and organizational communication remain important issues for further research. Forester's framework set a basis for evaluating communicative planning, but a new approach is needed to evaluate digital co-production.

The next section introduces a framework for evaluating participation, oriented towards twenty-first-century challenges in participatory planning.

A 'LASTR' Approach to Participation—Legitimacy, Accessibility, Social Learning, Transparency, and Representativeness

Participatory planning in Western democracies can take many guises but is rooted in an Aristotelian search for a city polity that connects "happiness and justice" (Habermas 1987, 2:110). The search for these ideals in urban contexts lead researchers and planners to consider a variety of engagement methods, including dialogic and guided data, encompassing a mixed approach to reconciling individual and organizationally-driven visions for planning that could lead to a 'good' city. Habermasian communicative action was premised on face-to-face interactions, fueled and facilitated by the fastest and most pervasive media available: newsprint, radio, and television (Habermas 1962). Habermas proposed four conditions of ideal speech—comprehensiveness of statements, accuracy about the real world, the legitimacy of the speaker, and sincerity of the speaker. The communicative approach has real-world limits, however, particularly in light of two broad issues. First, there are substantial critiques of the approach as idealistic, ignoring power and structural discrimination (Huxley 2000; Flyvbjerg 1998b), among other factors further detailed in Chapter 2. Second, the production and dissemination of knowledge in the information age have switched from being a one-to-many relationship, with media professionals as a key filter, to a many-to-many association, where networked publics simultaneously consume, produce, and disseminate information (Papacharissi 2014; Castells 2013; Wells 2015). The underpinnings of planners' and publics' communication with traditional media are changing, and new digital approaches to participatory planning deserve scrutiny. Chris Wells argues that a new approach to civic engagement—that of a digital citizen—"is profound enough to constitute a new paradigm of civic information, albeit one that is in its infancy and still incompletely formed" (Wells 2015, 21). Not only are questions of *who* produces knowledge for transportation planning up for debate, but also *where*. Adapting Forester's questions of pragmatic communicative planning, I propose a framework for building and evaluating public participation for the era of *network society* (Castells 2007), focused on the components of legitimacy, accessibility, social learning, transparency, and accessibility, which I shorten as *LASTR*.

Legitimacy

This study considers the degree to which a public planning process is designed to effect real outcomes is its legitimacy. Previous studies found legitimacy is supported early-stage process deliberation between planners and politicians (Legacy 2010), and harmed when engagement is designed to broadly appear genuine but lacking substance (Thorpe 2017). Sherry Arnstein's Ladder of Citizen Participation and John Forester's enabling rules and organizing practices (Forester 1980; Arnstein 1969) set the stage for an understanding of how to understand legitimacy in planning, albeit in different ways. I review their approaches related to legitimacy in some detail here, principally because legitimacy is a foundational concept for public participation, and because many years have passed since the original publications, with intervening interpretations that should not be confused with the present argument.

Forester's enabling rules and organizing practices stem from Habermas' critical communications theory of society developed in the 1970s, which Forester applied to the regular practice of planning with public participation. Forester's pragmatic communication expects others to speak comprehensively (relating to all pertinent issues), sincerely (following actual intentions), legitimately (aligning pertinent facts and perspectives), and truthfully (avoiding falsehoods) (Forester 1980). Forester describes that we experience distortions of legitimacy in planning through face-to-face communication when issues can be described out of context; organizationally when staff are unresponsive or dominant; and regarding a political-economic structure when an agency is not accountable for actions. Each of these can also apply to online communication through communication between individuals (one-to-one), organizations and individuals (many-to-one), and in the structures of economic and political feedback between publics and planning agencies.

New media communication does not necessarily prevent these distortions from being repairable, but it may complicate speaking roles when the identity of the message sender is unclear. Individuals can legitimate their communication by negotiating their roles. Organizations can clarify how decisions will be made through online media, but the political-economic structure is unlikely to be impacted directly online, as governing agencies still make decisions in an in-person context. This suggests limits to the role of online participation in the near future regarding legitimacy—individuals and agency communication structures may supplement or even supplant in-person communication, but this does not change the fundamental sites of political and economic structure.

Legitimacy has an increasing role in each of the rungs on Arstein's ladder, which I italicize in this section for clarity. Arnstein uses examples of community action agencies to show how the "bodies frequently have no legitimate function or power," but are used to cause the appearance of real involvement—only serving as a form of *manipulation* (Arnstein 1969, 218). She describes a tweak of manipulative approaches to promote intra-group communication as a form of *therapy*. *Informing* turns this approach around to information flow from a planning agency to the public, but notes that "informing citizens of their rights, responsibilities, and options can be the most important first step toward legitimate citizen participation" (Arnstein 1969, 219). The fourth rung is *consultation*, noting that at least “inviting citizens’ opinions, like informing them, can be a legitimate step toward their full participation” (Arnstein 1969, 219). In p*lacation, planners* “allow citizens to advise or plan ad infinitum but retain for powerholders the right to judge the legitimacy or feasibility of the advice” (Arnstein 1969, 220). *Partnership* and *delegated power* represent higher levels of citizen control, where legitimacy is apparent through cooperative action. *Citizen control* is the final rung, involving full decision-making authority by publics, with planning staff and officials in a support role. Most recent research on public engagement uses the Arnstein Ladder as a conceptual metaphor, rather than developing rigorous performance measures aligned with rungs. Readers are pointed to a special issue in the *Journal of the American Planning Association* on 50 years since Arnstein's Ladder that is under a call for papers as of this writing.

Research to date suggests that online participation, even when part of a more traditional approach, may offer more limitations than benefits regarding legitimacy to date. Online identity is a persistent problem for legitimacy. Though the choice to be anonymous online can be liberating in terms of promoting freedom of expression, it does not support accountability in the real world of place and position. Beth Noveck associated legitimacy of participation with accountability: “to be a legitimate expression of the general will, these dialogues must be reasoned, rational, and accountable” (Noveck 2003, 69–70). Many online platforms, such as Facebook, encourage people to use their real identities through verification via email and mobile phone numbers, this is not a significant barrier in practice. For instance, research carried out in 2015 demonstrated how programmers could develop bots that mimic humans online to influence elections (Murthy et al. 2016), and then the 2016 US Presidential election was influenced using these methods (Shane 2017). Though there are ways to improve the certainty of identity associated with online accounts, such as microtasks to verify human users, known as "captchas" (Lease and Alonso 2014), platform developers are under pressure to make users experiences as seamless and fast as possible. Regardless of how well-designed a public engagement platform is, a failure to incite sufficient engagement can undermine the effort. For instance, lack of citizen engagement or use of the data or results of a crowdsourcing effort, even that seems to legitimize data collection efforts for a good cause, will nonetheless show a general failure of the effort (Tironi and Valderrama 2018). Follow-through from design, recruitment, sharing results, and using them to effect positive change are therefore all important for legitimate online participation.

A significant advantage of online approaches, however, is that the public-developed online resources can support advocacy efforts. When an agency develops a mechanism for gathering online information, such as suggestions for bike share station locations, and posts information to support the collective effort, all contributors can typically see all previous suggestions, increasing transparency for all involved (Afzalan and Sanchez 2017). In this way, the supporting agency is providing an information technology infrastructure that any may use, and advocates for any position may potentially use it to their advantage. However, design decisions set the stage for what information is shared or prioritized, setting an agenda that could suggest a certain perspective (Rauchfleisch and Kovic 2016). However, an empowerment framework may also provide support for community advocacy. The following elements form the basis for designing online systems oriented towards empowerment (Álvarez Sánchez, Gimilio, and Altamirano 2015):

> 1. Awareness of both individual and collective capacities, as well as of the current situation of the economic, social and political environment.
>
> 2. Acquisition and development of competencies that allow active participation, either individually or in the group, in decision-making processes on issues deemed essential.

3. Development of an enabling environment that establishes both formal and informal institutions, ensures access to information, and sets accountability procedures to facilitate participation in decision-making processes at a local, national and even international level.

The first element of this framework relates to the communicative abilities of organizations to share knowledge, which connects Alinsky's *Rules for Radicals* as a grassroots organizing framework to the network-based crowdsourcing systems (Alinsky 1972; Brabham 2013). The second element referring to the competencies ties in the importance of developing both technical skills and social learning, which I review further below. The third element includes structural considerations, recognizing that the frameworks for governance restrict, but also support how publics can be empowered. In planning, development of collaborative frameworks is a necessary condition of empowering participation (Healey 1997), including those using a crowdsourcing approach.

Accessibility

For public participation, accessibility involves the ability of members of the public to involve themselves in a planning process. Accessibility involves spatial, temporal, and availability of the process from the perspective of language and technical skills.

Online participation methods offer significant advantages regarding spatial and temporal access, but are limited by language and technical availability—termed the digital divide (Sui, Goodchild, and Elwood 2013). Nonetheless, online methods show significant prospect regarding the number of participants. A recent study of online and face-to-face participation in Poland showed an increase of five (geo-discussion) and forty times (geo-questionnaire) the number of participants attending in-person meetings (Jankowski, Czepkiewicz, Młodkowski, Wójcicki, et al. 2016). This recent example also included similar levels of participation between different levels of education—showing that online or in-person participation do not necessarily bias participation among those with higher education. However, online participants were on average seven years younger, suggesting a role to continue both techniques to support diverse ages of participants. This is consistent with online access polls in the United States, with the digital divide lessening by income, education, and race, but with persistent lag for older persons (Pew Research Center 2016). The chief advantage of online participation is the convenience for participants, and scaling for staff—online methods support higher numbers of participants in a planning process.

As presented at the outset of this introduction, participation is fundamentally a problem of equity. Burgeoning research on performance measurement for public participation suggests that planning agencies tend to focus on *outputs* of involvement rather than *outcomes* (Kramer et al. 2013; Callahan and Kathryn 2009; Bailey, Grossardt, and Ripy 2015; Rowe and Frewer 2000). Some form of community deliberation forms the basis of successful public participation. For a focus on equity, this may involve traditional techniques like public meetings and advisory groups, but targeted outreach for low-income and minority households could require alternative methods (Karner and Marcantonio 2018).

Social Learning

Gaining or sharing knowledge or skills between participants in a planning process—including staff and publics—supports social learning. The idea of learning as both a precursor and positive side effect of civic participation is a tradition in pragmatic notions of democracy. Previous studies suggest that social learning in planning requires communicative and informatics components—that social learning "depends on the transfer or flow of information" (Gudowsky and Bechtold 2013, 7) that can be supported by technological tools in social contexts (A. F. Stewart et al. 2018).

Taking a broader perspective, John Dewey suggests that a good idea can spread, even beginning with a "minority of one" (Dewey 1927, 208). However, he describes that there needs to be a positive context for social learning to take place, that could lead to better decisions from a democratic process (Dewey 1927, 208):

> The important consideration is that opportunity be given that idea to spread and to become the possession of the multitude. No government by experts in which the masses do not have the chance to inform the experts as to their needs can be anything but an oligarchy managed in the interests of the few. And the enlightenment must proceed in ways which force the administrative specialists to take account of the needs.

So, Dewey distinguishes democracy led by a learning public as superior to leadership by experts, since an educated populace can direct a government to align resources with the actual needs of the people. Dewey did not describe *how* ideas spread, however, which were later articulated through the ideas of communicative action (e.g., Habermas 1990), network society (Castells 2007), and social capital (Wilson 1997). Patricia Wilson concurred with the development of social knowledge as a precursor to practical decisions, noting "power rests in the people' s capacity to make sense out of reality" (Wilson 1997, 749). Directed towards participatory planning, collaboration "produces a process by which participants can interact with each other, producing social learning outcomes characterized by changes, including convergence in perceptions" (Slotterback et al. 2016, 72). Raymond Burby's research shows the link between social learning and planning outcomes is critical, noting "the key is for planners to work hard to both educate and learn from citizens" (Burby 2003). There is some evidence that the richness of experience, such as including visualization of environmental data, can improve both social coordination outcomes and cognitive understanding (Hoch et al.

2015). When people participate online, however, they no longer have direct experience of social reciprocity, and iterative question-and-answer become more difficult with the introduction of time lags. Further, few online platforms include the combination of back-and-forth communication between citizens and experts, combined with visualization to improve common understanding (Cooper and Balakrishnan 2013).

In contrast, online participation platforms that include active participation in developing and sharing knowledge can support mutual learning. “A participant with low interest at first can develop into a player with decisive contributions, and another person, who is affected by the problem situation, receives and compiles essential information and solution options for his case, as well as a certain understanding for comprehensive contexts, etc.” (Wechsler 2014). Wechsler suggests crowdsourcing methods may be particularly helpful with improving understanding and dissemination of knowledge when participants grow from first-time contributions to sharing knowledge with others on the platform. A primary condition of knowledge sharing and developing networks is the level of openness for participation—which is one way to see the characteristic of transparency.

Transparency

Transparency has to do with the ability of people outside an organizational process to be able to find and answer questions about how decisions are made. In this way, transparency is intermingled with the concept of accountability—visible and coherent information about a process that helps ensure government decisions align with public needs (Pak, Chua, and Vande Moere 2017). Participants consider transparency as a requirement for trusting a planning organization, a key component of cultural capital for public planning (Mandarano 2015). In planning processes, we can think of transparency both in terms of the degree that participants can find and understand the process of planning, in addition to the data and information used in that process. Conceptually, transparency supports public engagement by helping them understand "the underlying basis for decision making, and more deeply involving them within that process" (Johnson and Sieber 2012, 668). Case evidence in transportation planning shows that participants become disenfranchised when planners fail to provide participants enough information about the process, and clear understanding of how their participation will influence decisions (Mattingly et al. 2010). Planning participation researchers identify transparency throughout the planning process; defining questions, producing and analyzing data, transparent reporting of the topics and locations of disagreement, and how final decisions are made.

Publicly-accessible planning tools also support transparency. Planning managers seek participation methods that increase transparency both for its direct benefit to the public, and also to the perceived image of city administration (Pina, Torres, and Royo 2017). For instance, Envision Tomorrow's spreadsheet structure allows public review of planning performance measures and the formulae that make each work, theoretically enabling public monitoring outside of sponsored planners' work (Minner 2015). Public participation geographic information systems (PPGIS) support visualization of data for planning, in addition to spatial commenting and disagreement of solutions (Kahila-Tani et al. 2016).

Transparent planning processes lend themselves to clear evaluation by people outside the process (Laurian et al. 2010). Government officials may see this as both an advantage and disadvantage, where increasing transparency may also expose problems that staff need to solve or help people see where and why their participation is not used in decision making. Publics might also use online tools to improvise transparency when governments do not offer it, as shown by the use of Twitter in the Arab Spring (Hermida, Lewis, and Zamith 2014), or Chinese use of Weibo and WeChat to share knowledge among networks of citizens (DeLuca, Brunner, and Sun 2016). As governments experiment with increasing transparency, they can incrementally improve their ability to respond to participants, and create more clear and responsive systems for planning (Johnson and Sieber 2012).

Big data is not necessarily transparent data. The complexities of online systems, the choices of data that is retained, shared, and found, all create new opacities—the opposite of transparency (Ashton, Weber, and Zook 2017). Larger datasets require algorithms to process and distill into meaning, often creating a black box where a company increasingly owns access to the knowledge—shifting power and influence from the participants (Orlikowski and Scott 2015). Some argue that when participants knowingly produce part of the data for planning along with government, they are empowered through learning and representation in the datasets used for making decisions (Linders 2012). However, this kind of co-production of information as a service leaves the field with conflicts and areas for future research (Sieber and Johnson 2015, 314):

> Reaching beyond the government as platform model towards participatory open data will require resolving the ethical-economic tension that drives opening data. How government balances the ethical (democratic in broadening participation, empowering with the inclusion of new voices) versus economic (a new source of monetization, crowdsourcing as outsourcing to volunteers as a way to reduce costs) will shape the way that government data is used to interact with citizens and the private sector.

Transparency of both the planning process, and the data used to support decisions, enables performance monitoring, and management. When a government agency transparently reports its performance criteria and results, that information "becomes useful knowledge" that "increases accountability" (Callahan and Kloby 2007, 11). Both theoretical explorations and empirical case results show that information and communication technology has the potential to increase transparency in the planning process, but that the structures of governance mediate this, and how planners work with the data, regardless of how open it is (Lin and Geertman 2015).

Governments, corporations, and individuals may have their reasons for not wanting to share all information, however. Inter-organizational relations theory suggests that organizations may resist sharing data with others because they may lose autonomy in making decisions with the data (Evan 1965; Goodspeed, Spanring, and Reardon 2012). Involvement of private companies in public participation may cause a conflict of transparency—wherein government may want to share a great deal of information, but companies do not want to share intellectual property that could have an economic value (Nakatsu, Grossman, and Iacovou 2014). Public participation via online tools also opens the possibility of having participants' information be misused or stolen (Afzalan and Muller 2018). Transparency is not a binary decision for planning organizations—it is gradational and multi-dimensional, in addition to being inherently uneven.

Representation

There are two principal ways to understand *representation* for online public participation in planning. First, it can describe the ways that data or information, such as in crowdsourcing, characterizes the phenomena of interest. In this dissertation, whether a crowdsourced bicycle trip route accurately depicts the actual route of the participant is this first notion of representation (Kam et al. 2018). This phenomenological perspective on representation is presented in Chapter 3 when aligning explanatory data to GPS-derived paths. Second, representation can refer to differences and similarities between a group of interest—such as crowdsourcing participants—and the larger population of a community (Linders 2012). This second meaning is what I refer to chiefly in Chapter 6 on the location of participation and how it does or does not represent local communities.

In democratic countries, we understand the idea of ensuring consistency between those making decisions and the larger population as *representativeness*. Though simple in concept, carrying out democratic representation has been a major concern since the founding of the United States (de Tocqueville 1840/2002), with white patriarchy the law of the land until the Civil Rights Act of 1964 (United States Department of Justice 1964). The Civil Rights Act did not solve problems of representativeness, of course, which continue to trickle into how governments involve publics in planning decisions. At issue in this dissertation is how crowdsourcing approaches may impact the representativeness of decision-making for planning. The brief review of research to date below suggests that digital inequality adds problems of representation to pre-existing ones, recognizing that participation may have never perfectly represented a public.

Nationally, 89% of US adults use the internet, with no appreciable difference overall between access by either race or gender (Pew Research Center 2018). However, inequality of internet access remains by age, income, education and community type. In 2018, only 66% of US adults over the age of 65 used the internet, compared with 98% of adults age 18-29 (Pew Research Center 2018). Among US adults making less than $30,000 a year, only 81% use the internet, versus 98% of those with incomes of $75,000 or more (Pew Research Center 2018). Education has a similar range, with 65% of those without a high school diploma use the internet, and 97% of college graduates (Pew Research Center 2018). Differences persist by community type, with 78% of rural residents using the internet, and 92% of urban residents (Pew Research Center 2018). Differences in digital access can translate into discrepancies of “computer and Internet abilities,” known as *techno-capital*, deepening inequities of access to opportunities

(McConnell 2014). Though the disparity of internet access between these groups has dropped over time, online participation alone will not reach significant portions of the population—the same demographics likely to be at risk from planning outcomes like displacement in the first place (Sandoval 2007).

These national statistics on digital inequality trickle into the case communities of Austin and Portland, as well. Both cities recognized the risk of having some parts of a community more digitally connected than others, such as access to economic opportunity (Lentz and Oden 2001), and put effort into developing public Wi-Fi in areas to help bridge the digital divide. In Portland, the city partnered with a local company to provide Wi-Fi service with a low-cost subscription ($20 per month) for basic broadband or a no-cost service supported by ads (Ortiz and Tapia 2008). "UnWire Portland" launched in December 2006, focusing on the downtown area, and was perceived by some as "'checking it off' their list and moving on to other areas of interest, without actually having addressed the more fundamental issue of how the ICT was used in the home" (Ortiz and Tapia 2008). A similar approach had been brewing in Austin for several years under the guise of the "Austin Wireless City Project", but also focused on the downtown area, leaving the problem that disenfranchised communities are less likely to have devices that could take advantage of a Wi-Fi signal, even when they were available (Fuentes-Bautista and Inagaki 2012). Portland and Austin are both known as centers for high-tech innovation, but researchers see their efforts to expand broadband internet access as having little real impact on disadvantaged communities.

Online participation in planning suffers from digital inequalities, but research shows nuances where internet engagement can help target certain underrepresented groups or co-produce knowledge for planning in different ways than with traditional means of engagement. Early studies of online participation acknowledge participation biases, in which online participation over-represented young professionals, yet they allow new ways for governments and publics to work together, potentially over broad geographic areas and high speed (Linders 2012; Bryson et al. 2012). Growth of social media and other online tools soon led agencies to adopt ICT approaches widely, and participation textbooks reflected this practice, steering professionals towards dealing with representation issues through both *thick participation* (few people having rich discussion) and *thin participation* (many people briefly participating, often online) (Nabatchi and Leighninger 2015).

Crowdsourcing and PPGIS approaches have added problems of representation for planning decisions since they are often anonymous. Whether to require participants to include information about themselves is a concern, since including extra steps adds 'friction' to the experience, and some may not participate (Noveck 2003). Sharing key issues of representation—like home location, gender, race, or age—could be important for planning in a political process. "Decision makers want to know who their stakeholders are, and crowdsourcing does not necessarily lend itself to making that known" (Seltzer and Mahmoudi 2013).

One way to mitigate population representation issues with online methods is to borrow an idea from traditional survey research—use an existing, representative panel of participants. Review of previous studies shows that this approach can improve sampling and response rates for participation, but that these participants, often paid, provide lower-quality contributions in terms of spatial accuracy on PPGIS platforms (Brown 2017). This again reflects a similar tension to the *thick* and *thin participation* issue—planners need to choose an approach likely to yield appropriate responses.

The reality of participatory planning is that it is often volunteer-driven; few online panels exist for specific geographies and planning needs. To date, studies of crowdsourcing and PPGIS show persistent biases against traditionally marginalized communities. These problems persisted through studies in Chicago, Cincinnati, Philadelphia, Portland (Piatkowski, Marshall, and Afzalan 2017), and Brussels (Pak, Chua, and Vande Moere 2017). However, more nuanced analysis of planning in Muncie, Indiana showed that planners' analysis of participation during the process could inform planners on how to change participation to achieve more representative participation (Radil and Jiao 2016). Representation biases in participation create a quandary for planners—if participants do not reflect the population, empowering the *participating* public could further marginalize those that could not participate.

Overall, online tools create several new problems of representation for public participation. First, there is the challenge of *who* uses a particular online platform, and how that sample population varies from the composition of the full population in the geographic area of interest. Second, *how* they use the platform is also important. For instance, Twitter use may be high enough for a specific study need, but only about one percent of Twitter users share their GPS location along with tweets, so this would magnify problems of representation if spatial accuracy is needed (Leszczynski 2017). Representation is a moving target over time, as well, so *when* participants have access to the right app might or might fit needs for a participatory planning effort. These are the pragmatic issues of representation with online participation, but there are also ontological issues with many open questions, such as in which situations a social media post about an action accurately reflects that action. Leszczynski notes, however, "very rare exceptions such as the social sharing of quantified self-activity logs via platforms such as Strava [smartphone app for sharing outdoor activities], social media data do not code for socio-spatial practices, activities, or broader processes (Leszczynski 2017). Therefore, the similar core crowdsourcing data of logged bicycle trips via the Ride Report platform, introduced in Chapter 3, does not have the ontological representation concern but has similar epistemological problems of representation to other specialized social media.

Legitimacy, accessibility, social learning, transparency, and representativeness encompass key issues for evaluating participatory planning in the 21st century. This approach, abbreviated as LASTR, does not replace the models provided by Habermas, Forester, Arnstein, and others, but may offer precision when working with a mix of online and in-person approaches, which I claim most planning agencies are likely to continue. Each of these five components can be envisioned as lenses, or panes of a window shown in Figure 1, which may offer different levels of luminosity from a planning process' context to the actions of planners, and from the work of planners to outcomes on the ground.

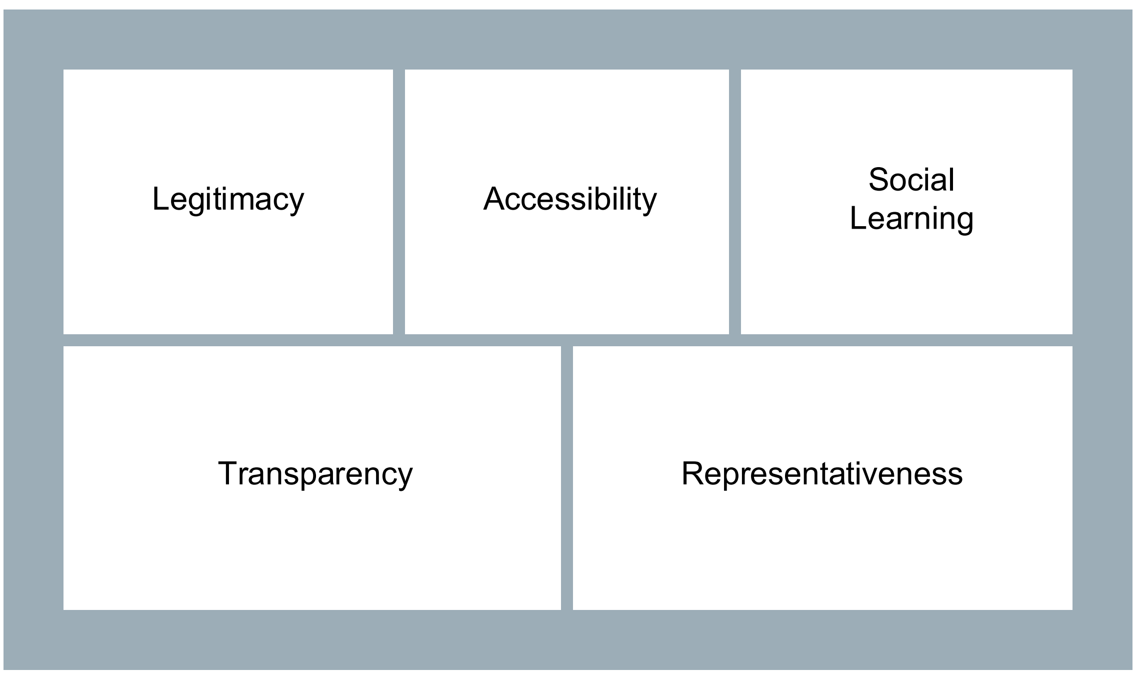

Figure 1: A 'LASTR' Evaluation Window for Public Participation

A NOTE ON POSITIONALITY

This dissertation serves as a bridge. On one end, we[1] will explore new approaches in crowdsourcing from a rather common perspective in transportation planning—pragmatism. We will also pull in perspectives of crowdsourcing from different directions entirely, taking a constructivist approach that sees knowledge development as highly situational and dynamic. A broad sweep of post-positive approaches recognizes the role of bias in the construction of knowledge—such as determining which research questions are suitable to pursue—suggests an important role of the researcher's position on a topic and background (Cope and Elwood 2009; Rose 1997). This issue is only recently making a significant impact on transportation scholarship, long influenced by positivism (Griffin 2014; Battista and Manaugh 2017). Hence, my role as an insider and outsider of the techno-communities of crowdsourcing, transportation planning, and bicycle as a noun and verb deserve mention.

My relatively poor town in southeast Texas growing up may have had little regarding cultural or academic resources, but I did have access to quality bicycles and computers, for a kid in the 1980's. So, I was able to explore beyond my neighborhood on a bike and could operate a MS-DOS computer before the age of ten or so. These tools made it easier for me to see the world from technological perspectives at an early age, and to appreciate the independence afforded by both techno-artifacts. Bicycle racing, and later, land surveying with my father were part of my childhood through undergraduate degree—which both now figure in my use and valuation of geographic information systems (GIS) as a window to crowdsourced bicycling information. Community participation in my early planning work at the City of New Braunfels and Texas Parks

[1] I compose this dissertation in the first person, but when I use "we", I intentionally refer to the joint path of reader and author.

and Wildlife informed my later work in public involvement and active transportation with the Capital Area Metropolitan Planning Organization in Austin.

This dissertation is part of my larger life as a researcher, with several related studies simultaneously underway in my work at the Texas A&M Transportation Institute. As of this writing, I am also the principal investigator of two studies under the Safety through Disruption University Transportation Center (Safe-D): "Sources and Mitigation of Bias in Big Data for Transportation Safety" (Griffin, Simek, et al. 2017) and "Street Noise Relationship to Vulnerable Road User Safety" (Griffin, Hankey, et al. 2017). I am also the field coordinator for a Texas A&M study focused on Austin, "Physical Activity Impacts of a Planned Activity-Friendly Community: The What, Where, When and Why of Environmental Approaches to Obesity Prevention" (Ory 2015). I serve a supporting role on studies on public messaging for departments of transportation, bicycle and pedestrian monitoring using crowdsourced and mechanical means, the economic impact of bicycling, and others. I focus the empirical results of this dissertation on three defined, new studies, and bracket knowledge from the other projects "as an antidote to letting visions of what ought to be get in the way of a firm grasp of what is empirically happening" in the context of the dissertation at present (Flyvbjerg 2004, 296).

OVERVIEW OF DISSERTATION

This dissertation began with a description of the problems of participation in planning from both tradition and online means and suggests an integrated approach to evaluating participation in light of the new challenges afforded by Internet communication. Chapter 2 reviews communicative theories *of* and *for* planning, suggesting a role for co-productive planning participation that corresponds to an emerging civic style. Chapter 3 describes the specific research questions, cases, and methods used in the dissertation. Chapter 4 resolves a fundamental question of the usefulness of crowdsourced information through an empirical test of bicycle safety. Chapter 5 explores the spatial role that crowdsourcing may play in fostering participation at broader geographic scales. Penultimate Chapter 6 takes a sociotechnical approach to understand crowdsourced public participation, tracing changes in understanding and perceptions among five relevant social groups. Chapter 7 offers conclusions of co-productive opportunities and limitations for crowdsourcing, based on this dissertation's analysis of crowdsourcing for bicycle transportation geography and planning. Table 1 shows the general emphases of the empirical chapters across the LASTR framework, with the final chapter including an overview of each LASTR component.

Table 1: Empirical overview of LASTR analysis

Empirical Chapter Emphasis	**4-safety**	**5-geography**	**6-sociotechnical**
Legitimacy	●	●	○
Accessibility	○	●	○
Social Learning	○	○	●
Transparency	○	○	●
Representativeness	○	●	●

Legend: ● = Priority analysis, ○ = little or no direct analysis

Chapter 2: The Radical Pragmatism of Co-production

INTRODUCTION

Public and professional co-production of information for planning—covering all stages of the process instead of just public *comments* on professional work—constitutes a radical, but pragmatic, reconfiguration of planning. Saul Alinsky's conception of radical pragmatism incorporates practically any tactic that so-called have-nots—communities without existing power over a particular condition—can exercise to influence the "haves" (Alinsky 1972). Alinsky states these approaches should be within ethical rules of engagement, but outside of what the haves expect. In this chapter, I trace the roots of contemporary participatory planning through theories of communicative action, collaborative planning, and co-production, providing evidence of crowdsourcing cases for all three approaches, in addition to positing theory supporting the potential for more radical implementations.

Public engagement using crowdsourcing—online, bottom-up production of some portion of the planning process following a top-down call for participation (Brabham 2013)—can be evaluated through traditional communicative and collaborative theoretical frameworks. This chapter provides case study evidence and theoretical support for these, in addition to an emerging co-productive lens. Many of the critiques of communicative action in urban planning remain obdurate through advances in information and communication technologies, and crowdsourcing's dependency on technology creates new challenges regarding power and representation. Notwithstanding these issues, crowdsourcing methods differ from methods emphasizing discourse in that they facilitate some action rather than just language. This chapter responds to calls for evaluating the effect of technology-facilitated participation regarding impact to theory and practice (Castells 2013; Goodspeed 2016c; Trapenberg Frick 2016).

Communicative and collaborative planning were substantially critiqued just as Internet-facilitated methods grew in practice, suggesting a need to reconsider the validity of these critiques as new media has affected the field in recent years (Allmendinger and Tewdwr-Jones 2002; Fischler 2000; Forester 2001; Healey 2003; Huxley and Yiftachel 2000). New research suggests that technology may have potential to re-frame the division of work between planners and the public (Goodspeed 2016c), echoing more significant trends in the casualization of labor and automation (Davis et al. 2010). This chapter argues that crowdsourcing, defined as an online environment for a community of participants to work on an organizationally-defined task for mutual benefits (Brabham 2013), can contribute to participatory planning in practical ways that have been described (Brabham 2009; Seltzer and Mahmoudi 2013), but not sufficiently connected to urban planning theory. Following Habermas' contributions to communicative action theory and discourse ethics, scholarship on collaborative planning theory centers on discourse, rather than direct action (Healey 1997). However, it incorporates the institutionalist perspective, recognizing the role of structures in power and communicative action (Healey 1999). Through top-down tasking by the institution, and bottom-up creation and evaluation, crowdsourcing has the potential to expand the roles that the public can play in a planning process beyond language, and this advancement can both broaden and rejuvenate participatory planning theory and practice. However, crowdsourcing and other forms of new media are subject to many limitations of practice already described by others, but Habermasian communicative action remains a visible, if problematic, goalpost for technology-supported participation to pursue.

The boundaries of terms used in participatory planning require disambiguation, particularly in light of emerging technologies such as crowdsourcing. Without delving into significant debates in participatory planning, recent scholarship offers definitions of communicative, collaborative, and emerging co-productive planning that useful for working through crowdsourcing processes. Communicative planning, stemming mainly from Habermasian communicative action's discourse ethics (Jürgen Habermas 1984, 1987), seeks (though many argue utterly fails) to open discussion leading to planning actions to "promote the deliberative aspect of democracy and create and protect the conditions for deep and genuine civic discourse" (Sager 2013, 5). Robert Goodspeed suggests discourse ethics can be translated to digital platforms directly: "Does the group find the medium understandable (comprehensibility), have its assumptions and limitations been examined (sincerity), is it appropriate for the context (legitimacy), and what level of uncertainty is there about its accuracy given a particular purpose (truth)?" (Goodspeed 2016c, 12). A communicative crowdsourcing platform for planning would then be focused on language, but not necessarily limited to text. Collaborative planning, as formulated by Patsy Healey, is more informed by Giddens' structuration theory than communicative action (Healey 2003). This approach helps address some critiques of communicative planning by addressing power and action through the structures inherent in planning processes, by "helping those involved work out what it means to build new collective ways of thinking and acting, to re-frame and re-structure their ways of proceeding" (Healey 1997, 312). This perspective offers tension for crowdsourcing applications, which often use more of a top-down approach taken from early work in business applications (Brabham 2013). Co-productive planning is a newer perspective taken from development studies and public administration and that focuses on action and learning more than debate and may support differing parties in meeting both instrumental and relational goals (Albrechts 2012; Watson 2014). A co-productive perspective is described as addressing many of the critiques to communicative and collaborative approaches, offering "community control over all stages from initiation of intervention, to data collection and analysis, to planning, implementation and management" (Watson 2014, 71). Planning projects have used crowdsourcing in manners consistent with all three perspectives, as I show later in this chapter. Rather than offering a definitive evaluation of these approaches in crowdsourcing, I seek only to stimulate debate on how emerging approaches may affect each's theoretical relevance in the context of developed, democratic, societies. This approach may also be of use in studies of developing countries and the Global South; if or when technological barriers are reduced.

The common factor in participatory planning is communication. The characteristics of a communicative city are largely compatible, if not symbiotic with normative concepts of effective urban planning (Jeffres 2010). Principal components of the communicative city as initially described by Gumpert & Drucker include places of interaction, infrastructure for communication, and places for politics and civil society discourse (Gumpert and Drucker 2008). More specifically, Jeffres defines the communicative city as one "whose environment facilitates development of a communication system that integrates its residents into a dynamic whole, that enables its citizens to get involved in civic activities and participate in a variety of roles, and makes possible a balance between mobility and stability" (Jeffres 2010, 100). New media can be seen as supporting these concepts through freedom of communication, but also in conflict with traditional urban values of public discourse space. Gene Burd posited the challenge as considering "whether postmodern communicative cities can thrive and survive with less and less geographical place may depend on how, and if, the convergence of the new communications technology creates and connects physical and virtual sites in the concurrent community" (Burd 2008, 219). Crowdsourcing's emphasis on information and communication technology to leverage collective intelligence to solve shared problems (Brabham 2013), provides a pivotal perspective for evaluating participatory planning through new perspectives. Theoretical background and three empirical cases of crowdsourcing in planning demonstrate that technology-mediated participatory planning can fit within each of the three perspectives: communicative, collaborative, and co-productive. However, co-productive planning offers an emerging perspective that could be particularly fruitful to address past criticisms of communicative and collaborative planning, through additional case studies. International trends in both technological advancement and democratic (de)evolution suggest a timely appraisal of approaches.

Focusing on the means and ends of crowdsourcing for participatory planning would be reductive. Similarly, emphasizing the role of crowdsourcing's enabling technologies could fall into technological determinism (Bennett 2008). The forces of innovation and planning process require simultaneous consideration of multiple factors, "since all human activity takes place within society, all science and technology has society at its centre" (Collins and Pinch 1998, 6). This dissertation considers the phenomenon of crowdsourcing as a boundary object, which "both inhabit several intersecting social worlds *and* satisfy the information requirements of each of them" (Star and Griesemer 1989, 393), in two senses. First, crowdsourcing connects technological and economic worlds by leveraging the internet as a new site of 'work,' involving cooperative task performance, whether volunteer or paid. Second, my use of crowdsourcing bridges the interests of bicycling publics with that of transportation planners, providing information that may be useful to either support traditional top-down planning approaches, or to counter them in an advocacy role. Lewis Mumford suggested such a dichotomy of technology in 1964, offering two kinds of *technics* that have existed "since late Neolithic times in the Near East, right down to our own day" (Mumford 1964, 2). "One authoritarian, the other democratic, the first system-centered, immensely powerful, but inherently unstable, the other man-centered, relatively weak, but resourceful and durable" (Mumford 1964, 2). If "technology is society made durable" (Latour 1990), then whether a technology is authoritarian or democratic might be distinguished by tracing its development in the context of its application. Social construction of technology (Bijker 1995, 2009b), explored most in Chapter 6 of this dissertation, provides a framework and method for seeking answers specific to crowdsourcing for bicycle transportation planning,

This chapter frames participatory planning in three traditions, briefly summarized in Table 2. The communicative tradition is first, developed principally by John Forester's work building on the social mobilization roots of communicative action. This approach enables, which I term a *practical affordance*, civic engagement as fundamentally a communication process that supports a healthy democracy. Patsy Healey, Judith Innes, and David Booher extend a social learning perspective, applying structuration concepts to support changes in how the public works with government on planning projects. Appaduri (2012) connected the same foundation of social learning towards deep democracy, giving people a part in performing their services, which Vanessa Watson most directly connected to the vein of participation theory as *co-productive* (Watson 2014).

Table 2. Overview of participatory traditions for crowdsourcing

	Communicative	**Collaborative**	**Co-productive**
Defining Literature	Forester, 1989	Healey, 1997; Innes & Booher, 1999	Albrechts, 2012; Watson, 2014
Theoretical Tradition[1] (adapted from Friedmann, 1987)	Social Mobilization: Frankfurt School → Communicative Action (Habermas, 1990)	Social Learning: Pragmatism and Neo-Marxism → Structuration (Giddens, 1984)	Social Learning: Pragmatism and Neo-Marxism → Deep Democracy (Appadurai, 2012)
Practical Affordance	"promote the deliberative aspect of democracy and create and protect the conditions for deep and genuine civic discourse" (Sager, 2013, p. 5)	"helping those involved work out what it means to build new collective ways of thinking and acting, to *re-frame* and *re-structure* their ways of proceeding" (Healey, 1997, p. 312)	Can involve "community control over all stages from initiation of intervention, to data collection and analysis, to planning, implementation and management" (Watson, 2014, p. 71). "Direct experience is the most effective way to gain knowledge" (p. 72).

[1]This is a simplified interpretation, with differences between traditions emphasized over cross-pollination.

This chapter first focuses on a background in communicative action and approaches to the problem of rationality in planning. Then, I explore the evolving role of technology in the public sphere, using three examples of crowdsourcing in communicative, collaborative, and co-productive applications. I conclude with a section synthesizing the range of theories relating to communicative rationality, and their implications for planning practice, and pedagogy.

PRAGMATIC TRADITIONS OF COMMUNICATIVE PLANNING

Pragmatism emerged a theory for social and political action in the United States at the beginning of the twentieth century, often associated with William James (1904), John Dewey (1927) and George Mead (1934). A German philosopher of social mobilization, Jürgen Habermas, connected Mead's emphasis on the role of communication in social interaction to the foundations of Greek and contemporary philosophies to build a theory of communicative action (Habermas 1981/1987). Habermas sought to explain how understanding communication in a holistic, interactive conception of the lifeworld broke down dominant social science paradigms at the time rooted in functionalist reason—shaking the basis of instrumental planning. John Forester translated these concepts into pragmatic norms for the planning of comprehensibility, sincerity, legitimacy, and truth, and explained how communicative distortions in the planning process ultimately impact power relations and planning outcomes (Forester 1988). "The pragmatist approach integrates structural, systemic and personal power asymmetries within specific situations framing deliberations about practical possibilities for each context" (Hoch 2018, 120). The work of Forester and colleagues re-invigorated pragmatist thought to counter synoptic rationality in planning through the 1980s and 1990s, emerging as a neo-pragmatist approach (Hoch 2018; Allmendinger 2002).

Collaborative pragmatists focus on discourse between and among planning stakeholders, suggesting that resulting compromises, if imperfect, improve upon alternatives of the extremes or no alternatives (Hoch 2018).

Perhaps ironically, pragmatism can also be considered a form of radical empiricism—turning away from preconceived ideologies. "Instead of knowing first what to do and how to do it, the pragmatist emphasizes contextual inquiry closely tied to social learning, practical experimentation and democratic deliberations (Hoch 2018, 127).

COMMUNICATIVE ACTION AND CONTACT THEORY

Jürgen Habermas developed communicative action theory widely in the 'The Structural Transformation of the Public Sphere,' which was later translated into English, leading to a broadened impact on western thought (1962). His principal goal in what became a vast body of work started with a relatively concise concern of developing a sociological clarification of the public sphere, and a systematic comprehension of Western society through the lens of the public sphere. A growing understanding of these concepts became the foundation for his theory of communicative action.

Aristotle's concepts of deliberative democracy informed much of Habermas' communicative rationality. Michael Lowry described Habermas as asserting "that two or more people confronted with a problem will naturally progress toward agreement and consensus, if they are permitted to deliberate in accordance with certain 'discourse ethics;''' in which "(1) everyone capable of deliberation is entitled to participate, (2) everyone is permitted to introduce new arguments and/or critique the claims of others, and (3) all participants are equally empowered" (Lowry 2010, 41).

Habermas was developing his concepts during an era dominated by communication methods of a one-to-many relationship. Radio and television had largely replaced the coffeehouse culture he described as once achieving a communicative ideal. This change "from a culture-debating public to a culture-consuming public" (Jürgen Habermas 1962) becomes a centerpiece of concern. Capitalism had collaborated with government control to manage relationships of bourgeois power and money carefully. Now a new vehicle of capitalism, mass media, has risen to perpetuate these relationships.

Before diving into communicative action theory, Habermas first seeks to define several presuppositions of the public sphere. He develops communicative action theory with rational processes involving both *instrumental mastery*, and *communicative understanding* (Jürgen Habermas 1984, 11). Habermas distinguishes communicative rationality from cognitive-instrumental rationality as the "intersubjective relation that speaking and activating subjects take up when they come to an understanding with one another about something. In doing so, communicative actors move in the medium of a natural language, draw upon culturally transmitted interpretations, and relate simultaneously to something in the one objective world, something in the common social world, and something in each's own subjective world" (Jürgen Habermas 1984, 392).

Habermas concludes the first volume of *The Theory of Communicative Action* with a section on *The Critique of Instrumental Reason*, containing a normative argument for why the human species relies on communication as the driver not only of sharing facts concerning the shared lifeworld but that communication is part of human action based on reason as well. He argues that individuals' teleological processes are bound to society, and instrumental rationality is subject to being subsumed under a blind self-preservation "that has gone wild" (Jürgen Habermas 1984, 398):

> A process of self-preservation that has to satisfy the rationality conditions of communicative action becomes dependent on the integrative accomplishments of subjects who coordinate their action via criticizable validity claims. Thus, what is characteristic of the position for modern consciousness is less the unity of self-preservation and self-consciousness than the relation expressed in bourgeois philosophy of history and society: The social-life context reproduces itself both through the media-controlled purposive-rational actions of its members and through the common will anchored in the communicative practice of all individuals.

In this manner, objective rationality is necessarily part of communicative practice, and the communication of results and thoughts play as valuable of a role as the rational observation. Habermas contends that following his analysis of a philosophy of consciousness, more work on the problem of how knowledge is manifested, or in his terms, *rationalization/reification* is needed. This is the focus of the second volume in this work of *The Theory of Communicative Action*.

The Foundations of Social Science in the Theory of Communication

Habermas calls the second volume *Lifeworld and System: A Critique of Functionalist Reason*, in which he distinguishes communicative rationality from Weberian theory of action. Functionalism has been defined as "…the doctrine that what makes something a thought, desire, pain (or any other type of mental state) depend not on its internal constitution, but solely on its function, or the role it plays, in the cognitive system of which it is a part" (Levin 2004). Therefore, Habermas is positing that communicative action provides a system for organizing thought that is not dependent on the way that it operates. He develops a foundation for the relationship of communication, knowledge, and consciousness by analysis of Mead's social psychology. The root of this relationship is in gesture-mediated interaction, where "…the gesture of the first organism takes on a meaning for the second organism that responds to it. This response expresses how the latter interprets the gesture of the former" (Habermas 1984). In this way, the behaviors of one organism affect the reception of a form of communication. Gestures have a symbolic role in communication, and this could be taken as an origin of the relationship between media and message, and how each is interdependent as the uptake of knowledge is shared. Habermas interprets Mead signifying that communication or prelinguistic call systems predate the appearance of *Homo sapiens*, implying this system of communication is a universal relationship than those bound to Western, modern society or even humanity. These processes form a basis for the development of human communication, in which a child assimilates a social world of "…regulated interpersonal relations, builds up a corresponding system of controls, and learns to orient his action to normative validity claims, he draws an increasingly clear boundary between an external world…and an inner world of spontaneous experiences, which come out not through norm-conforming actions but only through communicative self-presentation" (Habermas

1984, 42). Their social experiences shape children's perceptions, and in time they develop communicative capabilities that express their inner thoughts that are not a mirror of the world, but a filter from their own experiences. This experience of an individual, their communicative contacts, and the whole of the public sphere, are all part of the lifeworld. Habermas contends that analysis of phenomena as part of a lifeworld cannot be separated from its system. Habermas was largely following Mead's path regarding the construction of relevant meaning, which continues to be relevant when we consider new media and crowdsourcing tools.

Lowry characterizes the Internet as a promising information and communication technology (ICT), providing the opportunity for immediate access to deliberation for citizens at virtually any time or location. He notes that most of the criticisms of online deliberation include concerns regarding the limits of access to the information from all citizens, and how other methods can be (or not) incorporated. Though limited deliberation is often thought of as a characteristic of neoliberal planning contexts, recent research shows highly regulated contexts can form barriers to deliberative engagement as well (Haughton and While 1999; Legacy, March, and Mouat 2014).

Communication technologies directed towards impacting policy will need to strive toward "intelligence on the human level" if G.H. Mead's approach to meaning is still relevant (Mead 1934, 75). To approach this level of communication, new media could facilitate sharing of "significant symbols," which are "gestures which possess meanings and are hence more than mere substitute stimuli" (Mead 1934, 75). Habermas further distinguishes communicative action from strategic action that would seek to "*influence* the behaviour of another by means of the threat of sanctions or the prospect of gratification in order to *cause* the interaction to continue as the first actor desires" from that which "*seeks rationally to motivate* another by relying on the illocutionary binding/bonding effect (*Bindungseffekt*) of the offer contained in his speech act (Habermas 1990, 58).

At present, most social media provide the communicative flexibility to operate at either the lower or higher levels according to Mead and Habermas' conceptions, but how a planning organization frames issues, such as through crowdsourcing ideas for development tends to occupy a moderate space between strategic and communicative action. However, the trajectory of technologies that facilitate human interaction and *Bindungseffekt*, such as real-time video, may enable more engaging and responsive media-based participation (Daft and Lengel 1986). However, the role of communicative technology in continuing relationships of power in planning is part of the relationship between power and polis (Castells 2013). Justin Hollander explored the application of Habermas' ideal speech conditions with insights from pragmatist philosopher John Dewey and complexity science to form a theoretical approach incorporating diversity, interdependence, and authentic dialogue to examine the role of new media in the collaborative planning process (Hollander 2011). Patsy Healey shared this perspective on the contributions of a "Deweyan view of the democratic potential of inquiry processes" (Healey 2008, 281), that tends to support the development of avenues of informed discourse. Hollander contends that Habermasian speech conditions of diversity, coherence, non-abuse of power, and healthy skepticism form the basis for a strong tradition of collaborative rationality. These conditions are likely challenging to meet in many urban planning contexts, whether in person or online. Current research on new media in urban planning focuses on the role of technology in public deliberation, recognizing that digital discourse can have a valuable role in the public sphere even if it falls short of Habermasian criteria. The main interest in Habermas' criteria of deliberation is oriented toward its potential for impact, subject to its interface with existing power structures.

As a student of the Frankfurt School of Social Research, Habermas was all too familiar of the Marxist critique of Western capitalism and sought a thorough understanding of this system to develop a democratic communicative theory capable of providing a balancing force (Soules 2007). To identify the interchanges between the system and lifeworld, Habermas lays out their relationships from the perspective of the system. Economic systems relate principally to the public sphere through labor power, income from employment, goods, and services, and demand for the goods and services. Here, the economic system relates to the private sphere through money as it pertains to power. Conversely, administrative systems correspond to the public sphere, levying taxes, prioritizing organizational accomplishments through political decisions driven by mass loyalty. Habermas lists these as power-driven interchanges, though each relates to money as well. He describes taxes as a power interchange, rather than money, presumably because the administrative system's control is through the setting of tax rates directly, rather than the actual expenditures of the levied funds. Habermas sees this result of "monetarization and bureaucratization of labor power and government performance" as painful, but functionally fulfilling the lifeworld better than the "institutions of the feudal order" that preceded capitalism (Jürgen Habermas 1984, 321). He notes that professionalization has distanced experts and the public, limiting opportunities for culture to realize its potential envisioned during the Enlightenment. In theory more than practice to date, crowdsourcing offers a bridge between the work of planners and the public. Recent research supports the development of empowerment-oriented crowdsourcing (Álvarez Sánchez, Pardo Gimilio, and Isnardo Altamirano 2015), which we will return to, but crowdsourcing remains subject to the struggle between structural power and communication.

In *Planning in the Face of Power*, John Forester carries Habermas' ideas into the realm of planning, positing that planners need to engage with power using language to make an impact (Forester 1988). He positions communicative action as a critical response to instrumental action, stating that planning is inherently argumentative. By sharing productive language regarding desirable and possible futures, they can engage the public and political power to seek better planning outcomes. For Forester, the process of planning is tied to its results, and communication plays a valuable role. These systems regarding power and money are also vital areas of critique of the theory of communicative action.

Critiques of the Theory of Communicative Action

Scholars have implicated communication technology in significant societal changes such as the Arab Spring, and nationwide elections (Castells 2013), yet many remain critical of the potential for change in light of structural power systems. Bent Flyvbjerg contrasts two candidates for critical thinkers for civil society as being Jürgen Habermas, oriented toward discourse, and Michel Foucault, dealing primarily with power analytics (Flyvbjerg 1998a). Flyvbjerg contextualizes the perspectives of both philosophers and couches communicative rationality as having mainly a procedural, rather than substantive orientation. Also, Habermas' top-down, normative approach to process is conflicted with a bottom-up, relativistic evaluation of outcomes. Habermas makes it clear that his perspective is bound within existing legal relationships, contrasting with Foucault, who seeks to challenge the sovereignty of law when deemed appropriate. Even Habermas' faith in the writing of democratic constitutions is challenged through a lack of empirical and historical evaluation. Habermas is seen as lacking both the evidence to support his many claims of the value of discourse and a clear path toward implementing discursive decision making. Flyvbjerg claims that Habermas requires that rationality and power be distinguished from each other in communication, but this statement implies an oversight on behalf of Flyvbjerg: Habermas described that rationality through a lifeworld has to be viewed within its system of power. Flyvbjerg attacked Habermas on his rhetorical ground, wounding communicative rationality as a social theory through its disengagement with power. I largely agree with his attack on Habermas' verbose descriptions that ultimately provide weak footing for argumentation, chiefly through a lack of examples germane to planning. However, Flyvbjerg himself writes that the ends must be evaluated to find real solutions, rather than just the means; and this is where the argument stops. Flyvbjerg provides no substantive results demonstrating that Foucault's power orientation necessarily leads to better results than communicative rationality. However, he does offer an intriguing challenge to reconsider the notion of the public sphere in light of Foucault's focus on conflict, power, and partisanship. In later work, Flyvbjerg demonstrates through his inquiry on phronesis and the public intellectual that rational communication indeed has its own power, and uses it to render excesses and misrepresentations found in the planning of mega-projects (Flyvbjerg 2012).

Huxley and Yiftachel delve into the more practical issues that Flyvbjerg misses. They criticize the communicative turn in urban planning as a misdirected attempt at creating an overarching theory of planning, since communicative action lacks many of the essential turns of postmodernism, certainly including feminism. Rather than dismiss the approach, they deem it inadequate as a framework for improving planning practice. They list six propositions why this is so, starting with the claims of theoretical dominance as overstated. This and their second proposition that planning theory does not dislodge planning's claims to universal legitimacy are founded on the proposition that communicative rationality is a theory of planning. Some may have offered this claim, but it need not be fully realized for the communicative turn to be considered a useful theory for planning. Their third claim relates to the conflation of normative prescription with proper theorization. I would contend this claim confirms my earlier proposition against Flyvbjerg's critique: all of the claims for rationality lack objective evidence. A scientific theory should be based on observation (but even this claim can be seen as normative). This is also related to their fourth proposition concerning the confusion of theory and method and means and ends. Huxley and Yiftachel state that a rational (one could read: grounded and empirical) perspective is needed to demonstrate the impacts of planning practices, rather than starting with a normative assumption. Anything else is an untested theory, which the leading philosophers in this chapter offer in abundance. Their fifth proposition is more challenging, that theorization requires a perspective outside of the field of planning. They neglect the constant attacks from both the academic and practical political actors, and this perspective deserves more critical analysis from our profession. Finally, Huxley and Yiftachel state planning theory cannot ignore the state and public production of space. This is another valuable link for opportunities of critical discourse with our cousins in political science and geography. Indeed, these criticisms of communicative rationality are valuable and productive areas of inquiry, but they also do not fundamentally challenge the value of communication in and for planning.

Andrew Whittemore recently critiqued communicative rationality in light of a phenomenological approach to planning, in which direct observations play a role, but attention to perception, emotion, and feeling are also valued (Whittemore 2014). He describes an opportunity for planners to add depth of understanding of the people and places they plan through phenomenology. He offers, "a phenomenological theory of planning procedure would encourage planners to note what objects in their communities have meaning, and how different frames of reference give different meanings to each object" (Whittemore 2014, 304). Whittemore's angle of phenomenological planning is certainly participatory, which can be difficult to distinguish from that which is communicative. He notes that the phenomenological approach is "…commendable because it would represent an effort by planners in context where the knowledge is especially unfamiliar to put their clients' beliefs and feelings first" (Whittemore 2014, 307). He does charge that much more needs to be done to forge new methods of planning, but the 2014 work falls short of offering a strong rebuttal with proactive solutions to the shortcomings of communicative rationality. These authors have shown rigor and acumen in their critique, but it is easier to punch holes in the views of a past generation's social philosopher in regards to urban planning than it is to develop a comprehensive theory capable of rationalizing the role of the public and the future built environment they inherit. Recent contributions reacting to neo-liberalization of planning and governance suggest the emergence of a post-political planning context with changing roles for communicative action, potentially "to replace antagonism and agonism with consensus" (Allmendinger and Haughton 2012, 89). The relationship between new media and consensus-building in the public sphere remains a challenge to researchers and practitioners. One example of this approach to crowdsourcing comes from comprehensive planning in Seattle.

Communicative Crowdsourcing in Seattle (US)

Seattle 2035 is the city's latest major comprehensive plan update, which used a variety of in-person and online engagement methods. The city crowdsourced discourse to guide the plan using a new tool called *Consider It,* which the city primed with "Key Proposals," asking the public: "Do these Key Proposals make sense for Seattle over the coming twenty years?" (Consider.It 2015). Previous evaluations of civic discourse projects involving this platform demonstrate that participants "engaged in normatively desirable activities, such as crafting positions that recognize both pros and cons, as well as points written by people who do not agree with them" (Kriplean et al. 2012, 1), providing a transparent discourse platform designed to centers on ideas, rather than identities. Planning staff in Seattle recruited participants using a variety of methods, such as this example from their use of Twitter account @Seattle2035: "Have you tried Seattle 2035's Consider.It tool? Discuss your opinions on the Draft Plan! #Seattle2035 seattle2035.consider.it/" (City of Seattle 2015b).

Participants evaluated proposals using a sliding scale of whether they disagree or agree with the proposal, and then describe why they felt that way, expressed in written pros and cons, which could be either drafted by the participant or dragged on-screen from previous participants' comments that they wished to support. This affords participants the opportunity to evaluate claims and assumptions of others, including the city—meeting an essential requirement of communicative rationality (Habermas 1990; Innes 1998). The platform aggregates responses visually, creating a histogram of opinion frequencies for each topic, with the detailed description below the proposal, such as in Figure 2: Seattle 2035 Consider It forum for the Key Proposal "Increase the diversity of housing types in lower density residential zones, including single-family zones" (City of Seattle 2015a).

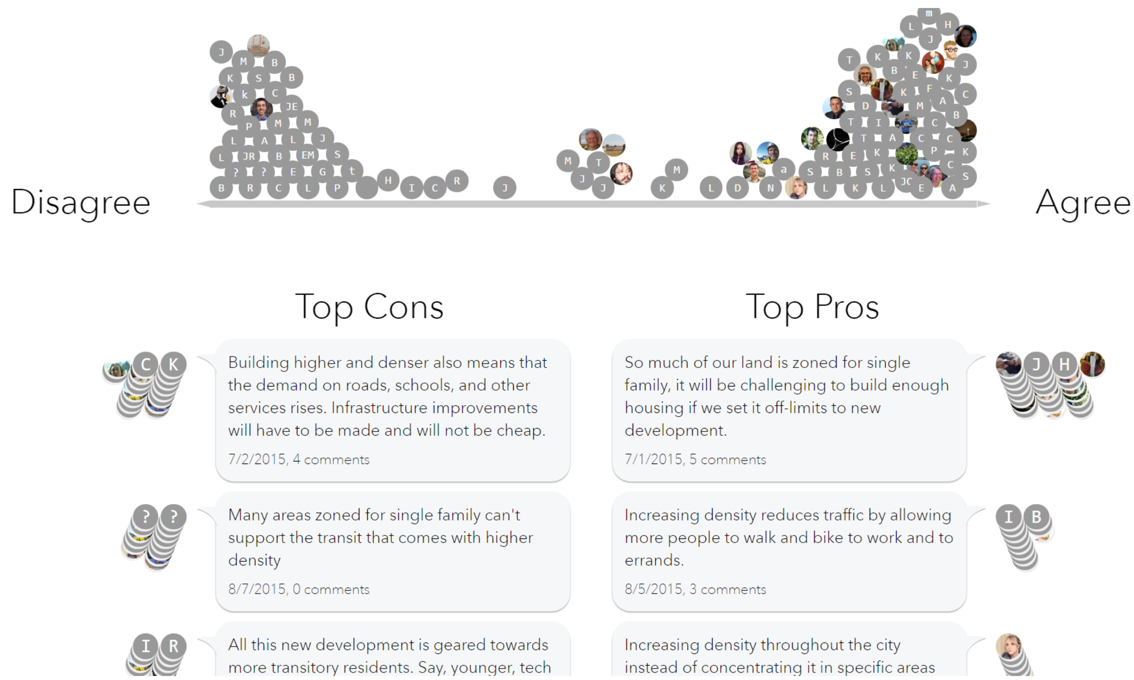

Figure 2: Seattle 2035 Consider It forum for the Key Proposal "Increase the diversity of housing types in lower density residential zones, including single-family zones" (City of Seattle 2015a). (Used with permission)

A desktop review of the adopted plan and the Consider It forum suggests planners included the proposals rated highly by participants in the plan in some form. The proposal to "guide more growth to areas within a 10-minute walk of frequent transit" was supported by the plan goal GS G1: "Keep Seattle as a city of unique, vibrant, and livable urban neighborhoods, with concentrations of development where all residents can have access to employment, transit, and retail services that can meet their daily needs" (City of Seattle 2016, 24). Similarly, highly-ranked proposals regarding school location and land use planning considering future urban villages are relatively prominent in the adopted plan. However, the city's deployment of the platform took a top-down approach of having seeded discussion with city-suggested proposals to evaluate, which conflicts with

Innes' definition of communicative rationality as all participants having equal empowerment in the discourse (Innes 1998). The platform lacks information to evaluate all conditions of communicative rationality, but further study of such a platform with supporting information could lead to additional insights into the use of crowdsourcing in communicative planning contexts.

COLLABORATIVE PLANNING AND STRUCTURATION

Communicative and collaborative planning have both been described as part of a "communicative turn in urban planning" (Tewdwr-Jones and Allmendinger 2002, 208). However, collaborative planning differs from communicative by emphasizing existing power structures and finding ways for disparate groups to learn together (Friedmann 1987). Collaborative planning, as formulated by Patsy Healey, is more informed by Giddens' structuration theory than communicative action, seeking more to transform institutions rather than "agency and the mechanisms and direct outcomes of inter-personal relations" (Tewdwr-Jones and Allmendinger 2002, 209). This approach helps address some critiques of communicative planning by addressing power and action through the structures inherent in planning processes, by "helping those involved work out what it means to build new collective ways of thinking and acting, to *re-frame* and *re-structure* their ways of proceeding" (Healey, 1997, p. 312). Healey's conception of collaborative planning incorporates the institutionalist perspective, recognizing the role of structures in power and communicative action (Healey, 1999). Margerum's definition of collaborative planning emphasizes an "iterative process of consensus building and implementation using stakeholder and public involvement" (Margerum 2002b, 237). Later work by Margerum deconstructed the factors impacting collaborative results, supporting evaluation through passive and cooperative approaches, in addition to adaptive network factors that sustain collaboratives (Margerum 2011). Healey describes how Giddens' structuration theory restrains and orders communication and power (Healey 1997, 45):

> We are born into social relations and we live through them during our lives. Through these relations we are linked to particular histories and geographies which constrain our material and conceptual resources and experiences. In this sense, our efforts in working out our individual identities and social relations are 'structured' by what has gone before…They carry power relations from one period to the next.

In this way, collaborative planning recognizes the limits imposed on communication by any given person in any given planning process, expressed through the power to effect change for community and individual contexts. Giddens summarizes the constraints of communication clearly regarding co-occurrence: "All social interaction is situated within time-space boundaries of co-presence (whether or not this be extended via media such as letters, telephone calls, [now Twitter] etc.) (Giddens 1984, 332). However, some contend that technology is not without agency in organizational contexts. Adaptive structuration theory extends Giddens' conception, arguing "advanced information technologies trigger adaptive structurational processes which, over time, can lead to changes in the rules and resources that organizations use in social interaction" (DeSanctis and Poole 1994, 142–43). Participants' choices whether to use technological features can then structure social interactions. This is not to suggest that technology *determines* social interactions, but that communication technologies are nonetheless part of an organizational structure, and therefore may impact the agency of individuals or groups in a planning context.

The notion of technology interacting with collaborative planning is not the same as suggesting an improvement—technology can be a barrier to collaboration as well. As described in the first chapter, digital inequality represents a broad topic of limitations imposed by technology. However, review of planning cases involving web-based planning support systems and digital interaction can support collaboration towards smart governance in the right contexts (Lin and Geertman 2015). Planners can use online technologies to broaden access to their databases to support collaboration on planning solutions. Institutional design towards public empowerment, clear rules for engagement, and intentional inclusion of disadvantaged communities support collaborative planning with technology (Lin and Geertman 2015).

The structures of technology may impose even more limits to collaborative planning, given the distinguishing characteristic of collaborative planning as seeking to influence the structures of interaction. Some technologies for planning may have no overlap with this notion of collaborative planning. If one accepts Brabham's definition of crowdsourcing, for instance, as offering online, bottom-up responses to a top-down call for information or solutions (Brabham 2013), this would seem to reinforce, rather than challenge, existing structures of planning.

A counter-argument to an inherent conflict between collaborative planning style and incorporation of communication technologies could suggest that consideration of any one technology is too simplistic. Successive use of complementary communication technologies may support collaboration, particularly for "information, problem-solving, persuasion, and status tasks" (Stephens 2007, 499), which I argue align well with collaborative planning contexts. The combination of activity-based modeling and visualization tools in a collaborative setting "not only improves the prospects for social coordination and agreement but importantly contributes to the cognitive grasp of how policy and program ideas interact and what this may mean for environmental outcomes (Hoch et al. 2015, 333). Collaborative analysis of data and likely futures use of digital knowledge technologies, "such as urban computer models, geographic information systems, and planning support systems" (Goodspeed 2016b, 577) in collaborative planning contexts implies the successive use of technologies, recognizing the work of recruiting participants through media, explaining methods online or in-person, and then interactions for decision-making. I argue that the successive use of technologies is now implicit in contemporary planning contexts, but am not aware of any research on successive technology use specific to the field of planning. Goodspeed's work, however, recognizes that collaborative planning with digital knowledge technologies requires re-focusing on the interaction of technologists, planners, and stakeholders, ultimately requiring "rethinking – but not abolishing – the division of labor between professionals and stakeholders" (Goodspeed 2016b, 577). A review of online participatory technologies suggests that planners can improve the use of online participatory technologies (OPTs) by "better integrat[ing] OPTs with existing digital services by collaborating with key stakeholders inside or outside of their organization" (Afzalan and Muller 2018, 173). Considering collaborative inquiry as labor, or action-oriented begins to push the boundaries of traditional notions of collaborative planning. The next section suggests a third approach to participation that emphasizes actions over statements.

Collaborative Crowdsourcing in Melbourne (AU)

Few examples of truly collaborative crowdsourcing techniques exist, if one relies on a strict definition of collaborative planning, capable of supporting participants in "work[ing] out what it means to build new collective ways of thinking and acting, to re-frame and re-structure their ways of proceeding" (Healey 1997, 312). The Future Melbourne plan's last two updates may come closest to meeting this goal, by opening up its planning process in two critical ways. First, the "Future Melbourne Wiki" invited participants to work online with city planners on the city's plan, reportedly resulting in the "world's first collaborative city plan," with "not a single instance of spam or offensive contribution" (Elliott 2012). Second, the city's update to the plan started with a collaborative idea platform, where 2,000 participants composed over 950 of their thoughts for the city plan, which included quantitative ratings (thumbs up or down), in addition to open commenting about the ideas (City of Melbourne 2017). Following synthesis of the ideas and analysis by planning consultants, a citizen jury of 50 people reviewed and re-wrote the plan, with six ambassadors appointed by city council to support their deliberation.

Melbourne's approach to deploying crowdsourcing platforms as collaborative media accomplishes many of the tenets of collaborative planning. However, the top-rated ideas for supporting Melbourne community radio, and developing a youth engagement hub, were not included in the adopted plan. This may confirm some critics concern over the use of crowdsourcing to empower participants with final authority, as the facilitators of the open competition to name the British polar research vessels' top-rated choice, "Boaty McBoatface" discovered (Wilson, Robson, and Botha 2017). Future Melbourne was adopted in late 2016, and pragmatic, *a posteriori* (Dewey 1927) evaluation will be able to consider the effort's accomplishments as it is implemented over time. The next section introduces the concept of co-production, and how it differs from collaboration by emphasizing action throughout all stages of the process (Watson 2014).

CO-PRODUCTIVE PLANNING AND ACTUALIZING CIVIC STYLES

Alinsky suggested "change comes from power, and power comes from organization. In order to act, people must get together" (Alinsky 1972, 113). Co-production is concerned with what people do after they get together. Co-productive planning is a relatively new contribution to planning theory, though it has a rich literature in public administration and development studies (Watson 2014; Albrechts 2012). Elinor Ostrom observed in the 1970s that public services were “assigned to government agencies to produce, while citizens were given the passive role of consumers and clients” (as interpreted by Albrechts 2012, 48). Her analysis of sewage system co-construction in Brazilian *favelas,* Nigerian schools, and other contexts demonstrated improved outcomes as compared with traditional service provision models (Ostrom 1996). Recognizing the potential for deep divisions between the interests of citizens, developers, and the state, Vanessa Watson proposes co-productive planning as an approach that emphasizes actions over words (Watson 2003). Though co-productive and collaborative planning share many similarities, co-productive planning has several distinctions that seek to subvert agonism (Hillier 2002) and structural divisions of power (Watson 2014). Following are the five key distinctions of co-productive planning mentioned by Watson, who also provides context and explanations for these claims in the original work (Watson 2014, 71):

1. Co-production “works outside (and sometimes against) established rules and procedures of governance.”
2. Co-production supports not only planning but also “delivery processes and subsequent management of projects.”
3. Power and conflict are considered differently in co-production, and “there is an awareness (drawing on Foucault) that power is embodied in development processes and in technologies of rule such as surveys and maps.”
4. Co-production relies less on “talk and debate and more on showing and learning by doing.”
5. Co-production can support scaling of “local practices through global networks.”

One example of co-productive crowdsourcing is a new platform for aggregating the route preferences of bicyclists called Ride Report (Knock Software 2017), which can be used as an example of all five of Watson's distinctions of co-productive planning. Figure 3 is a screenshot of the online map from Ride Report in Austin. The system reverses the flow of traditional knowledge in transportation, such as motorized level-of-service models that use a priori standards imported from expert knowledge to a bottom-up rating system that is constructed by participants in the context of their actual routes. Planners can use the resulting aggregated map of route preferences for future improvements, but it also provides a real-time bicycle map to inform users' route choices. Traditionally, engineers and planners' information is a source of power (Innes 1998), which this method provides to its users, supporting advocacy supported by data. This type of crowdsourcing is centered on GPS data, and a comfort rating of routes, rather than discussion—users see the result of their contributions, and can learn how their own experience of the city is situated with others'. Finally, automation of the platform supports scaling beyond the local level, with the numbers of participants and sufficient server space the only limits to the scaling of the system.

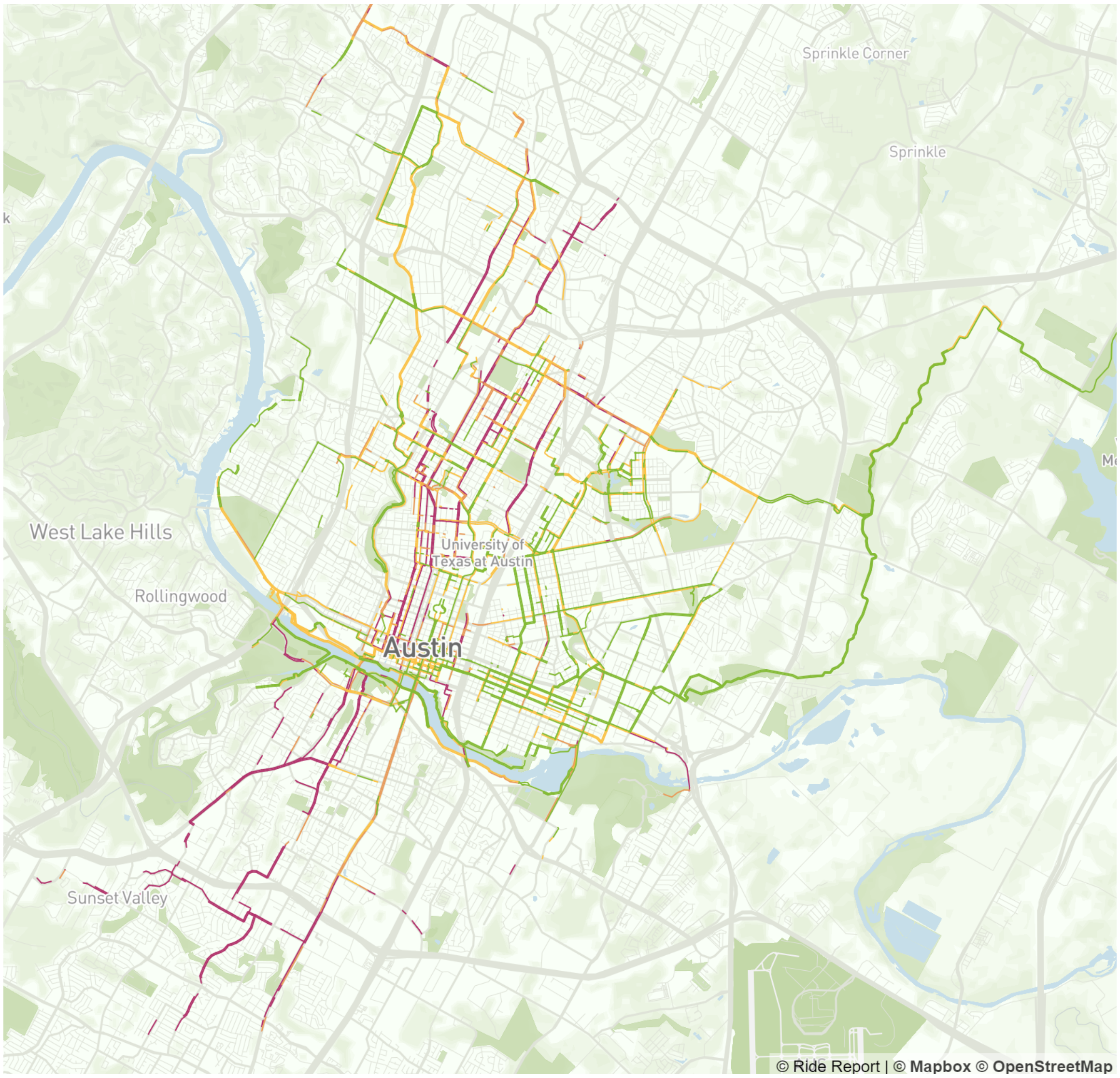

Figure 3: Bicyclist comfort ratings crowdsourced through the Ride Report app in Austin (USA) as of June 23, 2018 (Ride Report 2018a). Red is more stressful, green is more comfortable, and grey has too few ratings to classify. (Used with permission)

Whereas communicative and collaborative traditions are rooted in well-developed, democratic societies (Healey 2003), co-production's roots are from the global South, supporting planning at varying levels of cooperation with state-sanctioned planning (Watson 2014). Co-productive planning theorists have yet to incorporate a more historical view of the approach. Peter Hall's "City of Sweat Equity" cases of resident-planned and built *barridas* in Lima, and Christopher Alexander's pattern language experiments in Berkeley demonstrate a co-productive perspective, where the state may or may not have a role in plan-making, but people can and will work together to improve their environments (Hall 2002). This approach aligns with a radically pragmatic perspective. "To give people help, while denying them a significant part in the action, contributes nothing to the development of the individual" (Alinsky 1972, 123). Conceptually, co-production through crowdsourcing could foster both self-development and organizational strengthening.

However, co-productive planning theory is nascent, as are substantial evaluations of crowdsourcing in planning. "Co-production certainly merits development, but the only way to do this…is to build theory from case studies, i.e., from contexts" (V. Watson, personal communication, January 27, 2017). Though not without challenges, crowdsourcing might be able to serve both less-developed communities, as well as technologically-savvy areas. Though all three bodies of theory for participatory planning—communicative, collaborative, and co-productive—can be connected to crowdsourcing methods, a critical review of the benefits and limitations of this approach of participation is warranted.

Turning Co-production into Radical Tactics

I argue that a radical perspective on co-production should orient toward meeting, rather than overthrowing, the rules of planning organizations, and should be both productive and fun for participants. These are Alinsky's fourth and sixth rules of tactical engagement. "Make the enemy live up to their own book of rules" (Alinsky 1972, 128) suggests that publics can produce the information meeting planning requirements, that might in some cases counter the findings of the organization. By playing by the planning organizations' rules, advocates can counter the power balance without having to overthrow legal structures. "A good tactic is one that your people enjoy" (Alinsky 1972, 128) involves developing approaches that people do not need to spend very long to learn and take some delight in the process. Wells' conception of actualizing civic styles shows that smartphone-based participation, in the mid-and-late 2010's, supports individual expression and experience in support of organizational goals, and are capable of effecting change.

Digital Co-production

Co-production is not a new concept for planning, but the use of information systems and online tools supports working together in new ways—potentially increasing the number and geographic scale of participants. Afzalan and Muller's (2018) review and guidance for implementing online participatory technologies begins with defining objectives. This chapter suggests that planners can broadly characterize these objectives as aligning with communicative, collaborative, and co-productive approaches. Either participants or planners could lead a co-productive approach to online participation, but defining objectives can help guide choices about how to implement and evaluate digital co-production. The preceding decade of online planning participation synthesized by Afzalan and Muller shows a wide range of approaches to conduct and evaluate online participation in general, but few studies involve co-production where participants "*do* some of the work of planning, instead of just *talking* about it" (Griffin and Jiao 2019a).

Aligned with recent emphasis in evaluating on-ground outcomes of planning (Fainstein 2010) versus communicative process outputs, co-productive planning invites analysis of planning impacts. However, plans often take a decade or more to implement, since intervening changes including political leadership and even neighborhood structure can hamper alignment of planning actions to specific outcomes. However, bike sharing systems provide a relatively simple and expedient example of digital co-production.

Planning processes for bike share systems in the United States during 2012-2016 were mostly planner-led approaches that incorporated online map platforms for the public to suggest where to place bike share stations, described in geography and planning literature as public participation geographic information systems, (PPGIS). Planners incorporated this online map input with traditional public meetings and workshops to achieve broad and detailed involvement. Analysis of planning bike share in New York (Citi Bike), and Chicago (Divvy) showed limits to the use of PPGIS for digital co-production (Griffin and Jiao 2019a). Use of two metrics that relate the proximity of bike share station suggestions to actual placement by the systems show implementation of between 5% and 17% of suggestions (Griffin and Jiao 2019a). However, the study suggested that the PPGIS could support learning about the planning process by performing actions, while planners could learn from local knowledge of the streetscape to locate bike share stations. This work supports the emergence of co-productive participation in planning as an impactful approach, but one that remains limited by communicative, collaborative, and power-based constraints—still more pragmatic than radical.

From digital divide to inequality

One of the reasons for the limitations of digital co-production's impact on planning is democratic—online participation remains limited by technological means and skills. This separation in developed democracies is no longer rigid, considering that most of the adult public has access to a mobile phone, but many still lack a full computer with broadband internet (Pew Research Center 2018). This fact suggests opportunities for participatory planning research in a range of contexts. "The most promising research in these areas will take advantage of the range of tools developed for collecting mobile data…while engaging directly with poor communities to understand how disadvantaged communities network and relate to urban space by dint of smart-phone access" (Marler 2018, 14). The communicative affordances of mobile media may counter some of the structural forces of digital inequality. The social diversification hypothesis suggests that people can use mobile media to reach beyond their geographic and cultural groups, but evidence shows structural limits to the impact on inter-group ties (Arie and Mesch 2016).

Net neutrality is an internet policy that considers the carrier network "as a common-use infrastructure, access to which cannot be blocked, subject to conditions, or discriminated against by the carrier operator vis-à-vis different users" (Castells 2013, 106). For digital co-production, the Federal Communications Commission's 2017 ruling effectively ending net neutrality poses many problems, including whether not-for-profit planning applications, will slow for some or all internet customers. *Planning* magazine reports that the loss of net neutrality could cause "universities or government networks that stream a lot of video such as council meetings or hearings, for example, could end up in the slow lane…because they won't be able to pay for fast-lane access, as big content companies will" (Bergai 2018, 12). On March 4, 2018, Washington State Governor Jay Inslee signed broad legislation to reinstate net neutrality for internet service providers within the state, but actions from this state and others may face legal challenges from private companies or the federal government (Kang 2018). The issue of net neutrality is far from settled at this writing but is likely to impact the equality of participation in the future for digital co-production of information for planning.

Co-productive Prospects for Planning

An open question for planning research is whether digital methods of co-production, like crowdsourcing, create or dissolve communities of interest. The Arab Spring, for instance, is an example of digital media's affordance to pull disparate groups together from vast geographies into a meaningful cause (Hermida, Lewis, and Zamith 2014). However, more localized issues of planning may not be dependent on digital media for organizing groups toward progressive change. In contrast, digital participation may foster the impression of co-production without true organization. Alinsky framed the concerns of *process* and *purpose* as part of a continuum. "The very process of democratic participation is for the purpose of organization rather than to rid the alleys of dirt. Process is really purpose" (Alinsky 1972, 122). Applying this logic to crowdsourcing for planning, participants should do more than complete digital tasks and walk away—planners and community organizers need to develop approaches that frame crowdsourcing as part of the community planning process, while also fostering stronger social ties through in-person and digital communication to support refinement of purpose and sense of organizational belonging. The relationship between crowdsourcing in planning and social capital is relatively unexplored, and future research should both align the process of planning to both social capital outcomes, and substantive outcomes include on-the-ground changes.

Re-centering the Locus of Production

Co-production offers an approach to reconsider local communities as not only the site but also the means of producing information for planning. However, there are several challenges to such an approach. New tools and techniques in planning—including those developed ostensibly for democratic, rather than authoritarian ends (Mumford 1964)—do not guarantee even empowerment or even access to participation. Further, high-technology approaches may exacerbate perceptions of valuable participation, even as the information gathered could have severe problems for use in planning, leading to "idiotic data" rather than improving the smartness of cities (Tironi and Valderrama 2018). The breakdowns in accurate and useful information shown in Tironi and Valderrama's case study assume a strong separation between the creators of the technology and its users, which is the case in most urban planning instances. However, Haklay has framed these problems, termed "Neography and the delusion of democratization" as both a challenge and a way forward, noting the "separation between a technological elite and a wider group of uninformed, laboring participants who are not empowered through the use of the technology" (Haklay 2013). Haklay proposed an approach toward hacking, understood as "the ability to alter and change the meaning and use of a specific technological system" in four democratic levels, shown in Figure 4.

Type	Number of Participants	Issue
Deep technical		Significant skills, negotiation and translation of knowledge
Shallow technical		Skills, control over application
Use		Knowledge of web apps, legitimacy of outputs
Meaning		Outputs, legitimacy of interpretation

Figure 4: Levels of democratic hacking (adapted from Haklay 2013)

Each level of democratic hacking shows a way forward towards planning, which could be meaningful next steps in research and practice. Planners and researchers can use this framing to work with large numbers of people (meaning and use levels), and with technologists interested in improving planning processes and outcomes (technical levels). The crowdsourcing platform at the core of this dissertation, Ride Report, might be interpreted as a deep technical hack of crowdsourcing for bicycle planning since its founders identified limitations in the approach to date in order to develop a new approach using existing smartphone hardware.

Another challenge to crowdsourcing as a method for co-productive planning involves the re-orientation of public participants as having roles as workers in the process. If led by planners, as in Brabham's conception of crowdsourcing as responding to a top-down call for participation (Brabham 2013), then many of the problems of aligning the costs and benefits of online work through crowdsourcing apply as well—principally compensation for labor and control over work. The labor compensation issue is contested elsewhere (Rosenblat and Stark 2016; Harris 2011; Deng, Joshi, and Galliers 2013), and cannot be a primary focus of this dissertation. In principle, if participatory planning is re-oriented towards public members as critical producers of information for which planners and consultants were formerly paid, then participants could argue in favor of requesting payment for their labor in the process. Further, crowdsourcing participants' relationships as workers suggest additional struggles for control in this newly-defined co-productive workplace. Keri Stephens' work on organizational control regarding the use of mobiles suggests tensions with groups, organizations, customers, and interpersonal (Stephens 2018). One of the ways she shows these tensions manifest in organizational communication is in hierarchical control, where both explicit organizational power and inherent differences based on professionalization and prestige are applied to "control workers and groups." As of this writing, these challenges—labor compensation and mobile-communication control—are established socio-technical problems in the broader field of online work, but have not been deeply explored in urban planning. For these reasons, I return to issues of labor compensation and mobile-communication control as future research topics in the concluding chapter of this dissertation.

CONCEPTUAL CONCLUSIONS

This chapter integrated co-productive planning in the tradition of participatory planning and extended the concept beginning with pragmatic roots into socio-technically constructed knowledge. Through this analysis, I conclude with four broad propositions.

1. Co-productive planning is associated with communicative and collaborative planning traditions. Vanessa Watson connected and disambiguated collaborative and co-productive planning (2014), and this chapter shows how co-productive crowdsourcing also connects to communicative planning and may need new evaluation approaches.
2. Crowdsourced co-production provides an approach to participation that centers on action across the planning process. Participants in the Ride Report platform in Austin (TX) and Portland (OR), contribute to basic knowledge about bicycle volumes in each city, while evaluating comfort on specific routes—spanning traditional planning phases of existing condition data collection, and analysis for improvements.
3. Digital crowdsourcing methods involve interconnected social and technical processes, which may require a new evaluation framework. Such a framework is proposed, covering topics of legitimacy, accessibility, social learning, transparency, and representation (LASTR).
4. Crowdsourced co-production has implications for urban planning that merit additional research, including empirical topics in this dissertation—safety for bicyclists, geographies of participation, and sociotechnical embeddedness; in

addition to important topics outside the scope of this dissertation, including digital (in)equality and net neutrality, exploration of radical tactics such as democratic hacking, and concomitant organizational control of communication.

Why Co-productive Planning is Important

Co-production provides approaches to both perform action-oriented planning as introduced in this chapter and to understand how information is translated into power through the legitimization of planning as a socio-technical process—that is, an inseparable web of human and computational actions and information. Sheila Jasanoff uses the term *technocracy* as revolving "around the premise that expert 'technocrats' might seize the reins of power without respect for public preferences" (Jasanoff 2017, 261). This chapter framed co-production as an emerging tradition in participatory planning, and shows how new technologies do not determine co-productive planning, but instead are co-constructed through social processes of participatory planning that also incorporate digital tools involving social interactions that may not be visible without constructivist interrogation. Co-productive planning incorporates knowledge from the participatory traditions of communicative and collaborative planning while supporting development and critique of expert and lay-produced information for planning. The next chapter introduces opportunities and constraints of crowdsourcing in the cases of Portland (OR) and Austin (TX), suggesting future directions in co-productive technologies for planning.

Chapter 3: Constructing Cases in Austin and Portland

Spatial, Embedded, and Constructivist Approach

Preceding chapters introduced the problems of public participation in planning, and developed co-productive planning as a radically pragmatic approach. This chapter describes the data and approaches to analyzing these ideas through cases in Austin, Texas, and Portland, Oregon. In particular, I follow the use of a crowdsourcing platform for transportation planning called Ride Report, which aggregates bicycle trips and route ratings from its community of users for use by planners (Ride Report 2016). This dissertation searches for the opportunities and limitations of crowdsourcing in transportation planning as a process that is inherently geographic exhibited through the actions of planning and co-produced by planners, publics, technologists, and others.

This study evaluates crowdsourced participation as having both pragmatic and socially-constructivist implications—an important distinction as the technological tool is not seen as directing change (Bijker 1995; Klein and Kleinman 2002). This standpoint values the understanding of people creating and using information for transportation planning, rather than assuming that a technological output produces a given outcome. Crowdsourcing research requires a combination of social and technical system analysis. Science and technology studies (STS) and related fields have built a basis for social construction of technology (SCOT) approach, which contends there are limits to how much social process and technology can be separated (Bijker 1995; Hommels 2005). Generally, SCOT research assumes that relevant social groups interpret a technological artifact (such as a crowdsourcing app) differently. As a technology matures through use and definition from relevant social groups, the technological artifact becomes more resistant to change, or obdurate. Bijker suggests the epistemology of SCOT has a "clear correspondence to pragmatist philosophy," but few scholars have approached this connection to date (Bijker 2009b, 92). This study first evaluates a pragmatic application of crowdsourcing, then delves into a social construction of technology approach involving data generated by a 'crowd,' then triangulated with case study materials. I examine three research questions associated with this spatial, embedded, and constructivist approach.

RESEARCH QUESTIONS

The fact that Austin and Portland have taken some steps to incorporate the platform into their planning process does not suggest whether or how it might improve either the outputs or outcomes of planning. Through in-depth case studies of bicycle transportation planning in Austin, Texas and Portland Oregon, I will explore three research questions. First, I ask whether crowdsourcing may offer any implications for planning, through a critical case of the relationship between bicycle collisions and crowdsourced data. Second, I evaluate the geographic issues of crowdsourced participation, as compared with other participation methods. As the spatial extent of transportation plans increase—be it for high-speed rail or other modes—new approaches for incorporating publics may be valuable. Finally, I trace the process of crowdsourcing for planning as a socially constructed technology, to address what role, if any, this may play in how these algorithmically driven ensembles (mis)represent communities of interest. I frame these research questions more formally as the following:

1. Can crowdsourced bicycle route quality and volume predict collisions? (RQ1)
2. What are the geographic differences of spatial representation between traditional and crowdsourced public participation for bicycle transportation? (RQ2)
3. Does the social construction of crowdsourcing influence the representativeness of geographic communities? (RQ3)

Table 3 provides a brief overview of the questions, their units of analysis, data, and methods. The methods first interweave pragmatic, then constructivist methods: first quantitative-spatial, then mixed-methods, and finally qualitative. Studies of communication technologies in civic engagement naturally involves a mixture of quantitative and qualitative data, with both spatial and a-spatial characteristics, supported by a multimethod approach (Matsaganis 2016).

Table 3. Overview of Research Design. Dependent variables indicated with *.

Research Questions	**Unit of Analysis**	**Data**	**Method**
1. Can crowdsourced bicycle route quality and volume predict collisions?	Roadway segment	Bicycle collisions (fatal and injury)* Crowdsourced bicycle route ratings via Ride Report Crowdsourced bicycle traffic counts via Ride Report Density variables in Table 5 Diversity variables in Table 5 Design variables in Table 5	Difference in means Spatial regression
2. What are the geographic differences of spatial representation between traditional and crowdsourced public participation for bicycle transportation planning?	Geographical point of participation	Crowdsourced bicycle route ratings via Ride Report* Bicycle master plan documents Interviews (relevant social groups) Public meeting locations	Spatial extent through standard deviational ellipse Case study
3. Does the social construction of crowdsourcing influence the representativeness of geographic communities?	Sociotechnical ensemble (Bijker 2009a)	Interviews (five relevant social groups) Staff memos (planners) News reports (non-bicycling public) Bicycle master plan documents	Case study Qualitative constant comparison

CASE SELECTION

This section describes the what, when, and where of planning cases in this dissertation. Digital platforms for planning are now variegated, as shown in an adaptation of Duoay's digital urban planning compass in Figure 5. Some, like Cisco's 'smart cities', are led by big business institutional actors with closed platforms. Other companies, such as dockless mobility firm Lime, leverage a greater role for non-institutional actors in charging, placing, and using the service. Crowdsourcing spans the border of openness and non-institutional approaches, dominated by either a 'wiki' approach favoring individual contributions, to an 'open source' slant led by an organization. Ride Report is a platform most closely aligned with crowdsourcing, with participants at the core of its service, but only some of its data is open, and the company does simplify the data into dashboards similar to a 'smart city' corporate approach. Positioned close to the boundaries of each of these digital urban planning concepts leaves room for interpretation concerning where a platform like Ride Report might evolve, settle, or dissipate. Ride Report is a platform that could lend insights on many of the key approaches to digital urban planning.

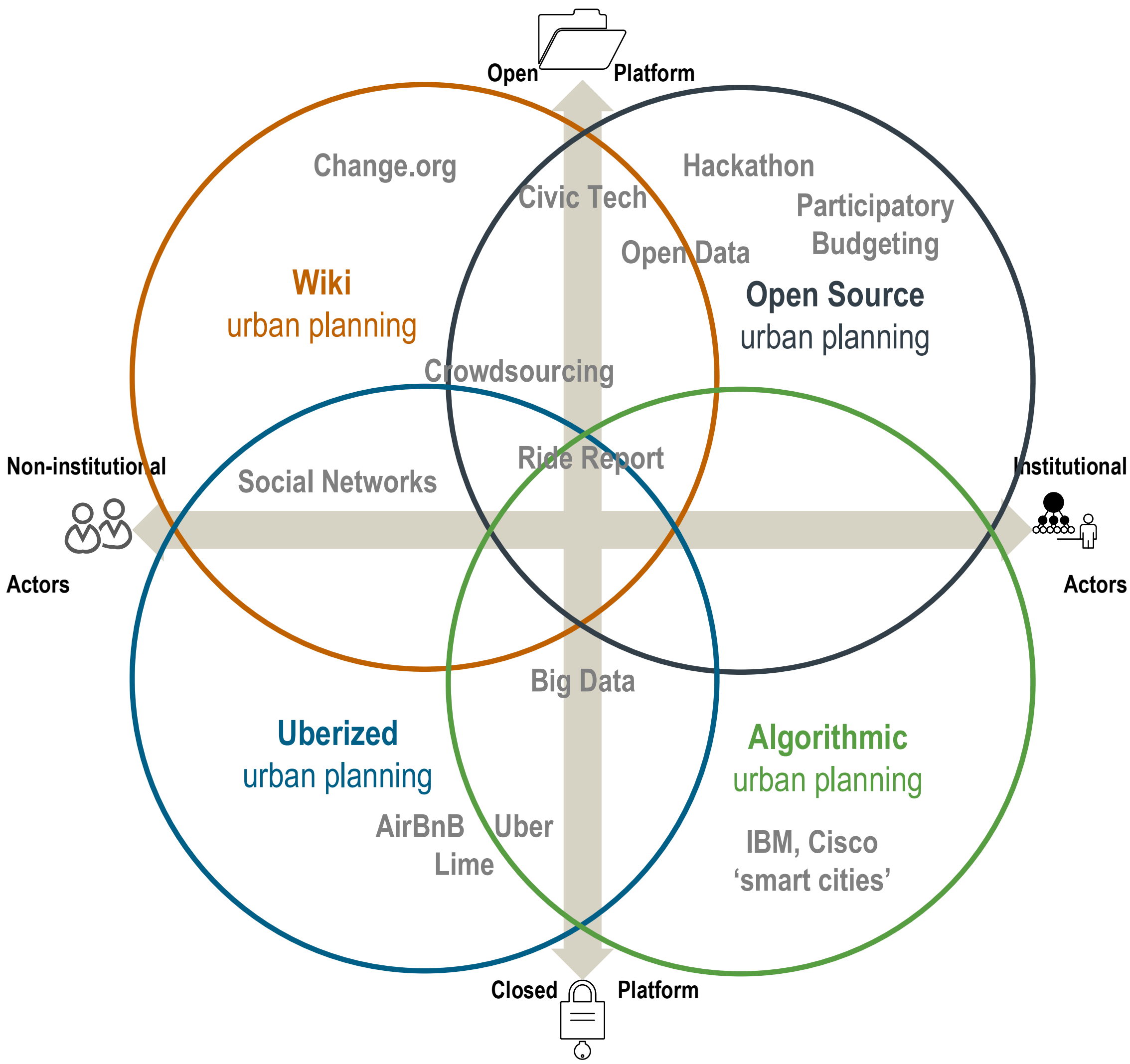

Figure 5: Digital urban planning compass (adapted from Douay 2018, 148).

Austin, Texas and Portland Oregon are chosen as cases for this dissertation as a locus of innovation (Lakhani, Lifshitz - Assaf, and Tushman 2013), where crowdsourcing in planning is maturing, allowing early-stage analysis of a stabilizing system. The cities are similar in size and economy, yet Figure 7 shows they are more than 2,000 km apart, and unlikely to have similarities directly attributable to geography beyond sharing national governance. Additionally, my previous work as a planner provides both direct and indirect professional contacts in each city, supporting access to internal knowledge and data for a comparative case study (Yin 2014). Niche-innovations, such as crowdsourcing, begin to interact with existing sociotechnical systems, such as public participation in transportation planning, in a "window of innovation," where new approaches are tested and refined in the real world (Geels et al. 2017, 1244). Ride Report is one example of a crowdsourcing tool developed elsewhere that is transitioning from the second to the third phase of transitions—the beginning of the window of innovation shown in Figure 6. By studying the system in its first year of use, this dissertation provides insight into not only its construction and potential but also early results from practical implementation.

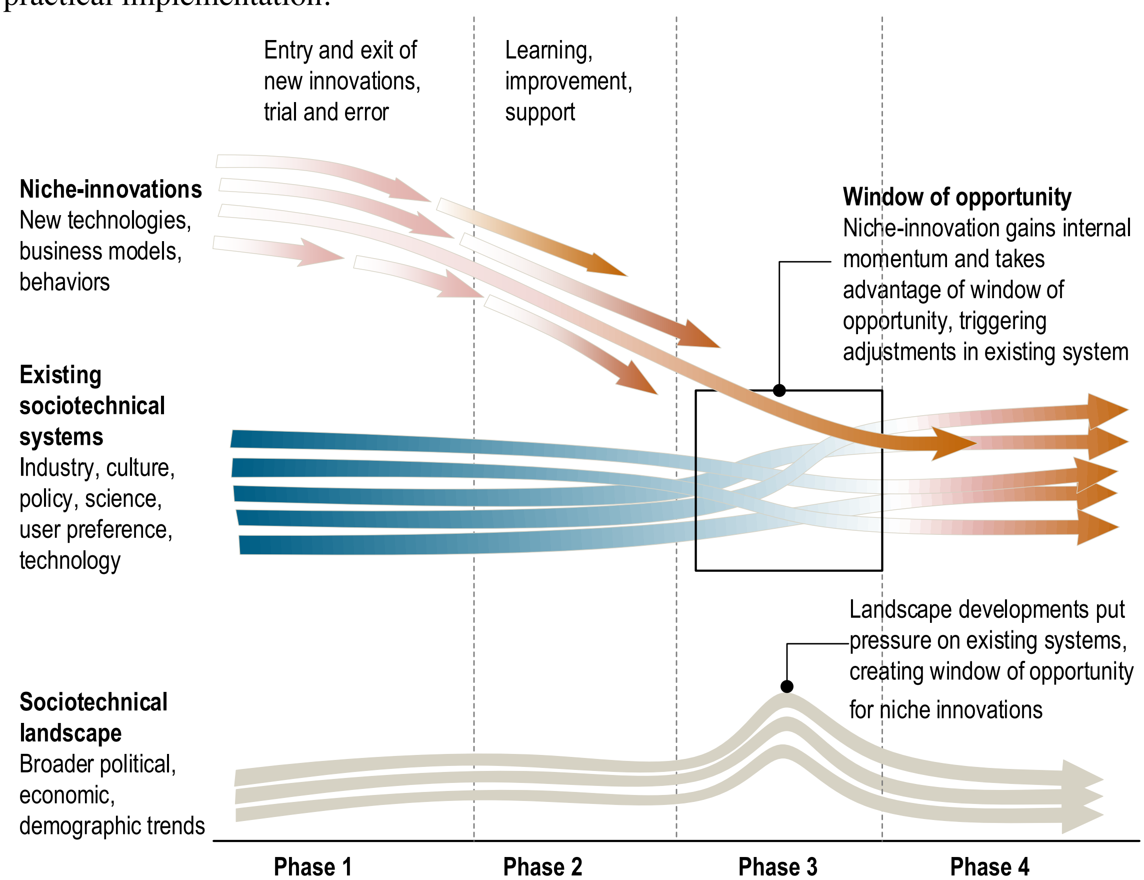

Figure 6: Sociotechnical innovation window of opportunity (redrawn from Geels et al. 2017, 1244)

Figure 7: Case locations in Austin (TX) and Portland (OR).

Other cities deserve consideration as well, but none provide the same opportunity for learning as Austin and Portland. Analysis of crowdsourcing in cities with limited experience with the approach may be valuable, but recent scholarship suggests a lack of resources including staff knowledge may play a direct role in acceptance or integration of the method (Afzalan and Sanchez 2017). Ride Report started in Portland, Oregon, and the service's online dashboard now reports over five times the number of trips than in Austin.

Though having more time to accumulate trips is one explanation, personal influence from the relationships between the city and Ride Report's staff is also likely a significant contributor to many of the trips. Portland may not be a good indicator of use in other cities. Ride Report has launched in 2017 in Atlanta, Georgia, Beaverton, Oregon, and then, Raleigh, North Carolina. However, these cities have many fewer trips than Austin, and may be more useful as comparative case studies after another year or more of crowdsourced data collection. Both Austin and Portland provide additional documentation and sources for interviews as key case study data, in addition to archival records in the form of geospatial data (Yin 2014). Finally, both cities progressively implement bicycle infrastructure, including traditional and innovative designs, as shown in Figure 8 and Figure 9.

Figure 8: SW Stark Street Bike Lane, Portland, OR (photo G. Griffin, June 23, 2018)

Figure 9: Two-way Protected Bike Lane on Rio Grande Street, Austin, TX (photo G. Griffin, June 10, 2018).

GEOSPATIAL DATA

This dissertation employs three classes of data for analysis: crowdsourced spatial data that compose the primary dependent variables, objective independent variables about the case location, and case study data that is primarily qualitative. I describe each category of data in the same order.

Crowdsourced Spatial Data

There are two primary dependent variables contained in the crowdsourced data from the Ride Report platform: bicycle trip counts and ratings by street segment. These data are the “Public Outputs” in Figure 10 that are the key resources produced through use of the crowdsourcing platform. The count data is just that—the number of people bicycling with the Ride Report app on a given street segment within the selected counting time frame. Count data is ratio-level with a fixed zero point, and analyzable using a variety of parametric statistics. Rating data comes from participants’ answer to an automatically-generated question at the end of every detected bicycle trip, designating the trip as either “great” or “not great” within Ride Report’s back-end. All ratings are overlaid, and averages computed for each segment. In an email exchange January 16, 2018, Michael Schwartz, the Director of Transportation Planning for Ride Report explained that “values between 0 and 1 represent the proportion of rated trips on a given segment that were rated ‘great’”. Therefore, each rated street segments have a rating within these two extremes, resulting as an interval statistic suitable for analysis with nonparametric methods.

Figure 10 shows maps of the crowdsourced traffic volumes, and street ratings in Figure 11 for Austin, Texas and Portland, Oregon, recorded from January 1, 2018 through June 30, 2018. The data was downloaded as a GeoJSON file from the current Ride Report online service for subscribers, converted to shapefile format using mapshaper (Bloch 2018) for analysis in geographic information systems and statistical packages.

Table 4: Descriptive Statistics of Crowdsourced Data in Portland (OR) and Austin (TX) by Transportation Segment, January 1, 2016 – June 30, 2018

Segment Type	N. of segments	Min.[1]	Max.	Sum	Mean	St. Dev.
Portland Counts	72,343	5	13,622	16,841,278	232.80	679.25
Austin Counts	16,308	5	2,039	1,802,304	110.52	147.18
Portland Ratings[2]	27,624	0.10	1	n/a	0.90	0.13
Austin Ratings[2]	6,310	0.14	1	n/a	0.8	0.1

Notes:
[1]To protect privacy, Ride Report does not show data for segments with fewer than 5 trips.
[2]Ride Report distinguishes high-confidence rating levels as having at least 20 ratings. This study omits segments with low-confidence ratings.

Statistics on the use of the platform are available to the author for Austin only, where Ride Report started in January, 2016. The City of Austin Transportation Department promoted use of Ride Report through an electronic newsletter and a department web page, describing the platform as including "trip reports and ratings (as anonymized and aggregated by Ride Report) [which] become crowdsourced feedback shown on a map that also helps ATD staff improve biking routes in Austin" (City of Austin 2018). The city's promotion of the app in the summer and fall of 2016 led to a total of 262 users in the month of November, 2016, which dropped to 130 users a year later. Austin Transportation Department and the downtown transportation management association, Movability Austin, promoted use of the app for Bike Month, May 2018, peaking at 403 users (Movability Austin 2018). Gender information is only available for individuals who connect the Ride Report app to a built-in health app on their smartphone. As of June 2018, 39% of the users providing gender information as female.

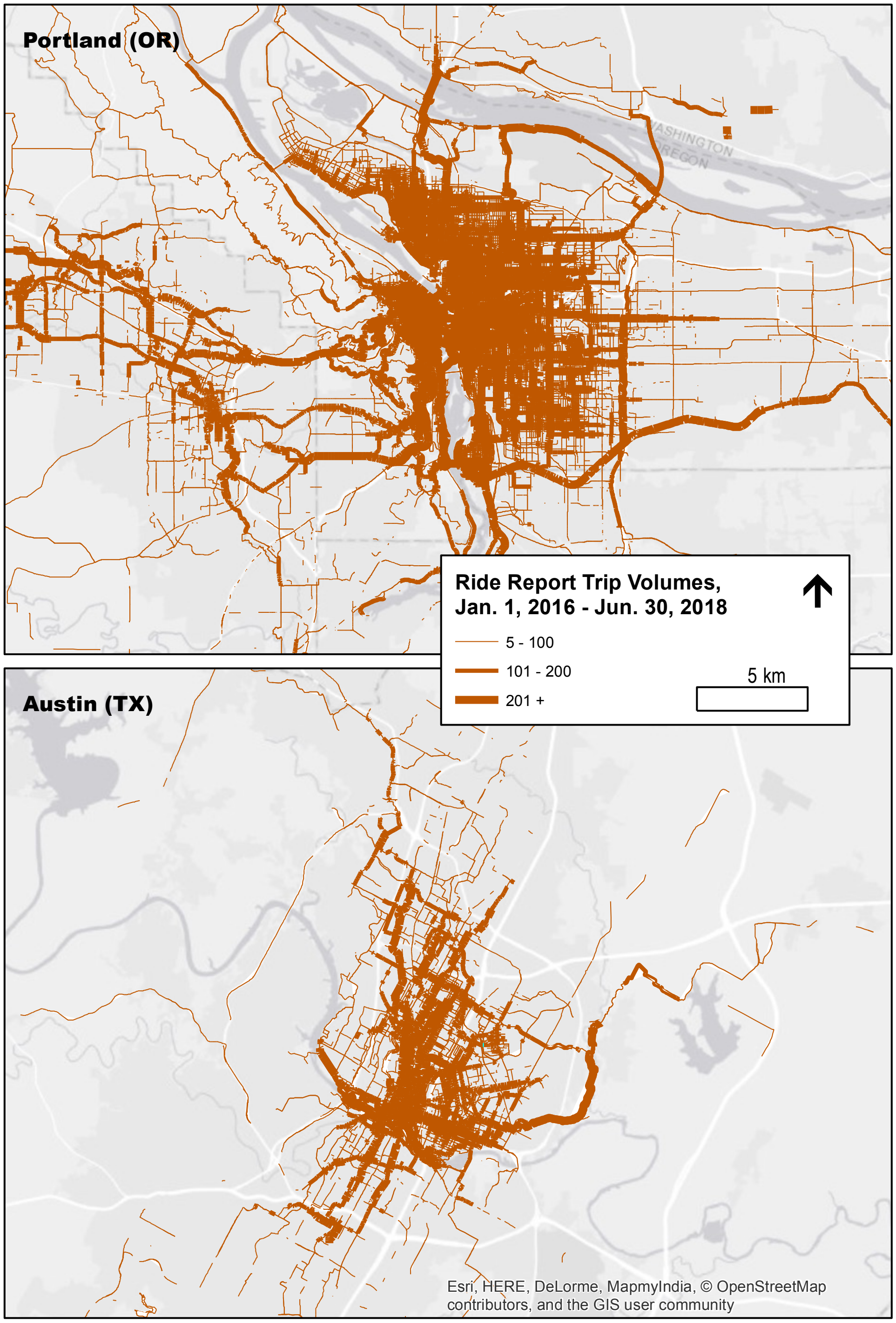

Figure 10: Crowdsourced Bicycle Trip Volumes from Ride Report in Portland (OR) and Austin (TX), January 2016 – June 2018.

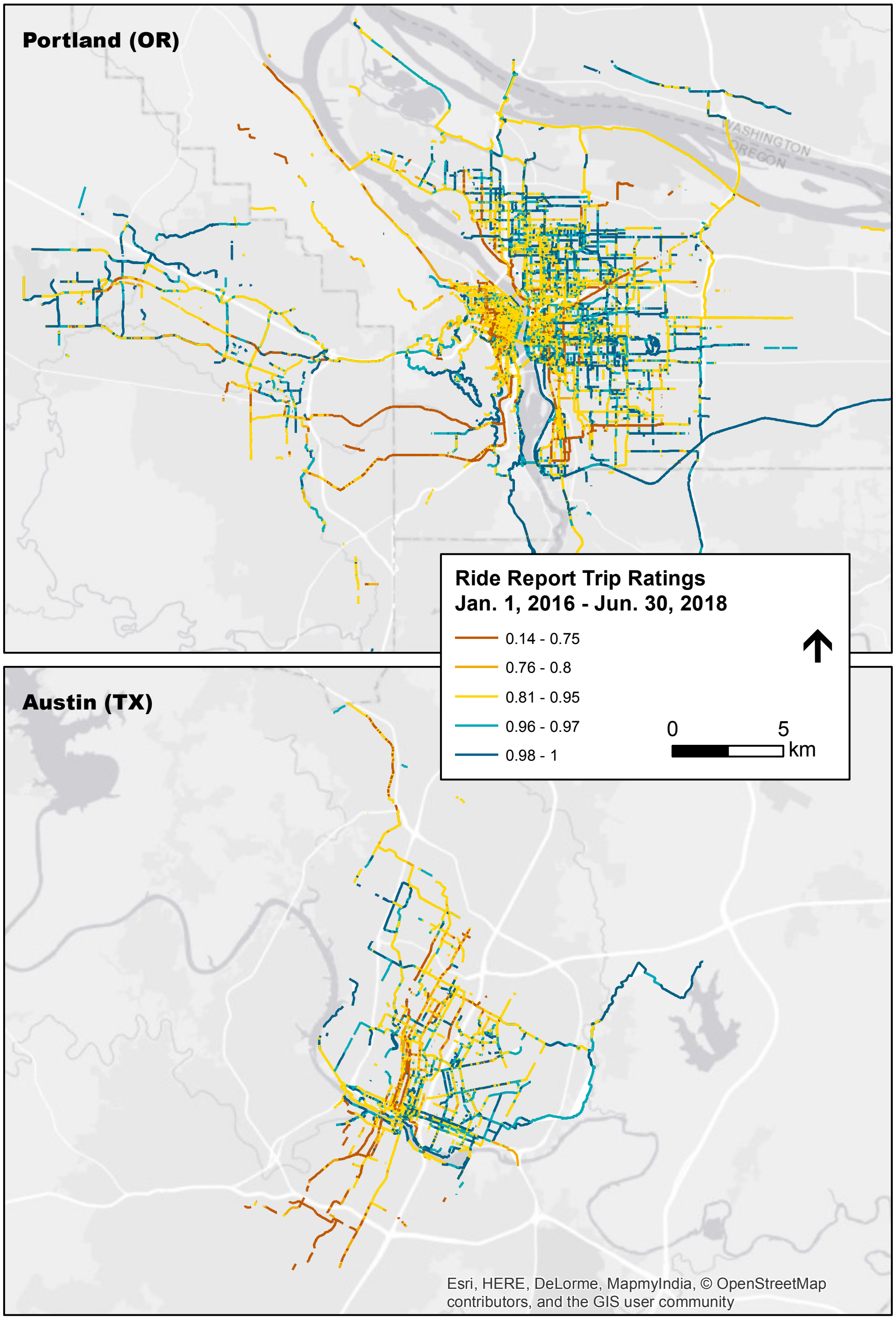

Figure 11: Crowdsourced Bicycle Trip Ratings from Ride Report in Portland (OR) and Austin (TX), January 2016 – June 2018.

Planning Case Data

Spatial Case Data

I use geographic data including built environment variables and demographics as independent variables for RQ1, and as case materials in RQ2 and 3. Table 5 lists the variables under a three-D (density, diversity, and design) framework related to bicycling trips (Cervero and Kockelman 1997; Cui, Mishra, and Welch 2014). Though this chapter includes modeling of the three-D built environment variables as having direct effects, recent research suggests indirect or moderating effects with self-selection, socioeconomic characteristics, and transportation system performance metrics (Zhang and Zhang 2018). As an exploratory study, this chapter focuses on the direct effects of spatial data on bicycle crash risk.

Since these variables exist as polygons, the values require conversion to match the roadway segment as the unit of analysis. To do this, I perform a spatial join of the independent variables to the roadway segments, determined using the centroid of each roadway segment. In this way, each roadway segment includes the independent variable data that represents its geographic center. This avoids problems with block group-level data used for the independent variables since road intersections are often used as boundaries for block groups.

Table 5. Independent variables for regression with bicycle collision rates

Variables	Source
Density	
Gross population density (people per acre)	American Community Survey, 2015
Gross employment density (jobs per acre)	Census Longitudinal Employer-Household Dynamics, 2015
Gross activity density (people + jobs per acre)	ACS 2015 + Census LEHD 2015
Diversity	
Race	American Community Survey, 2015
Income	American Community Survey, 2015
Percent of zero-car households	American Community Survey, 2015
Jobs per household	Census Longitudinal Employer-Household Dynamics, 2015
Trip productions and trip attractions equilibrium index; the closer to one, the more balanced the trip making	EPA Smart Location Database
Design	
Crowdsourced street ratings for bicycling	Ride Report
Bicycle level of traffic stress (further defined in the Appendix)	City infrastructure with researcher analysis
Network density in terms of facility miles of auto-oriented links per square mile	NAVSTREETS in EPA Smart Location Database
Network density in terms of facility miles of multi-modal links per square mile	NAVSTREETS in EPA Smart Location Database
Intersection density in terms of auto-oriented intersections per square mile	NAVSTREETS in EPA Smart Location Database
Intersection density in terms of multi-modal intersections having four or more legs per square mile	NAVSTREETS in EPA Smart Location Database

Qualitative Materials

Information related to the cases of crowdsourcing in Austin and Portland come from a wide variety of sources, each used to describe its representativeness of the community, perception by mainstream media, analyses by other researchers, and impact to the planning process. A literature review as case study material is limited to scholars' use and perception of the value and impact of crowdsourced data for bicycle transportation planning. This literature is nascent but is likely to influence later works as well. News reports vary widely, including limited coverage by popular media, and more in-depth coverage by bloggers who focus on bicycle transportation. Both are suspected of influencing social media, and wider perceptions (Wells 2015). Memoranda written by city transportation staff provide an insider's view of the use of crowdsourcing, or at least how they wish their audience—policy-makers and residents—to perceive the use of the information. Since the 2014 City of Austin Bicycle Master Plan was completed before use of crowdsourced information, the appendix on public participation will be used to characterize the geographic extent of traditional and online participation before crowdsourcing platform was involved. Demographics of use of the Ride Report platform are compared with the demographics of bicycle commuters, through descriptive statistics reported through the American Community Survey.

Table 6. Case study material, role, and analysis

Material	Role	Analysis
Literature review	Scholars' characterization of crowdsourcing for bicycle transportation planning	Constant comparison
News reports	News outlet's depiction	Constant comparison
Staff memos	Staff depiction	Constant comparison
Bicycle master plan documents	Extent of traditional and online participation	Geographic extent
Ride Report demographics	Representativeness of community participation	Descriptive statistics
American Community Survey demographics	bicycle commuter demographics	Descriptive statistics
Staff interviews	Staff perception of social construction of crowdsourcing and implementation	Member checking

Interview Process

Interviews serve three purposes in this research: description of crowdsourcing for bicycle transportation planning from multiple perspectives, interpretation of its social construction, and member checking for an insider perspective on developing inferences (O'Cathain 2010). Initial work with crowdsourced bicycle information suggested five different relevant social groups: planners/city management, app developers, researchers, bicycling public, and the non-bicycling public, diagrammed in Figure 12 (Griffin and Jiao 2015b; Figliozzi and Blanc 2015).

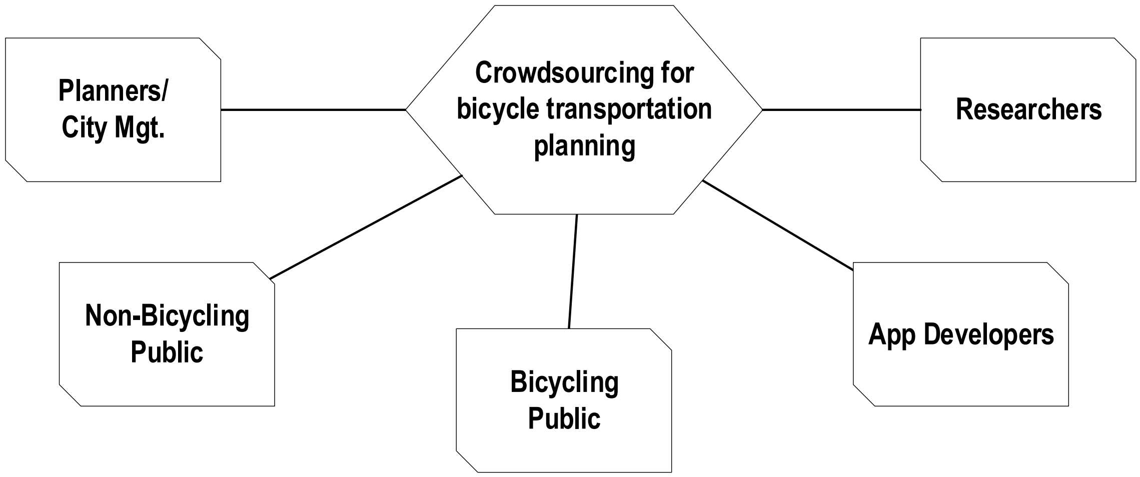

Figure 12: Relevant Social Groups of Crowdsourcing for Bicycle Transportation Planning

Online Interviewing

Since crowdsourcing for bicycle planning is an emerging topic, I did not assume that all relevant interviewees would reside in the case cities of Austin and Portland. However, people acquainted with the use of crowdsourcing for bicycle planning have access to online media. Therefore, I chose an online chat interviewing approach that would support a wide variety of times and places for interview subjects while providing a synchronous communication environment similar to face-to-face interviewing (Hewson 2014). Previous research of online media, such as crowdsourcing, find online interviewing appropriate, since "research participants are already comfortable with online interactions" (Kazmer and Xie 2008, 257–58). Qualitative researchers have been reluctant to adopt the approach widely to date, perhaps because of a perception of the medium not offering the richness of face-to-face interviewing. "However, considering the experiences of researchers who have engaged with IMR interview approaches, it is clear that rich, intimate, personal exchanges can occur online" (Hewson, Vogel, and Laurent 2016, 51). Nonetheless, scholars note both benefits and challenges to the approach.

Online interviewing supports flexibility in time and place for discussion, the candor of interviewees, and automatic transcription. Most of the interviewees in this study on crowdsourcing are working professionals who may have limited time away from a computer, and some working in the field may have been able to integrate the time into their daytime schedule. Online methods support access to specialists across large geographies (Hewson 2014)—an advantage suited to the study of crowdsourcing. This flexibility afforded by online communication has fit other research contexts "with time and/or mobility constraints" (Hewson, Vogel, and Laurent 2016, 51). Indeed, one interview with an expert from Jakarta, Indonesia took place over his lunch hour—midnight in Austin. Some interviewees let me know when they were being interrupted, and we were able to return to the discussion at their convenience. In other cases, participants apologized for long pauses that might have been interruptions or lack of focus, but I attempted to set them at ease by mentioning that flexibility as a benefit to online interviewing. The self-transcribing nature of instant messaging platforms provides an "essentially perfect transcription, since all interactions can be stored in logs and entire [chat] windows can be saved as [text] files" (Brabham 2010, 70), not only for the researcher but for the interviewee. A summary of research of online interviewing suggests that visually anonymous interviewing reduces the "social cost of disclosure," which could reduce inhibitions during the interview (Hewson, Vogel, and Laurent 2016).

Some of the challenges of online interviewing include more time required by interviewees, establishing rapport, loss of affective cues, and fragmentation of the conversation. Typing responses to interview questions generally takes more time than face-to-face communication to convey the same information, even if the time is more than made up by removing the researcher's work to transcribe interviews (Kazmer and Xie 2008). To control use of the interviewee's time, I provided periodic checks on time with the participant during the interview and held firmly to any participants' stated time limits. Internet chat cannot convey several types of information gathered through face-to-face meetings, including "nonverbal cues, facial expressions, and tone of voice" (Brabham 2010, 70). These issues may be partially mitigated with the use of emoticons to convey sentiment briefly (Kriplean 2012; Stephens and Barrett 2016), but research on social information processing suggests they have mixed impact on recipients (Walther 2016). The sensation of anonymity that could support candor may be a barrier in terms of establishing rapport, especially if the researchers do not use strategies to connect with interviewees at a personal level (Hewson, Vogel, and Laurent 2016). To account for this, my messages to participants include tailored language, in addition to web and social media links to offer interviewees an opportunity to understand more about my goals and positionality (Rose 1997), in addition to personalization and flexibility mimicking a face-to-face meeting during the interview (Hewson, Vogel, and Laurent 2016). Lacking immediate, extralinguistic cues of a face-to-face meeting, an interviewer might interpret a typing pause with a thought completion, and continue to the next question while the interviewee would rather complete her thought. The resulting transcript resembles a 'written conversation' that could require cleaning and organizing before analysis (O'Connor et al. 2008). Mitigating the challenges of online interviewing provided a balance of the method's advantages with tolerable limitations, gaining a practical method to incorporate insights from the relevant social groups.

Recruiting and Scheduling Interviews

I recruited interviewees through my existing professional contacts, identifying followers of the Ride Report Twitter account, and through an online search of Google Scholar search of "crowdsourcing" "bicycle" "planning" or the crowdsourcing platform

"Ride Report," restricted to the year 2017 or later. Out of 66 initial contacts, 33 responded affirmatively and completed interviews.

In most cases, I scheduled online meetings via email, sending information about the study approved by The University of Texas at Austin Office of Research Support and Compliance (Interviewee Invitation in the Appendix, study number 2017-05-0127), requesting a date and time convenient for the participant. I replied with an individualized link to The University of Texas at Austin's Adobe Connect platform, which provided a professional, UT-branded online meeting site. I assigned each interviewee with a unique number, and included the number in the online interview title and email, to enable later anonymized participant tracking. Compared with free and low-cost forms of real-time messaging, Adobe Connect is regarded as "generally easier to set up and more flexible" (Hewson 2014). Following an email or direct message invitation, some interviewees expressed a preference for using other platforms for the interview, including Twitter direct messaging and the WhatsApp platform, which I obliged.

Conducting Interviews and Recovering Transcripts

I started interviews with a brief introduction to the study, or more information about myself, to establish rapport and strike a balance of professionalism and friendliness. The semi-structured interview guide in the Appendix, reviewed by The University of Texas at Austin Institutional Review Board, includes eight questions covering the participant's perceptions and experiences with crowdsourcing for transportation planning. Following the brief introduction discussion, I started by copying or tailoring interview questions, generally in the same order as the guide. In some cases, I added transition sentences to introduce topic changes. I did not use the bulleted probe topics by default, but only if interviewees hesitated in their responses or appeared unsure how to relate their experiences to my questioning. In some cases, I used probes to re-direct our conversation back to the core topics. Most interviews took about thirty minutes, but I allowed some to go over an hour if the interviewees were unusually engaged and did not indicate time constraints.

At the end of the interview, I confirmed an e-mail address for sending an electronic gift card as a recognition of their time investment. Several interviewees declined the gift card; some completed interviews while at work in the context of their job and reported they could not accept the incentive. The Adobe Connect chat tool supports emailing a complete transcript, which included clear separations for each speaker, and time stamps in the text file. Counts of completed interviews are shown in Table 7 by relevant social groups and location.

Table 7: Interviews by Relevant Social Groups and Location

Location	**Planners/City Management**	**App Developers**	**Researchers**	**Bicycling Public**	**Non-Bicycling Public**
Austin	2	0	0	1	3
Portland	4	2	1	1	0
other	5[P]	4	5[R]	4	1

[P] Including two from Canada, and one from Jakarta, Indonesia.
[R] Including one from Canada, and one from Zurich, Switzerland.

Preparing Interviews for Coding

To support coding by research assistants, I formatted the transcripts in the standard question order provided in the Interview Guide. To focus assistants' work on accurate coding rather than learning software, I developed tables of responses in Microsoft Excel workbooks for coding. I adapted a method to structure interview data in Excel (Ose 2016), where each interview question was represented in a spreadsheet column, with each respondent's reply in a row. Each code was in a separate column so that each question-response would be the unit of analysis for coding. In some instances, this response unit could constitute several paragraphs of discussion, and it could be a single word response.

Identifying information, including automatic identity stamps from the interviewee, were removed from the interviews. Each row then included the study's interviewee number, the content of their response, and then separate columns for each code.

Coding Interviews

I provided each of two coders with an Interview Codebook (provided in the Appendix), including instructions for using the workbooks for coding, in addition to a description of each code, inclusion criteria, and exclusion criteria, to reduce ambiguity (Saldaña 2016). First cycle codes were patterned after *structural coding* to designate a phrase that ties the response content to the study's research questions—an approach suited to categorize semi-structured interview data (Saldaña 2016). The eight structural codes included the LASTR framework introduced in the first chapter, and three additional concepts related to the research questions introduced in chapters four and five: ROUTE QUALITY, SAFETY, and GEOGRAPHIC DIFFERENCES. Structural coding by two research assistants minimized the chance for my biases to impact the emergence of thematic structures, and support rigorous analysis of code reliability.

GEOSPATIAL ANALYSIS

The first two research questions are principally quantitative, spatial issues. This section provides an overview of the general method used to analyze the data described in this chapter. However, each empirical chapter (4, 5, and 6) include additional methodological description.

I address the first research question regarding whether crowdsourced bicycle route quality and volume can predict collisions through a difference in means test, and spatial regression. This approach provides a broad characterization of whether the higher-rated streets, and higher-volume streets, are more likely to have lower total crashes. The spatial regression technique adds detail to this approach by controlling for variables related to density, diversity, and design, in addition to spatial autocorrelation—whether location proximity to other variables plays a role.

The second research question concerns the geographic differences of spatial representation between traditional and crowdsourced public participation for bicycle transportation planning. To characterize the spatial extent and compass orientation of the differing participation methods, I apply standard deviational ellipses (Esri 2017; Yuill 1971). In addition to generalizing the location and area of a spread of observations, such as meeting locations, this approach "takes into account the directional bias of the geographical distribution" (Xu, Wong, and Yang 2013, 110), and is commonly used to characterize participation in urban planning (Radil and Jiao 2016; Jankowski et al. 2017; Jankowski, Czepkiewicz, Młodkowski, and Zwoliński 2016). Esri's application of the method represents a mean center for a list of point feature locations and then computes a sample covariate matrix represented by eigenvalues and eigenvectors, adjusted by factors relating to standard deviation levels (1, 2, or 3). The resulting ellipses include approximately 66% of the observations (meeting locations or crowd-rated street segments) at the 1st standard deviation level, 95% at the 2nd standard deviation, and 99% at the 3rd standard deviation.

Case Study and Social Construction of Technology

The third research question has two key components: analysis of how crowdsourcing is socially constructed, and what role, if any, that has on how crowdsourcing represents communities. Using Bijker's revised premise on the social construction of technology (Bijker 2009a), I identify crowdsourcing as a sociotechnical ensemble—the crowdsourcing app as an artifact is ontologically intertwined with the social group that creates and applies it (Bijker 2009a). In this way, I reveal the main limitations and possibilities of crowdsourcing through relevant social groups and technological lenses simultaneously. A critical review of neogeography suggests the limits of democratization lie between the "separation between a technological elite and a wider group of uninformed, labouring participants who are not empowered through the use of the technology" (Haklay 2013). More information—or even better information about cities—offers no guarantee of empowering or even ethical action. Social construction through a detailed case study of crowdsourcing will, however, provide some insight into the issue.

Most simply, a social construction of technology research process involves three steps (Bijker 2009b):

1. Sociological deconstruction of an artifact to demonstrate its interpretive flexibility
2. Description of the artifact's social construction
3. Explanation of this construction process in terms of the technological frames of relevant social groups.

Crowdsourcing as a sociotechnical ensemble is depicted in Figure 5, where the technological artifact of interest is connected to each relevant social group. Case materials listed in Table 5 form the basis for SCOT analysis of crowdsourcing for bicycle transportation planning. In the first step, each relevant social group will have their description of crowdsourcing in the case materials, which are then analyzed regarding how much they differ (interpretive flexibility). Second, the materials will be used to describe how this form of crowdsourcing developed as a social construction. Third, I will explain how each social group forms their understanding of crowdsourcing through their technological frame—how each group interprets the use of the artifact of crowdsourcing. Seeing crowdsourcing as an ensemble of both technology and culture, I will look for what might influence the degree to which it reflects publics of interest—rather than just the interested publics?

Chapter 4: Crowdsourcing Safe Bicycle Routes

Most cities provide bicycle route maps, presumably to support wayfinding that balances efficiency with safety. Recognizing that the straightest route could involve high-speed roadways without dedicated facilities for bicycling, bicyclists logically seek safe routes as close to the most efficient route as possible. Traditional maps and online interactive maps rely on updates to accurately reflect route conditions. Even when updated frequently, there is no assurance that a route rating—such as a green map color showing a high-quality bike route—reflects the comfort level or actual safety of the bicyclist. Could crowdsourced map information provide a useful representation of bicyclist safety?

This chapter addresses whether crowdsourced bicycle route quality and volume can predict collisions in Portland (OR) and Austin (TX). In doing so, this chapter aligns with two of the participation topics in the *LASTR* (legitimacy, accessibility, social learning, transparency, representativeness) framework for participatory process design: legitimacy and transparency. If the crowdsourced data is statistically related to bicycle crash rates, it is *legitimate* because planners could use it to evaluate priority street projects and recommend safe routes. Since the information is available online, at least in a summary map, it also supports *transparency*, enabling public use and critique. Before jumping into evaluating case data from Portland and Austin, I provide some background in why people choose to participate in a crowdsourcing platform such as Ride Report, and what the technology's affordances mean for participants and planners.

BACKGROUND

Communicating the Quantified Self

Some bicyclists use digital ecosystems, including smartphone apps, to record and then communicate their actions. This perspective bridges two contemporary trends: *quantified self* (Barta and Neff 2016) and *network-expressive* communication (Wells 2015). Quantified self practitioners record their behavior in some format, and in the process of processing and auto-feedback, gain an understanding of their patterns and alter their own behavior to achieve a goal (Riggs and Gordon 2017). Some form in-person groups as part of quantified self communities (Barta and Neff 2016) and others post activities online in a range of forums, such as the Strava community for fitness-oriented bicyclists, and social media sharing of others such as Ride Report, used in this study. Networked sharing of behavior might be to either show or question activities with a knowledgeable community, and it can also center on civic involvement, which Lance Bennett related to an *actualizing* civic style of communication (Bennett 2008). Chris Wells recognized the impact of this type of communication—networked sharing of activities to pursue an organizational or civic goal—as a new era of organizational communication: a network-expressive era that I have previously noted deserves further exploration in urban studies (Wells 2015; Griffin 2018).

Self-tracking apps like Strava and Ride Report afford users the ability to integrate geographically specific bodily experiences with local knowledges, expressed in an actualizing civic style. The hybrid offline and networked experience of tracking bicycle routes creates a community of practice around co-located activities, which researchers are only beginning to understand from an organizational communication perspective (Smith and Treem 2017). Recognizing that a social technology such as these apps only constitute a complete system when used and shaped by social groups, we see the importance of understanding whom the relevant social groups are for researching the social construction of technology (Smith 2017; Bijker 1995). Online platforms that support tracking and community-making for self-tracking bicyclists provide a rich source of understanding (Lupton and Labond 2018), potentially, for learning about the use of both the social and numerical datasets that could inform transportation planning. Recognizing that the app ecosystem for bicycling provides a wide range of potential sensory and social information sources, this chapter focuses on the affordances of route rating and traffic volumes through the Ride Report platform in Austin (TX) and Portland (OR).

RESEARCH QUESTION

Review of previous work suggests increasing capabilities of planners supported by crowdsourced information. However, research to date has not shown whether crowdsourced bicycle volumes or street ratings are associated with crash risk. The potential relationship matters because if either or both predict the risk of collision, then the information could be used to plan bicycle routes likely to be safer, potentially at the city planning level, and for individuals. Planners could use the information in developing plans to prioritize infrastructure improvements, such as sections of protected bike lanes, bicycle boulevards, or removal of on-street parking, shown to reduce risk across previous studies (DiGioia et al. 2017). At the individual level, apps might in the future use crowdsourced bicycle volume or rating information as a proxy for risk, algorithmically favoring routes less likely to result in a collision. Therefore, I propose the research question—can crowdsourced bicycle route quality and volume predict collisions? This chapter tests this question using hypotheses related to crowdsourced bicycle volume, and segment ratings.

H_0—Crowdsourced bicycle volumes, nor street segment ratings, are associated with a change in crash rate by street segment, at a 95% confidence level.

H_1—Crowdsourced bicycle volumes are associated with a change in crash rate by street segment, at a 95% confidence level.

H_2—Crowdsourced ratings of street segments are associated with a change in crash rate by street segment, at a 95% confidence level.

DATA

The crowdsourced bicycling data, provided through the Ride Report smartphone app and data platform (Knock Software 2017), represent aggregated bicycle trips recorded through smartphone sensors, in addition to quality ratings provided following the end of a detected trip. These data are aggregated at the level of network segments, which are generally divided at each intersection—essentially representing street blocks.

Segments as the Unit of Analysis

The crowdsourced dataset from Ride Report is built upon OpenStreetMap, itself a transportation infrastructure GIS dataset built from government datasets and volunteers. OpenStreetMap is more than 95% complete in the United States, and more than 80% complete globally, using visual assessment with satellite imagery (Barrington-Leigh and Millard-Ball 2017). However, completeness does not include the dimensions of positional accuracy and attribute accuracy, as evaluated in a single case study of London, Canada (H. Zhang and Malczewski 2017). Since OpenStreetMap is virtually complete in the United States, and Ride Report does not include tabular attributes of OpenStreetMap, only the positional, as in geometric, characteristics are of concern for this application. Since Ride Report distributes its geographic data using the street segment as the unit of analysis, I retain this unit to avoid introducing error in the key crowdsourced attributes: trip count and ratings.

Ride Report exports the crowdsourced data in shapefile format, which creates challenges for analyzing data using a segment as the unit of analysis.

Segment Ratings

In addition to the passive sensing of the *quantity* of bicycle trips, the Ride Report app crowdsources the *quality* of routes as well. The firm's whitepaper targeted towards planners interested in the platform positions the service as building knowledge from the bicycling community.

> Instead of planners trying to guess how stressful a route might be, Ride Report users can report their experience directly. When a trip is over, the app prompts the rider to rate it right on their phone's lock screen. This simple rating mechanism is an easy way for riders to provide data on the comfort of their trip. Using this crowd-sourced data, Ride Report has created the first ever Comfort Map based on people's real experiences (Ride Report 2016).

In an email exchange on January 16, 2018, Ride Report staff described the crowdsourced numerical rating attribute for each segment. Michael Schwartz, the Director of Transportation Planning, described that "values between 0 and 1 represent the proportion of rated trips on a given segment that were rated "great." Negative values mean there were not enough users or trips to provide a meaningful average rating while protecting privacy/anonymity". More specifically, he explained the negative values "range from -1 to -2, with -2 meaning 100% of trips rated great and -1 meaning 0% rated great". Ride Report Co-founder and Chief Technology Officer Evan Heidtmann defined that a rating of "-3 indicates a segment where we have too few ratings to generate a rating at all. In other words, a "null" rating is encoded as "-3". Rather than transform the low-confidence ratings for integration with the other segments, this study omits them, instead focusing on a straightforward, replicable method with potential for use by practitioners. The next sections briefly describe the core data of this chapter, trip counts and bicycle collisions.

Trip Counts

Portland streets have roughly double the amount of bicycling on an average street segment compared with Austin as recorded on Ride Report as shown in Table 8. Two differences between the cities explain dissimilar bicycle volumes recorded in this data. First, Ride Report was developed in Portland, and likely received more promotion within this community over a longer period of time. Second, bicycling overall is more prevalent in Portland, as shown by a 6.1% bicycle commuting rate in the city, versus 1.6% in Austin (analysis of American Community Survey 2011-2013 in Alliance for Bicycling and Walking 2016).

Table 8: Average Annual Crowdsourced Bicycle Kilometers Traveled (AACBKT), January 1, 2016 to June 30, 2018

	N Segments	Min	Mean	SD	Max
Portland (OR)	56,349	0.00	7.29	33.34	2,558.04
Austin (TX)	16,308	0.00	3.78	8.61	403.97

Collisions

Given the context of more bicycling in Portland than Austin, the fact that fatal and injury crashes involving bicyclists at almost the same mean frequency at the level of the street segment supports the safey-in-numbers hypothesis at the city level (Jacobsen, Ragland, and Komanoff 2015). Table 9 shows some variation in crashes, where most segments had no crashes during the safety data time period 2014-2015, with a maximum of five fatal or injury crashes on one segment in Portland over that time period.

Table 9: Pedalcyclist Collisions (fatal or injury within 15 m (48 ft) of Crowdsourced Street Segments, January 1, 2014 to December 31, 2015.

	N segments	Min	Mean	SD	Max
Portland (OR)	56,349	0	0.08	0.33	5
Austin (TX)	16,308	0	0.07	0.27	2

Explanatory Variables for Regression Analysis

Crash risk—as defined in this dissertation as fatal and injury bicycle crashes per 100,000 bicycle miles logged on the crowdsourcing platform by street segment—is the dependent variable to be explained through other spatial variables in both cities. The context of bicycle transportation is anticipated to play a role in both safety from collisions, and bicycle traffic volumes. Specifically, Ewing and Kockelman showed that variables of density, diversity, and design—which the authors named the 3 D's—related to multi-modal travel demand (Cervero and Kockelman 1997). Later work showed how these have a particular bearing on active transportation modes (Saelens, Sallis, and Frank 2003), but represent an incomplete framework for understanding active living, considering additional intrapersonal, social, and policy realms (Sallis et al. 2006). However, other researchers have proposed additional "D variables", including destination accessibility and distance to transit (Ewing and Cervero 2001; Ewing et al. 2015), and a sixth D for demand management (Ogra and Ndebele 2014). However, this study considers the first three variables as most objective variables, considering the debate in measurement of destination accessibility (Levine et al. 2012; Faghih-Imani and Eluru 2015), the tentative role of transit for bicycling (Hochmair 2014; Singleton and Clifton 2014), and potential tautological relationship with demand management (Akar, Flynn, and Namgung 2012; Hamre and Buehler 2014). Demographics is also considered a D variable by some (M. Zhang and Zhang 2018), which this chapter incorporates only related to income and race, as a component of diversity. Therefore, this chapter focuses on the original 3 D's of density, diversity, and design as variables to understand the environmental context of bicycle safety.

Further support for this relationship exists in literature related to the safety-in-numbers hypothesis, which suggests that the relative risk of collisions decrease with an increase in bicycling or walking traffic volumes (Jacobsen and Jacobsen 2003). The causal mechanisms of this hypothesis are still under debate (Bhatia and Wier 2011), but the relationship has been repeated in different locations and geographic scales (Lee, Zegras, and Ben-Joseph 2013; Jacobsen, Ragland, and Komanoff 2015; Dumbaugh and Li 2011). Since the uni-modal studies do not consider risks related to traffic volumes from other modes (e.g. pedestrian and motor vehicles), there is the potential for safety-in-numbers apparent from a single mode (e.g. bicycle crashes divided by bicycle volumes, as in this study) to be a self-referential statistical artifact—it may obscure a hazard-in-numbers effect as well (Elvik 2013). Elvik concludes that studies that do not consider volumes from all modes should be considered a "partial safety-in-numbers" effect (Elvik 2013, 62). Therefore, findings concerning safety-in-numbers may be considered exploratory, but should also consider hazard-in-numbers effects before being considered conclusive or causal. The most recent work in this area suggests that the relative strength of the safety-in-numbers effect decreases as the volumes of bicyclists and pedestrians increase, but across previous studies, a 1-unit increase in bicycle volume is associated with a 0.43 decrease in crash risk (Elvik 2017; Elvik and Bjørnskau 2017). Support exists to expect relative bicycling safety to increase with greater traffic volumes, but no studies to date have examined the use of crowdsourced volumes explicitly in this manner.

The density, diversity, and design variables in this study are taken from national sources to support cross-city comparison. The Environmental Protection Agency's Smart Location Database (SLD) is applied for most built environment variables, but diversity variables related to race and income are updated with the most recent American Community Survey figures, the five-year data ending in 2000 (Ramsey and Bell 2014a). Design variables relating to traffic include the level of traffic stress calculations along segments and at intersections from a national effort leveraging Open Street Maps networks as base data (People for Bikes 2017). This level of traffic stress data has only three levels (1=low stress, 3 = highest stress), which is less refined than the original four-level standard developed to align with "Roger Geller's classification of the cyclist population and Dutch design standards" (Furth, Mekuria, and Nixon 2016, 41; Geller 2009). Street network density variables, including both auto-oriented streets (higher-speed arterials and highways) and multi-modal streets (lower-speed arterials and local streets) (Ramsey and Bell 2014a).

Regression analysis with the crowdsourced ratings requires limiting the number of street segments to those meeting Ride Report's proprietary minimum threshold of ratings. Therefore, multiple regression analysis uses this sub-set of the data, totaling 24,026 segments in Portland, and 6,310 segments in Austin. Table 10 summarizes the crowdsourced data, in addition to density, diversity, and design variables used in regression analysis to explain variation in crash risk.

Table 10: Explanatory variable descriptions for regression

Variable		Model name	Source	Portland (OR) N=24,026		Austin (TX) N=6,310	
				Mean	SD	Mean	SD
Crowdsourced Rating		rating	Ride Report	0.89	0.13	0.87	0.12
Crowdsourced Volume		AACBKT	Ride Report	600.82	1085.68	218.55	185.62
Density	Employment + Housing Units	D1d	SLD	34.17	52.66	36.23	57.55
	Jobs per Acre	D1c	SLD	26.41	49.68	31.72	57.03
	Zero-Car Households per HH	PCT_AO0	SLD	0.22	0.22	0.11	0.09
	Residents per acre	D1B	SLD	13.74	9.41	9.44	8.15
Diversity	Jobs per Household	D2A_ JPHH	SLD	36.34	449.16	9.71	14.40
	Median Household Income	MedHH Income	ACS 2012-2016	66971.48	21661.82	54439.22	22642.15
	Non-white Race Ratio	NonWhitePer	ACS 2012-2016	0.16	0.10	0.22	0.17
	Trip equilibrium of productions and attractions (1=balanced)	D2C_ TRIPEQ	SLD	0.49	0.19	0.47	0.18
Design	Level of traffic stress by intersection (1=low stress, 3=high)	SEG_STR	BNA	1.46	0.60	1.06	0.13
	Level of traffic stress by segment (1=low stress, 3=high)	INT_STR	BNA	1.03	0.09	1.54	0.65
	Intersections (auto-oriented) per sq. mi.	D3bao	SLD	5.45	8.38	4.81	5.73
	Network (auto-oriented) links per sq. mi.	D3aao	SLD	2.65	4.30	2.15	2.74
	Intersections (multi-modal with four or more legs) per sq. mi.	D3bmm4	SLD	24.34	22.94	8.80	8.26
	Network (multi-modal) links per sq. mi.	D3amm	SLD	4.16	2.93	2.75	1.94

Notes: AACBKT=Average Annual Crowdsourced Bicycle Kilometers Traveled, SLD=Smart Location Database (Ramsey and Bell 2014b), ACS=American Community Survey, BNA=Bicycle Network Analysis (People for Bikes 2017)

METHODS FOR CROWDSOURCED SAFETY ANALYSIS

The overall process for analysis of crowdsourced information with safety data included preparation of datasets for each case (Austin, TX and Portland, OR), and calculation of variables. The crowdsourced bicycle route volumes and ratings, along with the bicycle crash data described in Chapter 3 provide the core data for responding to this research question. I followed the same process to prepare Ride Report data in Austin and Portland. To calculate average annual crowdsourced bicycle kilometers of travel recorded via Ride Report (AACBKT), I divided the total count by the number of years of data each represented, then multiplied the count of each segment by the length of each segment in kilometers. This value represents the use of the Ride Report app for each segment, and I do not intend for it to serve as an estimate of all traffic volume. This chapter's analysis focuses on the relationship of app use with crashes since the use of the app represents a sampling bias—only those bicycling with a smartphone who choose to run the app. Though weighting use of the app by total bicycling volumes is a straightforward process, this chapter concentrates on the role of crowdsourcing in estimating bicycle traffic safety.

I computed explanatory variables as the average of all block groups that intersected a 15 m (48 ft) buffer of the crowdsourced street network dataset. The average was chosen to minimize the potential for extreme variation related to the modifiable unit area problem (MAUP), which would be exacerbated by using the direct values of a large block group that the center of a street segment happens to cross through, or inclusion of only one of several small urban block groups (Mitra and Buliung 2012; Zhang and Kukadia 2005). The uncertainty of geographic context, including time lags as well as spatial, between variables remains, and is not quantified further for this chapter (Kwan 2012).

Calculating estimated risk values involves merging the crash dataset to the Ride Report data. Since the spatial accuracy of crash data and the Ride Report data (using Open Street Map geometry) are imperfect, I joined crashes to the closest Ride Report segment, calculating the sum of the crashes occurring on or nearest each segment. The next two sections describe methods specific to each case site.

Calculating Crash Risk

To annualize the total trips recorded on Ride Report, I divided the total overall bicycle trips recorded by the duration of the dataset in years (January 1, 2016 through June 30, 2018: 2.5 years), resulting in an Average Annual Crowdsourced Bicycling trips (AACB) attribute, calculated for each segment in the crowdsourced dataset.

$$AACB = \frac{count\ of\ overall\ crowdsourced\ trips\ by\ segment}{years\ of\ crowdsourced\ data} \quad (2)$$

Next, I calculated the average annual crowdsourced bicycle kilometers traveled on Ride Report (AACBKT) by multiplying segment length in kilometers by the number of average daily bicyclists.

$$AACBKT = segment\ length\ in\ kilometers \times AACB \quad (3)$$

Calculating crash risk involves joining the GIS databases based on location, which poses at least two substantial challenges for accuracy. First, neither Oregon nor Texas department of transportation databases report the spatial accuracy of the location of the crash—either through global positioning system (GPS) dilution of precision (DOP) statistics (Sando et al. 2010), or whether a responding officer may have recorded location by providing an approximate address, which DOT staff later geocoded. Second, the context of the crash may include more than the closest street segment—conditions of neighboring or crossing segments may play a role in the crash location, particularly considering the variable speeds and directions of vehicles and bicycles in different contexts. Broadly, Mei-Po Kwan termed the spatial and temporal uncertainty of geographic phenomena as The Uncertain Geographic Context Problem (Kwan 2012). I mitigate this issue, at least partially, by considering Kwan's *situational contingencies*—"interactions with others in real time" with an intentionally-inclusive context, using a 15 meter (48 ft) buffer to count crashes as related to a street segment. This distance is the minimum width to span a four-lane, undivided rural highway by TxDOT standards (Texas Department of Transportation 2014), yet not wide enough to conflate both directions on many separated arterials. The temporal mismatch is necessarily broad: the most recent crash data available at the time of study is the end of 2015, whereas Ride Report data for Portland and Austin was available starting in early 2016. Similarly, site condition variables relate to the year 2015 broadly, and so the crowdsourced data cannot have a causal relationship to crashes observed before the Ride Report data was collected. These spatial and temporal mismatch challenges are part of the ongoing uncertain geographic context problem to be more fully addressed in later studies.

To calculate crash risk, I spatially joined crashes within the 15 meter (48 ft) buffer to the crowdsourced dataset, summing the number of crashes by each network segment. Figure 13 illustrates different crash site conditions that impact how crash counts are joined to the GIS dataset. Site A would not be included in the crowdsourced network and is not counted for this analysis. Crash site B occurred mid-block and is counted on a single street segment. Site C occurred at an intersection of two segments and is counted once on each segment. Then, I calculated crash risk as the number of crashes per year divided by 100,000 annual crowdsourced bicycle kilometers traveled, as shown in equation 4.

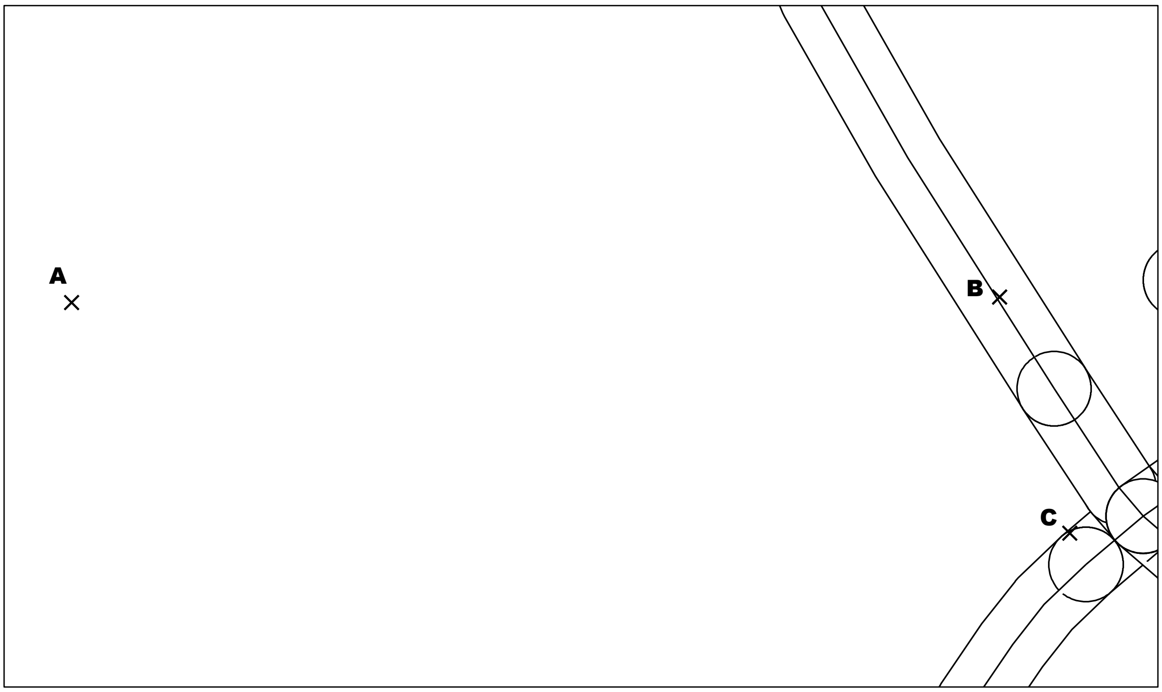

Figure 13: Three types of crash sites, and how they were spatially joined to the crowdsourced dataset. A is not included in the analysis. B is counted on one segment. C is counted on two segments.

$$Annual\ Crashes\ per\ 1{,}000\ BKT = \frac{crashes}{years\ of\ crash\ data} \Big/ \frac{AACBKT}{1{,}000} \quad (4)$$

Figure 14 shows the calculated crash risk in each city, with the upper quantiles of risk depicted as hot spots in orange and red.

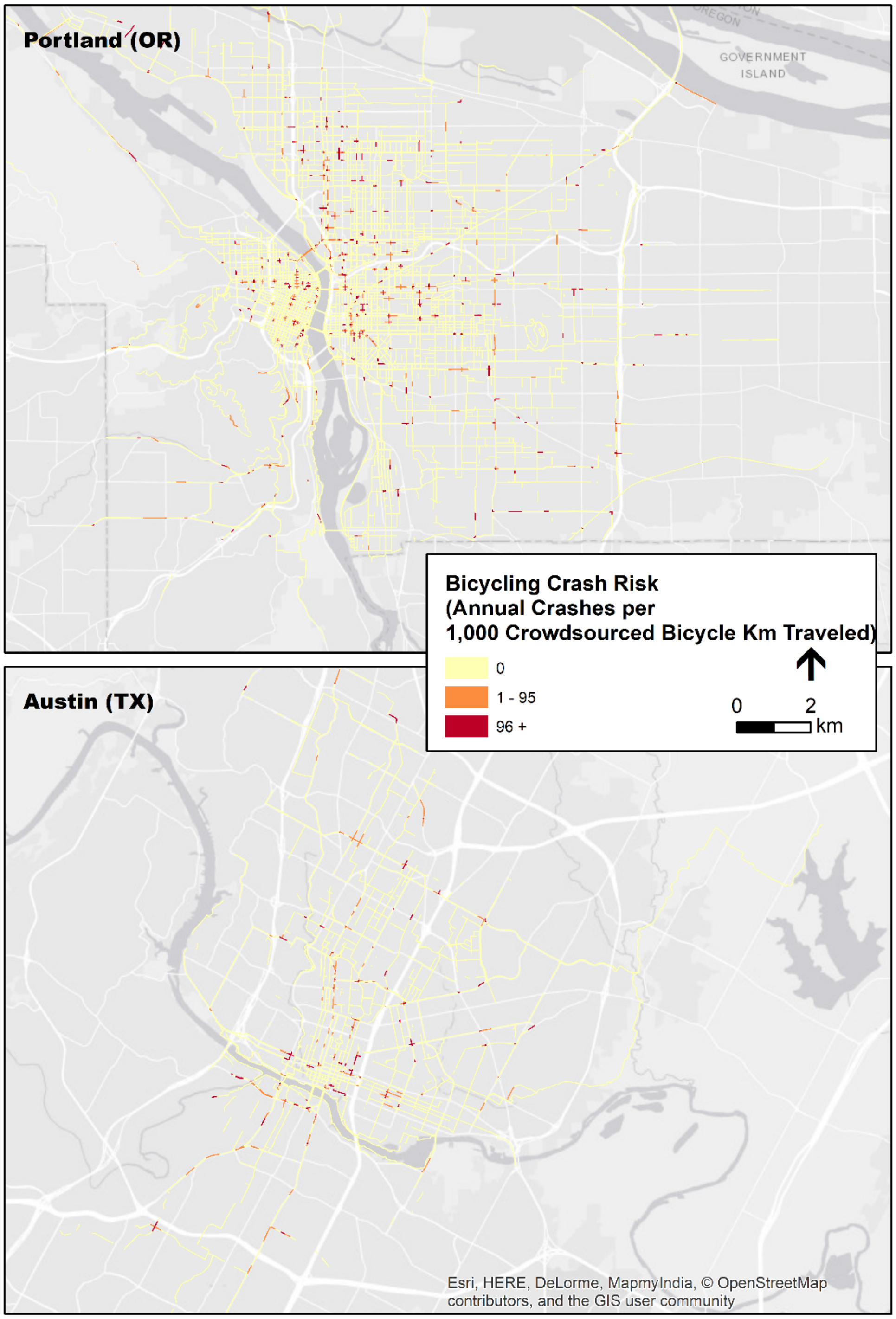

Figure 14: Bicycling crash risk in Portland (OR) and Austin (TX) as annual crashes per 1,000 crowdsourced bicycle kilometers traveled.

Multivariate Regression Preparation

The dependent variable, annualized crashes per 1,000 crowdsourced bicycle kilometers traveled, has a left skew in both analysis sites, similar to previous studies of bicycle and motor vehicle volume distribution, which is addressed by a natural log transformation (Ewing and Hamidi 2014; Menghini et al. 2010). Most dependent variables were within a normal distribution range, but some variables had a left skew in one city while being normally distributed in the other. To support comparison, all dependent variables in both cities were left untransformed.

Non-spatial regression analysis assumes that variables at case locations, such as street segments in a city, do not vary based on where they are—they ignore geography. This chapter instead follows Waldo Tobler's first law of geography: "everything is related to everything else, but near things are more related than distant things" (Tobler 1970, 236). Spatial weighting is a process to attribute values to nearness—how far away might cases interact, or does adjacency matter (Anselin et al. 1996; Yu et al. 2018)? In both analysis cities, I use a queen contiguity spatial weighting function that logically suits network-based data buffered into polygons, since it can interact along contiguous areas (e.g., down connected road segments), but does not 'hop' interactions over disconnected street blocks or natural barriers (Anselin 2018a).

The first model run for both cities was a standard ordinary least squares regression using GeoDa (Anselin 2018b), which provides several spatial diagnostics for refining the models. Lagrange statistics of spatial error and lag indicated spatial dependence (Anselin et al. 1996). Lagrange statistics with a p-value less than 0.01 were considered significant, supporting the use of spatial error models for the final regression analysis. The next section describes the results of this analysis, and full GeoDa output results are included in the Appendix.

RESULTS

This section includes both the difference-in-means tests of crash risk by bicycle volume (low and high groups), followed by spatial multiple regression using the same dependent variables in both Portland and Austin.

Crash Risk by Bicycle Volume

Results from Portland show that high-use street segments are safer than low-use streets, but the crowdsourced ratings of street segment were not significant. Table 11 shows results of difference in means tests with analysis of variance performed in GeoDa version 1.8 (Anselin, Syabri, and Kho 2006) between segments with bicycle traffic volumes both higher and lower than the mean, as recorded via Ride Report. Confirming expectation, the higher-volume segments in Portland had a much lower annual crash risk—the average risk of 3.74 crashes per 1,000 crowdsourced bicycle kilometers traveled (BKT) is 24 times less risky than the low-volume streets that averaged 90.16 crashes (df=56,347, F=61.81, p<.001). However, highly-rated segments in Portland posed a greater relative risk (df=24,024, F=95.13, p<.001).

Austin results were similar—street segments with high trip volumes are associated with less crash risk, but crowdsourced street ratings were not significant. Table 11 shows a significant difference between the 6.3 crashes per 1,000 crowdsourced BKT for segments with trip volumes above the mean, versus risk of 59.02 crashes per 100,000 crowdsourced BKT on less-traveled segments (df=16,306, F=46.62, p<.001). However, the average risk for highly-rated segments at 21.58 crashes per 1,000 crowdsourced BKT was only slightly lower than those with below average ratings (df=6,308, F=0.93, p=.334). This finding is consistent with the safety-in-numbers hypothesis (Jacobsen 2003; Elvik and Bjørnskau 2017), that places with more bicycling are also associated with lower crash risk levels, recognizing the limitation of this non-representative crowdsourced sample.

Table 11: Annual crash risk per 1,000 crowdsourced bicycle kilometers traveled by street segments.

	N	M	SD
Portland (OR) trip volumes	56,349	75.33	984.24
High-volume segments AACBKT > mean: 7.29	9670	3.74	14.19
Low-volume segments AACBKT ≤ mean: 7.29	46679	90.16	1080.79
Portland (OR) segment rating	24,026	21.96	196.85
High-rated segments Rating > mean: 0.90	16,116	17.75	57.28
Low-volume segments Rating ≤ mean: 0.90	7,910	11.09	28.70
Austin (TX) trip volumes	16,308	45.26	433.58
High-volume segments AACBKT > mean: 3.78	4,254	6.30	22.78
Low-volume segments AACBKT ≤ mean: 3.78	12,054	59.02	503.43
Austin (TX) segment rating	6,310	23.20	171.10
High-rated segments Rating > mean: 0.88	3,910	21.58	177.29
Low-volume segments Rating ≤ mean: 0.88	2,400	25.86	160.53

Note: Segments rated < 0 excluded as not meeting minimum quantity of ratings.

The difference-in-means test show that the more frequently ridden (tracked with Ride Report) street segments had a lower relative crash rate by segment. However, many contextual issues could be associated with either higher bicycle volume or lower relative risk. The next section describes results from a multivariate analysis of crash risk in both cities.

Multivariate Crash Risk

Multivariate regression was used to evaluate variables associated with crash risk normalized by bicycle volume (annual crashes per 1,000 crowdsourced bicycle kilometers traveled). In addition to the crowdsourced ratings and volumes, I evaluated a total of sixteen variables under the topics of density, diversity, and design, as shown in

Table 12 for Portland (OR) and Table 13 for Austin. Spatial error models were used in both cities since Moran's I tests for spatial dependence showed significant autocorrelation, and robust Lagrange multiplier tests showed significant spatial error.

Portland multivariate spatial error modeling describes more than half of the variation in crash risk (*df* = 23299, AIC = 146486, $R^2 = 0.55$). Results are consistent with difference-in-means tests, showing crowdsourced rating not to be a significant correlate to crash risk, though crowdsourced volume was significant, shown bolded in Table 12. None of the density, nor diversity variables were significantly linked to crash risk in Portland. However, design variables including both levels of traffic stress at the intersection and segments levels were correlated, as was the density of multi-modal streets.

The level of traffic stress variables in Portland conflicted in the direction of their relationships with crash risk. Intersection-measured traffic stress had an unexpected, negative relationship with crash risk. Transforming the logged outcome variable as an expotentiated regression coefficient, exp(-1.86) reveals a one-unit increase in the level of traffic stress (total scale is 1 to 3) is associated with an 84.43% increase in annual crashes per 1,000 crowdsourced bicycle kilometers traveled. However, the segment-measured level of traffic stress showed a strong, positive relationship with crash rate, where increasing segment level of traffic stress by one unit is associated with a 158.57% increase in annual crashes per 1,000 crowdsourced bicycle kilometers traveled. Finally, the density of multimodal streets was associated with crash risk as well, with one additional link per square mile associated with an 82% decrease in crash risk. Among the explanatory variables in this study, street design characteristics have the most robust relationship with crash risk in Portland.

Table 12: Portland (OR) bicycle collision risk spatial error model results.

	Variable	Coefficient	St. Error	Z-value	Probability
	CONSTANT	-20.36	0.99	-20.655	<0.001
	Crowdsourced Rating	0.086	0.375	0.229	0.819
	***Crowdsourced* Volume**	**0.006**	**0.001**	**8.197**	**<0.001**
Density	Employment + Housing Units in SLD	-0.003	0.063	-0.052	0.958
Density	Jobs per Acre	0.001	0.063	0.014	0.988
Density	Zero-Car Households Ratio	-1.197	1.134	-1.056	0.291
Density	Residents per acre	0.012	0.050	0.241	0.810
Diversity	Jobs per Household	<-0.001	<0.001	-0.357	0.721
Diversity	Median Household Income	<-0.001	<-0.001	-1.029	0.303
Diversity	Non-white Ratio	0.077	1.097	0.071	0.944
Diversity	Trip equilibrium of productions and attractions	-0.182	0.474	-0.383	0.702
Design	**Level of traffic stress by intersection**	**-1.865**	**0.590**	**-3.16**	**0.002**
Design	**Level of traffic stress by segment**	**0.947**	**0.101**	**9.419**	**<0.001**
Design	Street network density as auto-oriented intersections per square mile	0.020	0.037	0.540	0.589
Design	Street network density as auto-oriented links per square mile	-0.005	0.060	-0.085	0.932
Design	Street network density as multi-modal intersections having four or more legs per square mile	-0.005	0.008	-0.647	0.517
Design	**Network (multi-modal) links per square mile**	**0.180**	**0.068**	**2.644**	**0.008**
	LAMBDA (autoregressive error in spatial error model)	**0.870**	**0.004**	**200.382**	**<0.001**

Note: p<0.05 in bold.

Multivariate regression using the same methods in Austin revealed different results, with modeled variables explaining less than half of the variation in crash risk (*df* = 6393, AIC = 41221, R^2 = 0.44). Though the crowdsourced volumes were again associated with crash rate, density variables played a stronger role. An increase in one job per acre is associated with a 143% drop in crash rate (annual crashes per 1,000 crowdsourced bicycle kilometers traveled). Peculiarly, the combination of employment and housing density had the opposite effect at almost the same strength. Level of traffic stress increases of one unit, by segment, was positively associated with a 75% increase in crash risk. Similar to Portland, none of the diversity variables were significantly correlated with crash risk. Both density and design play roles in the risk of bicycle crashes in Austin.

Table 13: Austin (TX) bicycle collision risk spatial error model results.

	Variable	Coefficient	Std.Error	z-value	Probability
	CONSTANT	-21.484	1.675	-12.827	<0.001
	***Crowdsourced* Rating**	**-1.971**	**0.975**	**-2.022**	**0.043**
	***Crowdsourced* Volume (AACBKT)**	**0.015**	**0.006**	**2.354**	**0.019**
Density	**Employment + Housing Units in SLD**	**0.413**	**0.135**	**3.067**	**0.002**
Density	**Jobs per Acre**	**-0.427**	**0.144**	**-2.962**	**0.003**
Density	Zero-Car Households Ratio	-1.736	2.434	-0.713	0.476
Density	Residents per acre	-0.083	0.053	-1.557	0.119
Diversity	Median Household Income	<0.000	<0.000	-0.463	0.644
Diversity	Jobs per Household	0.104	0.053	1.963	0.050
Diversity	Non-white Ratio	0.012	0.011	1.063	0.288
Diversity	Trip equilibrium of productions and attractions (1=perfectly balanced)	-1.045	0.914	-1.144	0.253
Design	Level of traffic stress by intersection (1=low stress, 3=high stress)	-0.800	0.886	-0.902	0.367
Design	**Level of traffic stress by segment (1=low stress, 3=high stress)**	**1.746**	**0.191**	**9.145**	**<0.001**
Design	Street network density as auto-oriented intersections per square mile	0.003	0.086	0.037	0.970
Design	Street network density as auto-oriented links per square mile	-0.032	0.161	-0.201	0.841
Design	Street network density as multi-modal intersections having four or more legs per square mile	-0.062	0.033	-1.893	0.058
Design	Network (multi-modal) links per square mile -	0.123	0.155	0.791	0.429
	LAMBDA (autoregressive error in spatial error model)	**0.807**	**0.010**	**76.983**	**<0.001**

Note: $p<0.05$ in bold.

DISCUSSION

This chapter sought to address whether crowdsourced bicycle route quality ratings and volume can predict collisions in Portland (OR) and Austin (TX) and found that bicycle traffic volume was a very strong correlate in both cities, but that crowdsourced route ratings were inconsistent. I tested three hypotheses related to the topic. H_0—Neither crowdsourced bicycle volumes nor street segment ratings, are associated with a change in crash rate by street segment, at a 95% confidence level—was falsified in both cities. H_1—Crowdsourced bicycle volumes are associated with a change in crash rate by street segment, at a 95% confidence level—could not be falsified in either city. H_2—Crowdsourced ratings of street segments are associated with a change in crash rate by street segment, at a 95% confidence level, was falsified in Portland, but not Austin.

The consistent finding of a negative relationship between bicycle volumes and crash rates in both cities may not be generalizable beyond cities different from Portland and Austin. These two cities have strong bicycle infrastructure development programs, technology integration, and bicycling-supportive cultures (City of Austin 2014; City of Portland Oregon 2010; Geller 2009; McLean, Bulkeley, and Crang 2015; Fuentes-Bautista and Inagaki 2012). The type of crowdsourced bicycle volume data may not be useful predictors of safety in cities lacking one or more of these characteristics. Since absolute bicycling volumes and crash statistics are low relative to other travel modes and may take two or more years to accrue adequate samples, crowdsourced bicycle volumes could be a relatively rapid method to assess changes in transportation networks related to safety.

In the two bicycle transportation planning cases of Portland (OR) and Austin (TX), this form of crowdsourced information is both *legitimate* and *transparent*. This chapter shows that the information is legitimate because of its statistical relationship to crash rates. Both difference-in-means tests and multivariate regression showed a significant association of better safety outcomes on higher-traveled streets, as recorded through the Ride Report app in both cities. Planners can use these crowdsourced bicycle volume to support evaluation of priority street projects and to recommend safe routes.

Since the information is available online, at least in a summary map (Ride Report 2018a), it also supports transparency, enabling public use and critique of information that was not previously available. In addition to use by planners, bicycle advocates could use street volume information to show public officials where bicyclists ride (at least those using Ride Report), and thereby accommodate needs in future transportation projects. Conversely, people advocating against the inclusion of bicycle infrastructure can use the transparent information to show where bicycling volumes are unusually low, and then argue that specific accommodations, such as protected bicycle lanes, would not be necessary.

The primary risk of this type of information is consistent with other technology-based informatics: it may exacerbate inequalities (Sui, Goodchild, and Elwood 2013; Marler 2018; Blank, Graham, and Calvino 2018). If the users of the app are higher relative socio-economic status, then the data they produce may point out the needs of their population, while either ignoring or actively degrading lower socio-economic status communities. This logic assumes that bicycle infrastructure might be a net positive for a community, which is indeed not given (Hoffmann 2016; Vreugdenhil and Williams 2013). This topic regarding the geographies of participation, and how inclusion relates to equity, is taken up further in Chapter 5.

Though the primary focus of this chapter was to demonstrate whether crowdsourced bicycle ratings or volumes had potential application for transportation safety, the multivariate analysis also suggests additional important contextual relationships. Using the same modeling techniques in both cities that incorporated the potential for variables to be related to each other simply by their proximity, this chapter shows the importance of design for safety in both cities. Segment-based level of traffic stress, which is highest on high-speed roads with no bicycle lanes, is associated with an increase in crash risk, as calculated in Portland and Austin. However, the intersection-based level of traffic stress was inconsistent between cities and showed a strong counter-effect for safety in Portland. This counter-intuitive finding may be partially explained by differences in driving culture in Portland and Austin regarding yielding at intersections—though researchers demonstrated racial bias in Portland (Goddard, Kahn, and Adkins 2015), and there may be inconsistencies in the street network input to the level of stress calculations.

Limitations and Further Study

The safety-in-numbers finding can only be considered a partial relationship because this chapter did not include motor vehicle volumes as a separate crash risk for bicyclists (Elvik 2013). Elvik's review of safety-in-numbers studies involving bicyclists that risks from other modes should be incorporated as counts (Elvik and Bjørnskau 2017). Though this study calculated relative crash risk as a function of bicycle crashes and crowdsourced bicycle volumes, the inclusion of volumes as an explanatory variable is also partially tautological. Crash counts and volumes for each mode should be separated in further multivariate studies.

Related to the issue of traffic volumes and crashes as count data is the potential for improved results using Poisson modeling, which may provide a more accurate conception of the multivariate relationship between crash frequencies and explanatory variables (Zolnik and Cromley 2008; Siddiqui, Abdel-Aty, and Choi 2012; Chen, Zhou, and Sun 2017). Given the spatial autocorrelation present in the datasets, a method to incorporate the change in relationships due to spatial proximity is needed. Future studies should consider geographically weighted Poisson regression to account for these factors.

The physical and social contexts of Portland and Austin do not characterize many other cities, and so crowdsourced bicycle volumes should be evaluated with safety in other cities. Though this chapter did not show a significant relationship between diversity variables and crash rate, this could be because critical communities were missing as participants. Future studies should incorporate digital inequality measures explicitly, which could involve separate analysis of groups by socio-economic status to measure outcomes or evaluation of specific programs and incentives to affirmatively mitigate inequalities.

CROWDSOURCING SAFETY CONCLUSIONS

This first empirical chapter yields five conclusions regarding the use of crowdsourced information from bicyclists based on these two cases, which may be applicable to similar contexts (US cities with substantial online communities and growing bicycle-oriented infrastructure and communities.

1. Crowdsourced bicycle volumes were significantly associated with crash risk, suggesting this type of information may be critical for rapid safety analysis.
2. Crowdsourced bicycle ratings had no significant relationship with bicycle crash risk, and therefore my not be suitable for the evaluation of crash risk.
3. Both cities show a partial safety-in-numbers effect. Increasing bicycle ridership may improve safety outcomes, though specific causes are not fully known. Plans that seek to increase ridership for goals relating to the environment, traffic, or population health may also have positive safety outcomes as well.
4. This chapter supports previous research suggesting that streets built to support bicycling, as evidenced by a low level of traffic stress, may also improve bicycle ridership and safety outcomes.
5. Further study is needed to evaluate other city contexts, and to improve multivariate modeling through the inclusion of motor vehicle volumes and

regression with count variables using Poisson modeling, while accounting for spatial non-stationarity.

Chapter 5: Participating in a Megaregion

Megaregion planning is an emerging approach, reflecting the geographical convergence of regions in the United States, and the relationship of digital information as the primary commodity in a knowledge-based economy (Innes, Booher, and Di Vittorio 2011; McFarlane 2011; Nelson 2017). Megaregional scale presents three challenges for planners: larger areas are more likely to have information gaps across the geography, planning data are more likely to be formatted and quality-controlled differently in different jurisdictions, and traditional face-to-face public participation meetings are difficult to apply evenly across such a large area. Despite recent studies on possible structures of governance and other impacts related to planning, very little empirical work has been done to consider how public participation could function in a megaregional context. This chapter evaluates crowdsourcing as one potential perspective to support transportation planning at widely varying scales. Bicycle transportation planning in Portland (OR) and Austin (TX), serve as case study material, focusing on the geographic breadth of public participation received at the local level using two types of involvement: face-to-face meetings and an online crowdsourcing platform used in both cities called Ride Report. Ride Report is a crowdsourcing platform that addresses the similar challenge in bicycle planning as traditional methods—seeking to understand where the community is currently able to safely and comfortably bicycle, and where roadways present problems and barriers (Portland Bureau of Transportation 2018b; City of Austin 2018; Austin Transportation Department 2016). This study evaluates evidence from local bicycle transportation planning contexts to determine the challenges and opportunities for crowdsourcing in megaregional planning.

The objective of this chapter is to evaluate crowdsourcing as a method for public participation in transportation planning to scale from local and regional to megaregional contexts, through local planning evidence in Austin, Texas. This chapter includes sections on the background of online participation for megaregional planning, description of the data and methods used, before discussion and conclusions drawn from this case.

GEOGRAPHIES OF PARTICIPATION

Public participation is a well-acknowledged requirement of transportation planning in most democratic societies, and regulations generally require participation in public planning at all levels: local, regional, state, and national (McAndrews and Marcus 2015). No evidence suggests that megaregional planning should be different; we can expect citizens to demand involvement in any public planning process that involves significant resources or impacts (Alexander 2001). Structures of governance and involvement are only beginning at the scale of a megaregion (Innes, Booher, and Di Vittorio 2011; Dewar and Epstein 2007; Ross, Woo, and Wang 2016; Schafran 2013; Evers and de Vries 2013). One study does report that metropolitan planning organizations may offer the flexibility to help address megaregion problems, but "without formal funding or structures, MPOs have limited time and staff to apply to megaregion planning and tend to limit participation to projects or studies with direct and immediate benefits such as interregional rail plans or data access" (Peckett and Lyons 2012). Megaregions, then, could be a particularly challenging context for participatory planning.

Traditional public participation focuses on the use of language to support and direct planning to serve the needs of the community. This approach comes from a background that focuses on the conditions of discourse as meeting communicative ideals (Innes 1995; Hoch 2007) or supports public re-framing of planning challenges and approaches of working together through collaborative processes (Healey 1997; Margerum 2002a). However, co-production between the state and public offers an alternative perspective. Co-productive planning shifts the emphasis from words to actions—the public can be responsible for generating the data necessary for planning decisions, in addition to performing other tasks alongside, or in place of state sponsorship (Watson 2014; Albrechts 2012). However, when digital technology is involved in co-productive processes such as crowdsourcing, the digital divide implies an opportunity for bias that could further disparities by race, education, and income (Clark et al. 2013). Co-productive planning processes may support additional ways for people to guide their future communities, but the integration of technologies must consider the role of distributional biases.

Legitmate public involvement involves pulling people into the planning process—typically involving existing conditions, analysis of challenges, and review of draft concepts—with wide variation across the US (Federal Highway Administration 2018). Therefore, a participatory transportation planning process for megaregions would have to solve challenges of data availability, quality, and communication across an area that currently has no governance structure to support such an effort (Innes, Booher, and Di Vittorio 2011; Curtin 2010). Participatory geographic information systems (PGIS) may offer a way to combine all three of these issues by citizen-produced data, but traditional approaches to PGIS leave open questions of information accuracy and coverage (Brown 2012). Timothy Nyerges identified the need for democratic process combined with objective information about places, presenting "scaling up as a grand challenge" that community-based GIS faces (Timothy Nyerges 2005). Crowdsourcing is an online approach to solving problems with a "deliberate blend of bottom-up, open, creative process with top-down organizational goals" (Brabham 2013). PGIS that includes a specific top-down task that is guided by a platform to consolidate data formatting and accuracy, with bottom-up contributions by people knowledgeable about local conditions, amounts to what could be called a crowdsourced geographic information system (CGIS). This approach may be a match to what Peckett and Lyons identified as a future research problem specific to transportation planning for megaregions: "Uncertainty remains as to how megaregions can best encompass top-down leadership and bottom-up activities and how to transition between informal and formal megaregion activities" (Peckett and Lyons 2012).

Structural Limits and Post-Political Prospects

Current public participation methods for transportation planning tend to reflect, rather than challenge, existing political power structures. A 2018 text, "Transportation Planning and Public Participation," offers an evaluation framework that centers on the perspective of a public agency, rather than fostering change from a participant's point of view (Grossardt and Bailey 2018). Built through many actual transportation involvement cases, their QICE framework (Quality, Inclusion, Clarity, Efficiency) includes dimensions for evaluation reflecting various components of satisfaction, scored through brief survey instruments with participants (Bailey, Grossardt, and Ripy 2015). The performance measures evaluate each dimension both as averages and normalized by expenditure (e.g., cost/participant, cost/satisfaction points). The problem with this approach is that it ends at the participation moment—there is no evaluation of actual changes or improvements implemented by the agency, or consideration of what participation may have been valuable to improve projects. The emphasis on efficiency for the agency, rather than improving actual planning or built outcomes, reflects an orientation favorable to consultants seeking continued contracts, but not participants pushing for structural changes in transportation systems. The orientation towards consulting practice is most enthusiastically shown by their desire to maximize simple metrics with cost as a primary factor, saying "perhaps one day we will be able to 'Value Engineer' public participation processes!" (Grossardt and Bailey 2018, 84). A University of South Florida team developed a much more comprehensive approach, yet its complication may be a barrier for implementation (Kramer et al. 2013). Others use logic models to develop performance metrics for public involvement based on directed choices for analyzing specific decision points in the planning process (Griffin et al. 2018). The logic model conception supports targeted evaluation through a three-tiered process of observation, interaction, and incorporation of public participation (Griffin et al. 2018). Recent work on improving public participation through evaluation still considers work within the existing structures of power—not only following regulations and guidance, and provide limited challenges for political decision-making.

An alternative concept is to consider public involvement from a 'post-political' perspective, which seeks to foreclose "substantive disagreement, or 'dissent,' from established governing areas, especially forms of dissent that challenge existing systems of hegemony" (Radil and Anderson 2019). This suggests that participation systems such as PGIS serve only to legitimize control of existing state actors and business elites (Radil and Anderson 2019). A post-political approach seeks alternatives from participation in existing structures, whether developing learning-action centers through partnerships of scholars and activists (Radil and Anderson 2019), or technical innovation by non-state actors through civic hacking (Schrock 2016). The crowdsourcing platform studied in this dissertation's cases, Ride Report, was initially developed with a 'hacktivist' perspective (Carpenter 2016), but advocacy to date is limited. In an email exchange, Ride Report's Director of Transportation reported "we have some partnerships with advocates in

Atlanta, Bay Area, and Bike Portland where they encourage their members to use the app on behalf of the city. We had some advocates in Bakersfield, Seattle, and Tucson encouraging use of the app independent of a City partnership" (personal communication, Michael Schwartz, May 21, 2018). Opportunities exist for advocates to challenge transportation agencies through crowdsourced information, particularly where an agency has not invested in the data needed to counter an argument. Given the limited counter-hegemonic action and activism in this space, research questions in this chapter center on existing contexts that may offer new approaches and geographies for participation. Rather than countering existing governance for transportation planning, this approach may identify participation for new geographies where existing structures are sparse or weak—such as planning for a megaregion.

Research Questions for Megaregional Planning

Previous research shows legal, regulatory, and logistical challenges of megaregion transportation planning (Dewar and Epstein 2007; Hunn and Loftus-Otway 2018; Griffin and Jiao 2019), but little or no empirical research exists that suggests how public participation could scale to the megaregion, suggesting two research questions:

> What are the geographic differences of spatial representation between face-to-face meetings, and the Ride Report crowdsourcing platform for bicycle transportation planning in Austin, TX, and Portland, OR?
>
> How do biases differ between the categories of involvement?

A previous synthetic review of the literature suggests that future research on participatory spatial technologies must include the actual engagement process, rather than simply examining the technologies themselves (Brown and Kyttä 2014). Therefore, this study contextualizes the analysis of crowdsourcing with an empirical case, using evidence from Austin, Texas, and Portland, Oregon. Considering the LASTR framework of legitimacy, accessibility, social learning, transparency, and representativeness, this chapter emphasizes analysis of accessibility and representativeness through via geography, in addition to legitimacy, mostly through interview results. To address these questions requires a mixed-methods approach, including quantitative data to answer the first question, and qualitative insights for the second.

EVALUATING GEOGRAPHIC SCALE OF PARTICIPATION

The data for participation come from two different public participation processes in Portland (OR) and Austin (TX), each representing different participation purposes. Therefore, comparison of geographies in this study must be considered in the context of each separate planning process—the comparison of different planning processes might be likened to a fruit basket, rather than 'apples-to-apples.' This limitation is a tradeoff that enables an analysis of real, *ex-post* participation within one region, rather than simulated or modeled results that may show little about the way actual participation methods work. Data show actual results in the context of its planning case within each region.

The timing of each planning process spans widespread adoption of smartphone adoption in the US, along with rapid innovation in online platforms for public participation (Lowry 2010; Evans-Cowley and Hollander 2010; Evans-Cowley and Griffin 2012; Afzalan and Muller 2018). To help understand how this change impacted the geographies of public participation, the original concept of this chapter was to include online participation case data as a bridge between the evaluation of in-person engagement and crowdsourcing methods. Requests for online participation data with local and regional planners in Austin resulted in detailed results from an implementation of a public participation geographic information system (PPGIS) in the Austin region.

However, a telephone conversation with the Portland Bureau of Transportation Bicycle Coordinator Roger Geller confirmed that Portland had not conducted public participation for bicycling using comparable online geographic tools (personal communication, August 10, 2018). Therefore, an additional study outside this dissertation focused on geographies of participation in Austin (Griffin and Jiao 2018, 2019), and this chapter focuses on the comparable data of in-person meetings and crowdsourced participation in both cities.

In-person Meetings in Portland (OR) and Austin (TX)

Portland and Austin held in-person meetings as a core form of public participation during the development of their bicycle plans and recorded the locations and dates of each in the documents (City of Portland Oregon 2010; City of Austin 2014). The Portland Bicycle Plan for 2030 included two phases of involvement. The first phase initiated committees, outreach, and recorded existing conditions. The second phase of involvement included detailed planning, including six public open houses in May 2009, for public review of "proposed elements of the draft plan" (City of Portland Oregon 2010, 8). Three hundred eighty-two people signed in at these open houses, with 231 completing a survey at the event. The City of Portland plan's online engagement included a virtual open house open for "three months following the initial open house date" (City of Portland Oregon 2010, H-6). Austin also took a two-round approach to public involvement, centering on seven public meetings held between November 2013 and April 2014 (City of Austin 2014). In addition to the in-person, open house-style meetings, public engagement for the 2014 Austin Bicycle Master Plan also included a telephone survey, an urban trail intercept survey, an online survey, a virtual open house, and discussion at multiple City of Austin boards and commissions meetings (Austin Transportation Department 2014). Though few, the meetings connected interested persons with city staff directly—a rich engagement approach not afforded by online methods. I geocoded the locations of meetings to develop a point-based geodatabase for analysis. Table 1 shows that 144 people participated in the in-person meetings, contributing input on the draft plan concepts before further review by the city's boards and commissions.

Crowdsourced Participation in Portland (OR) and Austin (TX)

Ride Report is a smartphone application used by the Austin Transportation Department that records contributors' bicycle trips, detected automatically using the phone's accelerometer and GPS (City of Austin 2018; Ride Report 2016). The app detects the conclusion of a bicycle trip and prompts users to rate a ride as positive or negative. The platform aggregates multiple overlaid trips by all participants to compute an average rating, in addition to recording the total count of users for each roadway and trail segment. In this way, Ride Report provides planners with information about bicycling in a city as reported by its users. The company provides its clients with a real-time dashboard of statistics and an interactive map of street ratings and volumes recorded with the app. The company provided me full access to the customer platform in Austin including a data dashboard, but only the GIS summary data in Portland. Table 14 shows 123 people per month recorded trips in the Austin region on average, between January 2016 and June 2018. Publicly-accessible web maps for the two cities show that as of November 25, 2018, Ride Report users in Portland recorded 679,545 trips, and those in Austin recorded 126,358 trips (Ride Report 2018a, 2018b). Though the exact proportion of users and trips are not available, I estimate about 600 users per month in Portland, if the proportions between the cities are similar. Table 14 also shows lists the purpose of each form of participation, as described by the cities. Though in-person meetings and crowdsourcing represent very different experiences, the cities report using the feedback in similar ways.

Table 14: Sources of Participation Data

	Dates	Agency	Count of Events	Persons Involved	Purpose of Participation
Open House Meetings	11/12/13-4/2/14	City of Austin	7	144[a]	Receive public input "before the plans were taken to boards and commissions for review" (Austin Transportation Department 2014)
Open House Meetings	5/5/2009-5/18/2009	City of Portland	6	382[b]	"to inform residents about all the elements of the plan, validate the plan's general direction, and collect specific feedback on the proposed network and improvements" (City of Portland Oregon 2010)
Ride Report	1/1/2016-6/30/2018	City of Austin	n/a	123 users/month on average	"help to inform how the City prioritizes investments in the bicycle network" (City of Austin 2018)
Ride Report	1/1/2016-6/30/2018	City of Portland	n/a	Est. 600 users/month on average	"collect feedback…to help PBOT make better bicycle planning decisions" (Portland Bureau of Transportation 2018b)

Notes: [a]City staff report notes "86 participants completed a paper questionnaire and 58 completed the same questions offered in an online survey" at meetings. [b]The Portland Bicycle Plan reports 382 people signed in at the open houses, and 231 respondents completed a survey at the meetings or online.

The first full version of Ride Report launched on the iTunes App Store in mid-January 2016, and the company renamed the app at version 2.1 on Oct 11, 2018 as "Ride" (Knock Software 2018). Developed in Portland, people using an invitation-only beta version of Ride Report reportedly logged over 15,000 trips between April and mid-July 2015 (Andersen 2015). In Austin, the city Transportation Department announced partnering with Ride Report via Twitter on June 21, 2016, which was also broadcast by local advocacy non-profit Bike Austin and others (Bike Austin 2016). After enough trips were logged to provide a detailed online map of bicycling comfort, the Austin Transportation Department and local news media announced the map in November 2016, creating another spike of use (City of Austin Transportation Department 2016; Weber 2016). In 2018, the City of Austin coordinated with a bicycling encouragement company, Love to Ride, to develop social marketing bicycling promotions for Bike to Work Month in May, where people could win prizes by logging bicycle trips with Ride Report (Love to Ride 2018; Movability Austin 2018). Figure 15 shows peaks of users in November 2016 and May 2018.

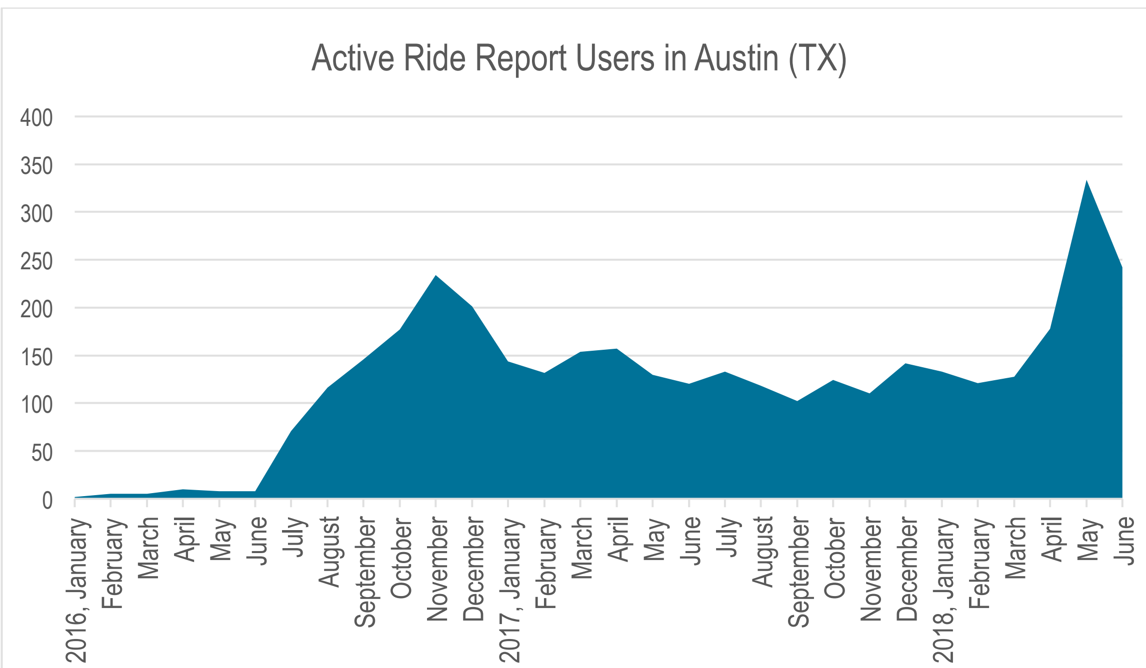

Figure 15: Active users of the Ride Report platform in Austin (TX), January 2016 – June 2018. Comparable data for Portland (OR) was not provided, but total trips recorded in Portland were more than five times greater than in Austin (679,545/126,358) as of November 25, 2018.

As Figure 16 shows, both cities held in-person planning meetings scattered near downtown and in suburban edges as well. Ride report users recorded trips throughout each city, shown in blue.

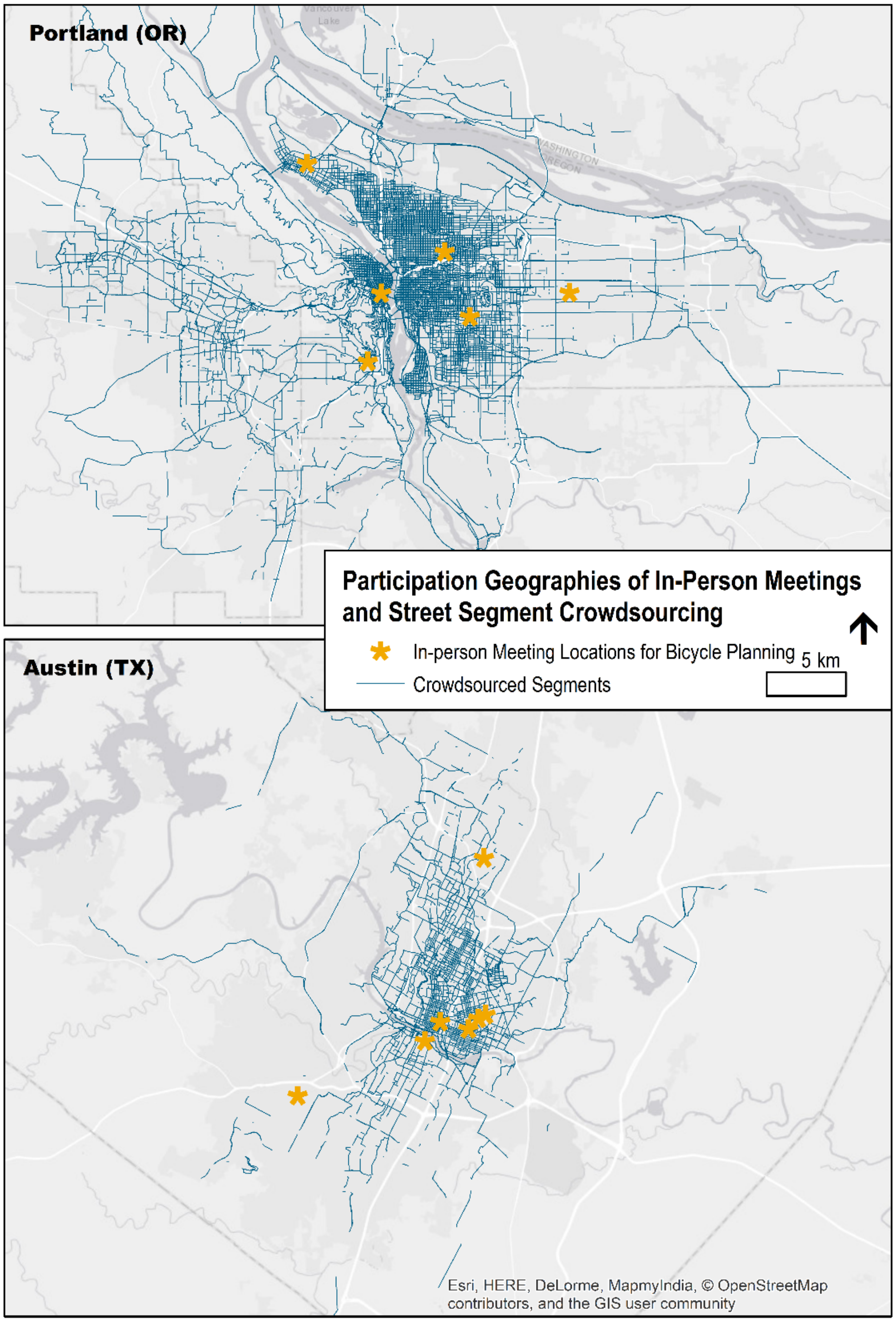

Figure 16: Participation Geographies of In-Person Meetings and Street Segments Rated on Ride Report in Portland (OR) and Austin (TX)

Spatial and Interpretive Methods

The first research question is addressed through case materials gathered from Austin-area bicycle planning staff and crowdsourcing data via Ride Report. City meeting records for recent planning efforts were obtained, identifying geographic locations for the location of participation. I analyzed the in-person and crowdsourced participation methods in terms of spatial extent, using directional distribution ellipses to generalize participation areas (Radil and Jiao 2016; Esri 2017). Finally, I used individual interviews with Portland and Austin bicycle planning staff for two purposes. First, the city planners' insights helped evaluate initial quantitative findings of RQ1, providing member checking as a form of external validation (O'Cathain 2010; Finlay and Bowman 2f016). Second, interviews help describe how planners used the different types of participation and worked through issues of geographic scale.

The second research question builds from analysis of RQ1, comparing the spatial location of the involvement methods with income levels and non-white race percentages by block group within the participation area defined by the directional distribution ellipses. Descriptive statistics and analysis of variance will indicate differences between the participation methods, in terms of the level of distributional bias observed from the case materials. Planner interviews were used as a check against the initial findings, and offer insights as to possible methods to mitigate biases.

GEOGRAPHIC RESULTS OF PARTICIPATION

Geography of Participation in Portland and Austin

The geography of participation via crowdsourcing is 72% larger than in-person meetings, as an average of standard deviational ellipses across both cities, listed in Table 15. Figure 17 shows the second standard deviational ellipse, including 95% of the participation points for each method. By excluding the same percent of spatial outliers, this approach provides a comparable analysis, recognizing that each method was part of a unique planning case for different purposes.

In Portland, the deviational ellipses are similar in northwest-southeast orientation, but the crowdsourced data characterized by the blue ellipse is smaller. Use of the second standard deviation to calculate ellipses allows 5% of the crowdsourced segments outside of the boundary, but the comparably low number of in-person meeting locations are all included within the orange circle.

Table 15 and Figure 17 show the participation geography of the Ride Report platform in Portland is 78% larger than the area for in-person meetings, as calculated through deviational ellipses. Proportions in Austin were similar—the crowdsourcing platform covered 64% more area than the in-person meetings for the Austin Bicycle Plan. Considering both cities together, the area of the in-person meeting ellipses covered 807 square kilometers, and the crowdsourced data covered 72% more area totaling 1390 square kilometers. However, a two-tailed paired *t*-test shows the difference not to be significant (p=0.18). The differences in time and biases for crowdsourced information cannot be ignored for participation, but the platform covers larger geography than where each city held in-person meetings.

Table 15. Geography of Participation through the Standard Deviational Ellipse

	In-person Meetings		**Crowdsourcing via Ride Report**	
	Sq. Km.	**Orientation** (degrees from North)	**Sq. Km.**	**Orientation** (degrees from North)
Portland (OR)	480.6	114.5	855.2	95.5
Austin (TX)	326.4	41.7	534.7	8.8

The directional distribution in Figure 17 shows the ellipses are oriented differently as well. In Portland, in-person meetings are oriented roughly northwesterly to southeasterly (114.5 degrees from North), while the crowdsourced geography was slightly oriented more west to east. Variance in Austin was more distinct, with in-person meetings aligned roughly with the Interstate 35 corridor splitting the city (8.8 degrees from North); while the larger geography of crowdsourcing with a more north-south orientation of Ride Report, likely reflecting the distribution of bicycling in the core area of the region.

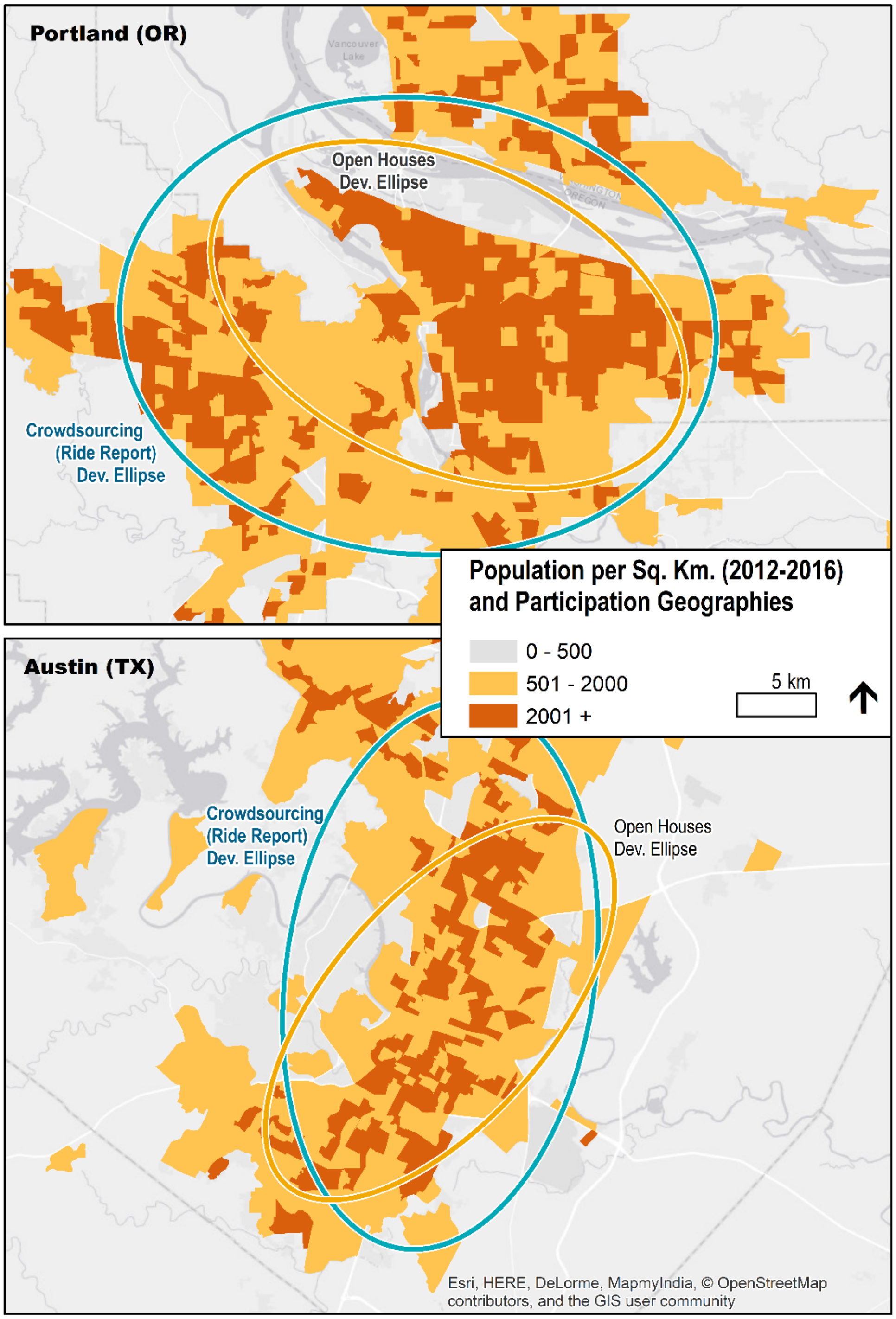

Figure 17: Map of directional distribution of participation ellipses and population density in Portland (OR), and Austin (TX).

Population Geographies of Participation

In Portland, Figure 17 shows that the geographies of the two participation groups—open houses and crowdsourcing—are quite similar. However, the city's open houses for the Portland Bicycle Plan 2030 process could reach a larger total population of 794,239 residents, as defined by the directional ellipse, calculated to the 2nd standard deviation (95% of open houses) using American Community Survey 2012-2016 estimates at the block group level shown in demographics in Table 16. In contrast, the same directional ellipse calculation for the crowdsourced data encompasses a population of 1,290,408, but this difference is not significant through a one-tailed paired t-test (p=0.14). Simple population comparisons say little about equity, however. In addition to the overall population, income and racial comparisons follow.

Table 16: American Community Survey demographics by participation geography

	In-person Meetings[1]			**Crowdsourcing via Ride Report[1]**		
	Population	**% MFI[2]**	**% non-white**	**Population**	**% MFI[2]**	**% non-white**
Portland (OR)	794,239	92.27	20.47	1,290,408	92.80	20.38
Austin (TX)	525,752	77.90	21.81	703,287	83.41	22.00

Notes:
1. All data from American Community Survey 2012-2016 5-Year Estimates (US Census Bureau 2018), calculated to include block groups with their centroid inside each participation methods' 2nd standard deviation directional ellipse.
2. Percent of FY 2016 Median Family Income (MFI) estimates for each metro area (U.S. Department of Housing and Urban Development 2018).

Income Geographies of Participation

Local income levels have implications for equity in participation. Low-income communities may have limited access to participate in urban planning participation opportunities by work schedules, family caretaking needs, lack of transportation, and computer and internet access (Triplett and Johnson 2011; Sanchez and Brenman 2013). Income as an interval-level value, such as a median, is not directly comparable between cities because of differences in relative wages. The 2016 median family income in the Austin-Round Rock metropolitan statistical area is $77,800, whereas in the Portland-Vancouver-Hillsboro region it is $73,300 (U.S. Department of Housing and Urban Development 2018).

Figure 18 shows income levels as a percent of the region's median family income in 2016, where 100% would be equal to the median. The lower income areas between 51-80% of the median are distributed broadly in Portland but cover more area five km east of downtown and north towards Vancouver (WA). In Austin, lower income areas generally lie to the east and southeast of the city. Some of the very low-income areas include high levels of subsidized housing. Austin, again has a distinct east/west income threshold, with exceptions of student housing complexes. Both cities have agricultural areas outside the cities with very low median incomes.

Income comparisons by participation method in Table 16 shows a consistent, but slightly higher income level within the crowdsourced participation ellipse. Variation in Austin was more distinct, with block groups inside the in-person meeting ellipse averaging 77.90% of the region's median family income; while the crowdsourcing area extended into the higher-income suburbs, at an average of 88.41% of MFI. Again, a paired, one-way t-test showed the differences between engagement methods were not significant overall regarding median family income (p=0.22).

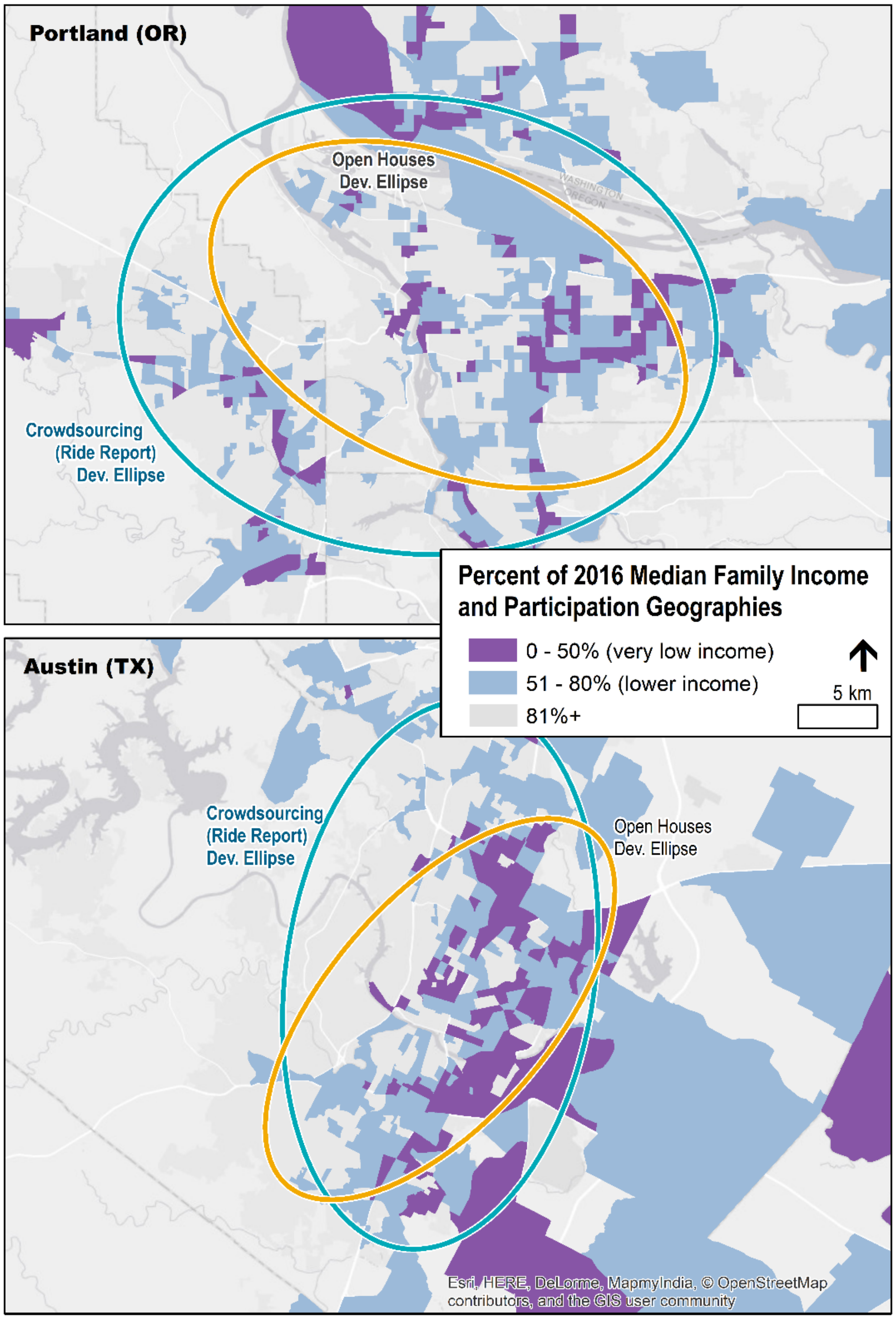

Figure 18: Map of percent 2016 median family income in Portland, OR (median=$73,300) and Austin, TX (median=$77,800) and directional distribution of participation ellipses. Income categories are set at U.S. Department of Housing and Urban Development descriptions (HUD 2018).

Racial Comparison

Using the same methods as population and income, Figure 19 shows the non-white population by block group as a percent of the total population. Portland shows a distinct urban/suburban divide racially, with the downtown and first-ring suburbs generally less than one-quarter non-white. Austin's spatial division by race is mostly east/west, with the downtown area and west mostly white. Both cities have undergone significant gentrification and displacement over the last decade, with negative impacts for transportation access and political power (Lavy, Dascher, and Hagelman 2016; McNeil et al. 2017).

Aligned with the suburban edges in Figure 19, the ellipse of in-person meetings inscribe the northern and eastern limits of the non-white population between a quarter and a half of the total. However, the percent non-white in Table 16 is quite similar between participation methods across the cities. As an average, the non-white population is 21.14% within the in-person participation ellipses, and 21.19% within the crowdsourcing ellipse—again not significant at the 95% confidence level (p=0.39).

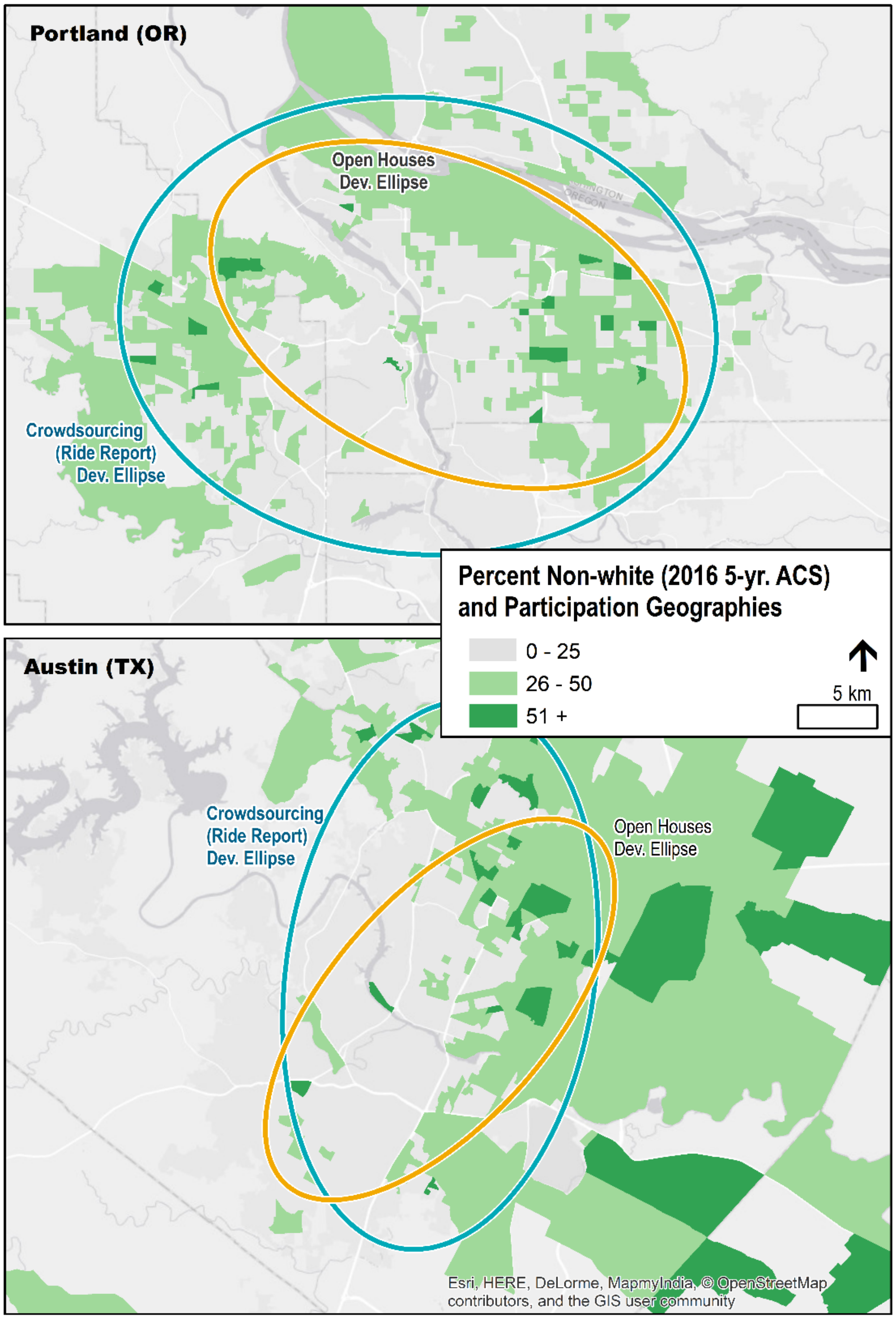

Figure 19: Map of percent non-white race (2016 5-year American Community Survey) and directional distribution of participation ellipses.

Interview Results on Bias and Representation

The second research question in this chapter concerns how biases differ between in-person and crowdsourced public involvement. While the case studies in this chapter showed crowdsourcing coverage of more extensive, but not statistically significant, geographies, simple quantification offers no insights on how the methods work, including issues of bias and representation. Interviews with 33 informants across five groups, including planners or city management, bicyclists, non-bicyclists, app developers and researchers, provide insights on the differences of engagement methods in practice and research from experiences. This section provides selected insights from each group before integrating their insights for conclusions on new directions for participation across megaregions.

Planners/City Management

Planners offer insights on two different ways that crowdsourcing introduces bias and also described how crowdsourcing might be changing participation in our field. However, none of the planners unequivocally considered the changes imposed by crowdsourcing as positive, or at least they cautioned use. One planner suggested that crowdsourcing does not represent the entire population, merely describing that "bias should be assumed until proven otherwise." If this planner offers good counsel for crowdsourcing for planning, what are the issues of bias, and what evidence might show where bias was not an important issue?

The first problem of representation is both practical and economic. "Well, not everybody has a [smartphone] device or even a computer," one planner offered. "Lots of people who bike are lower income, those are very unlikely to have a device." This statement implies that reliance on crowdsourced data is likely to exclude lower-income bicyclists—a major problem for equity. This is not to say that traditional meeting formats serve low-income communities well, or even better than through crowdsourcing, but merely that crowdsourcing may add a structural problem for equity by lack of access to technology. A planner in the Portland region noted the city specifically “has been using Strava and Ride Report for transportation planning,” adding that “most low-income and people of color live in Outer East Portland, but most Strava and Ride Report users live in Inner SE Portland.” Geographies of crowdsourcing participation may exacerbate inequities for transportation planning through (mis)representation in transportation data.

At least one planner sees this issue of representation bias as not necessarily a dead-end. This planner reflects crowdsourcing participants as one potentially-known portion of the population, which when removed from a total population such as through a census, might reveal insights on people missed by a crowdsourcing approach.

> Crowdsourcing platforms only reflect the communities that feed into them, which I can imagine may skew towards various demographics, incomes, backgrounds, etc. In that case taking crowdsourcing as a representative sample instead of a piece of the whole could be very dangerous for underrepresented groups or those with less access. I do believe that may be the case. I'm hopeful that we can use the representative populations in online platforms to learn more about those who aren't present.

Beginning with the knowledge of crowdsourced data as biased, this planner considers the possibility of leveraging known choices about bicycling to infer others.

As previously stated, no planners advocated for replacing in-person or other traditional forms of public engagement with crowdsourcing. Rather, informants suggested representation issues with different types of participation. “Traditional open houses wouldn't be very effective in reaching a broad cross-section of people, so instead we're relying on targeted in-person focus groups, workshops, a sounding board committee, and online interactive open houses.” To improve the representation of participation, planners use combinations of in-person and online methods.

The other aspect of representation in crowdsourcing concerns the fidelity of actions—the extent to which a bicycling trip is accurately logged and included in the complete dataset. A travel survey or log are the traditional analogues for Ride Report's approach to logging trips. Though this app is tailored for bicycle planning, many other devices and software in the Internet of Things (IOT) log actions providing a nuanced detail of actions, such as travel. "It is frustrating to know the level of user data that is out there held by Google for example that we don't have access to as planning professional. If we had the data google has we could much more consciously evaluate, discuss, and shape our cities". Both the volume of users and the ubiquity in a person's life experience, could make passive sensing of crowds more representative than purpose-built crowdsourcing efforts. This is a challenge to the relevancy of platforms such as Ride Report—evidence from Chapter 4 showed that the actively-provided street ratings may not indicate relative safety, but the trip volumes do appear to relay the 'smartness' of bicycle routes as indicated through crash risks. However, there are many other aspects of the fidelity of bicycle trip representations not considered in this study, including the likelihood of route choice by non-users of the platform, different experience levels or demographics, and subjective comfort, to name a few. Reflections from planners do point towards changes in the field through this period of advancement in participatory technologies.

Several planners suggested ways that crowdsourcing impacts the role of participation in the field, with one suggesting "crowdsourcing has fundamentally changed data collection in transportation as it allows people to be active participants. On the other side, planners may be skeptical because of the equity issues, questioning: "is this tool giving us a biased view"? Another perspective could be taken as indicative both as a sea change, and potentially another problem concerning a lack of focused effort on the part of the participant, and therefore perhaps less learning or impact: "Ride report is representative of a change where we get more data passively rather than requiring folks to actively participate in online open houses for example". The more significant issue at hand, as reported by planners, concerns the aggregation of personal data by private interests, then re-packaging it for sale to governments.

> It is a big wake-up call that the motives of for profit corporations (even though their former motto don't be evil and mission to bring together the worlds information) is largely about their own profit interests at this point where I have significant doubts that they would ever release the information transportation planners are interested in because competitors like Uber and many others would also be interested in that same data. The call to action is to create our own platform for the people/cities by the people/cities.

To date, there is no broadly-used, open-access, citizen-directed crowdsourcing application tailored for bicycle transportation planning, but insights from these planners suggest directions for developing new opportunities that could steer this direction. Insights from these planners specifically target the use of public input and objective data for achieving goals related to bicycling, but the next group to hear from are the bicyclists themselves.

Bicycling Public

The bicyclists I interviewed for this study likely are interested in the civic impact of crowdsourcing tools, research in this area, or perhaps merely following social reciprocity after being solicited for the interview. Several of them had insights for the differences between traditional public involvement and the use of crowdsourcing such as through the Ride Report app.

> Using GPS data is tricky. All bikers don't carry GPS, and not all of them know how do upload their data. Also: even using the internet to crowdsource something skews the data to some degree -- it assumes a certain minimum level of technical ability, motivation, etc. Then, of course, there is the possibility of participants gaming the system to skew it in specific directions.

Much of these insights mirror that of the planners, but the indication of "participants gaming the system" shows concern that bicycling peers may be motivated to recruit other users who follow similar paths, or perhaps find other ways to manipulate the data used for planning. This underscores caution with the instrumental use of crowdsourcing data—planners should be able to contextualize the data before applying it to avoid reproducing inequities—whether accidental or nefarious.

Prioritizing places or budgets for improving bicycling, whether in-person or online, conjures the political process, and the role of advocacy groups and individuals.

> Where to begin! hah. Let's first just acknowledge that mainstream bicycle advocacy groups (and mainstream bicycle industry groups as well) are overwhelmingly focused and engaged predominantly with white, middle class folks. There's a lot of historical vestigial reasons for this that we could go on and on and on about. But especially the Strava-type crowd, who are riding bikes for cycling and other sort of long distance fitness type athletic recreational activities, these are also the folks that get way into "quantified self" type stuff (who are, again, typically male, white, and at least middle class).

The role of crowdsourcing in advocacy is not well documented, except perhaps aspirationally (Carpenter 2016), which may in large part be due to the lack of advocacy resources to date, including knowing how to work with the data.

Returning to the problem of spatial representation, this bicyclist reflected much of the equity problems in Portland described by planners.

> Here in Portland, our center city's bike network is super robust and well documented on Strava or Ride Report data, but very little out in east Portland. To me, there's the reality that if you're riding a bike as a luxury lifestyle choice or as something that you're gonna post on Instagram or whatever, quantifying your miles is something you're likely to be proud of and interested in. A significant number of people are riding bikes for reasons of poverty and lack of alternatives - shitty bus schedules, can't afford a car, etc. These are the folks that, I think, are *never* using Ride Report, or at least significantly less frequently than what in popular imagination is considered a "typical bike rider." These are folks that are riding on the shoulders/sidewalks of busy arterials, that might not be able to drive due to a DUI or an issue with citizenship (in Oregon only legal citizens can get a

> driver's license) - in my opinion, these are the folks that all wings of the mainstream bike world - advocacy, retail, are all leaving out.

This bicyclist's critique extends far from the crowdsourcing genre of bicycle planning methods, further into the cultural and governmental structures that mis-balance participation in civic planning efforts, enforcing inequities in the non-profit and commercial sectors as well. From this light, whether planning participation in-person or online might not be as substantive as creating time and space for marginalized or low-income communities to be a part of urban planning decisions—whether through direct payment or other material supports. Another bicyclist suggests there might be ways to confront biased representation, such as through "programming or raffles or whatever to try and target folks from a specific zip code or demographic group to sign up, just to add some different perspectives. The gender gap alone is significant, I think". The gender gap referred to the informant could be that of participation in the crowdsourcing platform, or bicycling at large. Another bicyclist reflected the same perspective, stressing the importance of bicycling overall to support people who may not have a wide range of transportation options.

> Bicycles are phenomenal tools that allow people to hack their urban landscape in all sorts of ways - efforts to establish crowdsourcing software and study the data received from it must be designed as "big tent" and as inclusive as possible to gain maximum benefit and not just perpetuate existing norms of transportation planning that hinder and marginalize communities from the planning process.

These suggestions support future experimentation and practice to improve participation and planning outcomes for under-represented groups. The next section considers the perspectives of people who have some interest in civic crowdsourcing, but may not identify as regular bicyclists.

Non-bicycling Public

People who do not regularly bicycle nonetheless see challenges for equity in participation, which sometimes includes traditional involvement as well as technology issues involved in crowdsourcing.

> As much as one wants broad coverage, you'll probably invariably hit specific income brackets and education levels due to technology used. Also, I'm assuming that people working long hours or struggling with income are not making feedback or input for transportation planning a priority—broad assumption. If I lived in a place that I felt already had excellent transportation options and planning, I probably would not engage, either.

The last point reflects a notion not mentioned by other groups, but is pragmatic, if not obvious—another reason not to participate is overall satisfaction with transportation. Non-participation at any level suggests that results will reflect the population at large, and may over-represent people concerned or upset about a given issue. So, participants could most likely be dominated by those with high socioeconomic status, and who wish to suggest improvements to urban transportation. Another informant stressed the economic disparities associated with technology use, through the example of cellular phone data plans.

> Yeah, I don't think they would. For example, I'm getting kicked off the family phone plan this month and would definitely reconsider using a background app for crowdsourcing data if my monthly allotment is going to 2 GB [gigabytes]. Lots of folks are on those sorts of plans or have never heard of a given app and might not see the cost benefit as worth it if they have.

Even though the crowdsourcing apps can be prevented from using data by turning off a phone's consumption when needed, this is an unreasonable burden for people monitoring their data usage to save money. Despite cities' earlier efforts to democratize internet access through public Wi-Fi (Fuentes-Bautista and Inagaki 2012; Spence et al. 2012), data consumption remains a barrier for equal online participation. One might consider the developers of smartphone applications to be more optimistic. Interviews in the next section show a great deal more nuance.

App Developers

The mix of programmers and app developers I interviewed included only two from the central platform studied, Ride Report. Therefore, responses ranged concerning the representation of communities in crowdsourcing, but this group did convey more technical information that impacts how participants' data impact planning. The first change that a developer offered is the area of engagement; one noted that "the potential of crowdsourcing does allow planners to look at things on a larger geographic scale." Use of the word "potential" recurs, signifying that this ideal may not have been achieved in planning to date, or at least it has not been documented.

The accuracy of actions—in this case bicycling trips—is another source of optimism by developers. Most smartphone applications for logging bicycle trips require an action to start every trip, which means that most regular trips or unusually short journeys—a quick shopping trip, for example—do not get logged through these platforms. The geoparticipation typology would consider this "transactional geoparticipation," as opposed to "passive geoparticipation" that tracks actions without constant intervention by the user (Zhang 2019).

> Passive tracking [not requiring a smartphone action to mark a trip] will never be 100% accurate 100% of the time. However, if we capture 9 out of 10 of your trips and you might forget to push start/stop on 6 out of 10, then we are still capturing a much more robust picture of your travel and routing.

From the perspective of a technologist, crowdsourcing may not differ significantly from previous methods.

> Based on my experiencing working with the good people at the [metropolitan planning organization], I feel like I can say that they have always been

> crowdsourcing. It's just the accuracy and richness of the data that has changed and the speed at which you can gather it. [This localized crowdsourcing app for bicycling] was a glorified survey tool. That's what I always said. We could've followed people on the street and written their route down on paper.

This last suggestion connects the data accuracy and method between techniques in planning—the observational research form and state-of-the-art crowdsourcing platforms, implying improvements in speed and efficiency through digital techniques.

My probe with another developer about future changes in hardware or software that might change crowdsourcing for transportation planning in the near future suggested greater detail in spatial accuracy from these platforms, driven by improvements in smartphone hardware. "New GPS units will start shipping in mobile devices in the next year or two that support a much greater level of accuracy and could be used for things like pedestrian navigation."

In summary, developers suggested several ways in which crowdsourcing technology improves transportation planning—larger geographies, easy engagement for the participant, fast and efficient implementation, and ever-improving accuracy. These perspectives align with much of the "smart city" rhetoric from technology companies (Söderström, Paasche, and Klauser 2014; Anastasiu 2019), but perspectives from researchers offer challenges for improving planning.

Researchers

Informants working in the research community acknowledged the same inequality issues with participation, based on both income and time to participate. The following participant also suggested there may be an age or generational barrier to online participation, which was not mentioned by other interviewees specifically, is indeed suggested through national surveys (Pew Research Center 2018).

> I think it's likely to underrepresent lower income groups. Smartphones are certainly more prevalent than they used to be, but requiring a lot of data suggests that it may have too high of a barrier if you're watching your data usage. Maybe fewer older folks too? [I'm] less sure about that one.

Another researcher engaged in health monitoring through technologies worked with Ride Report to evaluate the app for accuracy against actual exercise. This approach is concerned with the experimenter's regress, the notion that a measurement of a phenomenon can only be considered accurate against the best-known assessment of the phenomenon, in this case bicycling trips (Collins and Pinch 1998). This challenge is recursive, where improvements in a reference measurement change later assessments before creating another cycle of measurement. However, changes in the measuring instrument, Ride Report, continue to alter calculations of physical activity, challenging the use of the app for monitoring health.

> From my side it's a lot about reliability and validity. We need to be confident that the data that are being collected are true, but that's very difficult with proprietary software. Another huge issue is the rate of change for these apps - it seems like Ride Report is tweaking their app, pushing new versions every few weeks. I'm still hoping to do a project of validation with them, but we had to work out how to keep the software the same for my participants throughout the study period. But then when they do change, will the validation still hold? It seems pretty futile.

Other perspectives show signs of progress and new directions for research for participation in urban planning and transportation. Though the platform may change somewhat over time, the global accessibility of it on smartphone app stores make the changes simultaneous, which might not pose a problem in studies of large areas. "Some of these broad scale projects like OSM [Open Street Map], make it easier to make comparisons across cities from a single data source." Instead, the platform provides a single measurement usable across different cities, which this researcher finds to be a substantial opportunity for urban planning.

One researcher who also has experience in planning practice sees similar opportunity but finds the issue is less of a comparison between in-person and online techniques, than a growing need for synergy between the approaches to improve urban planning with bottom-up knowledge.

> It seems how to funnel online complaints to action is a struggle all over. We can get city-wide views of transport issues as long as the medium is deployed at a scale and to a sample that will represent the population fairly. If anything was seen from our recent work on [the other online platform we work with,] the presence of online tools creates a need for more on-ground presence. The biggest risk with this kind of thing is the echo chamber effect where people are not forced to consider alternative visions than their own.
>
> GG: What happened with [that platform] that brings up the "need for more on-ground presence"?
>
> Good question. It's some of what [my collaborator] and I have written and discussed, but what we observed were people using the tool at meetings and making tradeoffs and having discussions with people around them. When we did parallel deployments without the on-ground community-type event, this did not occur and we ended up with more polarized viewpoints.
>
> GG: Oh, so you saw convergence between in-person participants, and divergence or at least more separation of concepts when people contributed online-only?
>
> Yes. And moreover we just observed some of the same issues that have plagued many of our online media tools. People don't go out of their way to experience things that may be different for them, or different ideas or opinions. If anything they gravitate / sort towards like-minded people. This is one of the challenges of online forums and one of the benefits of public meetings. People are forced to listen, even if they choose to ignore it.

Researchers reflected many of the difficulties in participation mentioned by the other groups—whether in-person or online and pointed toward directions to improve the use of crowdsourcing techniques in research. In-person and crowdsourced participation are plagued by biases—both in terms of who participates and the information they provide. A broader view of both the geographies of participation in Portland and Austin and results of interviews suggest ways forward with crowdsourced geographic information.

INTEGRATING QUANTITATIVE AND QUALITATIVE FINDINGS CONCERNING CROWDSOURCED GEOGRAPHIES

Analysis of the geographies of participation across in-person and crowdsourced engagement methods shows a larger overall area of input is possible through online engagement, but evidence from the two case studies did not show the difference was statistically significant, considering population, income, or non-white race of residence. Insights from interviews show varying levels of optimism and suspicion for how crowdsourcing may impact planning as the technologies and practical methods mature. Results show lessons for participation regarding equity, contextualization of results, needed areas of research, and a vision for creating future crowdsourcing systems.

Equity concerns are apparent in both the geographic analysis of in-person and crowdsourced participation and through interviews across social groups. If assumed to be representative or comprehensive, either approach to participation if considered as a sole engagement method can create problems in legitimacy, accessibility, and representativeness. In the worst case, crowdsourcing may further existing inequities through misrepresentation of communities that exist in contemporary planning processes. Interview results showed consistent support for the implementation of multiple participation methods to broaden opportunities for involvement. Developers highlighted efficiencies of crowdsourcing, and potential to scale participation beyond those already involved. If some combination of in-person and online engagement is assumed for significant participatory planning efforts, this may suggest an optimal use of crowdsourcing could be in relatively large planning efforts, such as regional or potentially megaregional contexts. However, evidence from the present cases in Portland

and Austin cannot confirm either significantly broader engagement or if the input is as applicable as other forms of participation, at least beyond the opportunities for safety planning shown in Chapter 4. The specifics of planning contexts may dictate whether crowdsourcing supports or conflicts with the legitimacy, accessibility, and representativeness of engagement. Interviewees cautioned the direct application of crowdsourced data to solve planning problems without consideration of excluded groups or inaccuracies of how the information presents a planning issue, such as traffic volumes and street ratings for bicycling.

Evidence from this chapter suggests future research on the crowdsourced participation for megaregions should include *ex-post* evaluation. I am not currently aware of existing contexts where planners have applied crowdsourcing with a completed plan or on-ground outcomes, but this should be a concern for the next areas of research. Additionally, cases focusing on equity of crowdsourcing in planning are needed. This could include instances of specific recruitment and promotion to improve the representativeness of involvement, and analysis of actual changes implemented through plans involving crowdsourcing.

Scaling crowdsourced public participation from local and regional to megaregional

Crowdsourcing methods may be useful for gathering structured public input over large areas, which are likely to be particularly helpful for megaregion-scale planning. These examples of planning from local and regional transportation planning suggest potential along these lines, but more research is needed to evaluate real impacts over the medium and long term.

None of these seeming advantages and problems should suggest that crowdsourcing tools provide a useful alternative to in-person participation in traditional public meetings. Rather, interviews with planners show an increasing need to find ways to combine a variety of methods in a way that is practical for both broad publics and planners. As the city and region's long-range plans are put into practice, the programming of funding and completion of projects will provide additional data to evaluate the ex-post impacts of crowdsourcing as a public engagement method.

Hacking the System

Recent research on crowdsourcing and interview results suggest visioning of new approaches to improve planning results, potentially through changing the geography of planning and development of participant-focused crowdsourcing platforms. If hegemonic power structures in planning depend on the alignment of capital to influence elected officials, changing the geography of participation through co-productive crowdsourcing (Griffin and Jiao 2018a) might support new alliances and greater transparency across jurisdictions to improve community outcomes. In this way, the geography of participation could be the hack.

One planner suggested problems with the corporate-driven model of crowdsourcing, offering a call to action for people-driven crowdsourcing. Such an approach might leverage global networks of open source development for a platform focused on the needs of people (Kelty 2008). Such a system would likely be dependent on open access to its input data—so it could not rely on contracts with mobile data providers, for instance—but could be directed towards megaregional impact (Curtin 2010). Considering the time and scale involved in such an effort, this chapter does not suggest this approach is anything close to inevitable. A people-driven megaregional crowdsourcing platform for urban planning would be an undertaking requiring extensive input and coordination.

CONCLUSIONS ON MEGAREGIONAL CROWDSOURCING

This chapter deploys case data from planning contexts in Portland (OR) and Austin (TX) in addition to interviews with five relevant social groups to respond to questions concerning the geographic differences of spatial representation between face-to-face meetings, and the Ride Report crowdsourcing platform for bicycle transportation planning, in addition to addressing how biases differ between the categories of involvement. This second empirical chapter yields four conclusions regarding crowdsourced participation for megaregional planning.

1. Geographic analysis results showed that the areas of crowdsourced involvement are larger in both cases, but that differences of population, income, and race did not meet statistical significance.
2. Interviews showed variance in perception about challenges to implementing crowdsourcing for bicycle transportation planning considering legitimacy, accessibility, and representativeness.
3. Crowdsourcing may be implemented to expand participation in planning potentially, but planners are cautioned to contextualize the input and work effectively to address biases for planning results and implementation outcomes.
4. Crowdsourcing approaches do not necessarily increase the geographic impact of participation. Interviewees reported challenges with recruiting and sustaining participation, and case evidence to date shows little execution of public input through these means.

Informants in this chapter described ways in which the fields of crowdsourcing and participatory urban planning co-evolve, and the technology continues to grow and change. Understanding the role of this evolution of technology through the perspective of the relevant social groups is the focus of the following chapter.

Chapter 6 Sociotechnical Representation

"In the beginning, there is no distinction between projects and objects" (Latour 1996). Bruno Latour's insight referenced the beginning of Aramis, an autonomous transit system developed and prototyped outside of Paris, but never came to fruition. The comment applies broadly, however, to any technological project where a project team understands, or at least think they know all of the steps necessary to make a concept real. Through smartphones and wearable computers, there is less distinction between human action and computer action. Few would argue the combination; however forboding as a cyborg vision, is of interest for planning. What if we could answer questions about how people move that could save lives? The technology exists. People willingly use their smartphones as trackers, sharing information with governments and more, supposing that they might contribute helpful information, and maybe learn something more about themselves. Planners use the information, too, even spending large departmental sums to acquire data who's vendors purport all of the benefits but few costs. The American Institute of Certified Planners' Code of Ethics reminds planners of their overall responsibility to the public—serving a "conscientiously attained concept of the public interest that is formulated through continuous and open debate" (AICP 2016). But what role do planners have in guiding the technology or implementation of crowdsourcing—do people even agree with what crowdsourcing is? Is crowdsourced information for planning an object, a thing with real benefit and a lasting prospect? Alternatively, is it just an experiment to try and make transportation better, to save lives—a research and development project?

This chapter traces the development of crowdsourcing for planning as a phenomena—part project, part object—as understood by people in different roles surrounding it. These people, these *relevant social groups* understand a concept like crowdsourcing differently when it is new, and then their descriptions begin to merge, or become *obdurate,* as described by social constructivists of technology (Bijker 1995; Hommels 2005). Social construction of technology (SCOT), an approach in the tradition of science and technology studies, also called science–technology–society (STS), is both an epistemology and a method (Bijker 2009). To understand the interactive construction of technologies and their social groups, the researcher builds knowledge of their understanding and use of the developing technology, often through embedded case studies and histories (Bijker 2009). SCOT is a rebuke to technological determinism, the notion that a new development *causes* society to change in some way, or at least creates an environment that alters the behaviors of groups, however subtle. SCOT researchers consider the technology and its societies as inseparable—more than a market and a producer, the perspectives of all interests influence the developing concept and its reciprocal impacts on society.

Seeing Crowdsourcing as an Ensemble of Technology and Culture

"With a technological project, *interpretations* of the project cannot be separated from the project itself, unless the project has become an object" (Latour 1996). Findings to date suggest that crowdsourcing is far from complete as an artifact, it continues to be re-conceptualized in different applications, leaving interpreters to judge each implementation in terms of what it might be as much as the present evidence shows. Considering crowdsourcing as a technology inseparable from its context, this chapter asks whether the social construction of crowdsourcing influences representation of geographic communities. That is, are there aspects of the evolving nature of crowdsourcing applications that impact the real or perceived representation of communities, and to an extent, potential for social learning in the planning process?

SOCIAL CONSTRUCTION OF TECHNOLOGY METHODS

This chapter uses a Social Construction of Technology (SCOT) approach to trace development and implementation of crowdsourcing for bicycle transportation planning, focused on the representativeness of geographic communities. Qualitative coding of interviews and constant comparison with case materials form the basis for SCOT analysis, following the conception proposed by Bijker (2009b).

The first step involved in SCOT is the deconstruction of an artifact—in this case, crowdsourcing—to assess its interpretive flexibility. Case materials are first used to clearly describe how the artifact is used in practice, using emerging evidence from Portland (OR) and Austin (TX). Then, interview results compare how different relevant social groups frame the artifact of crowdsourcing. Figure 20 shows the groups identified in the proposal for this research.

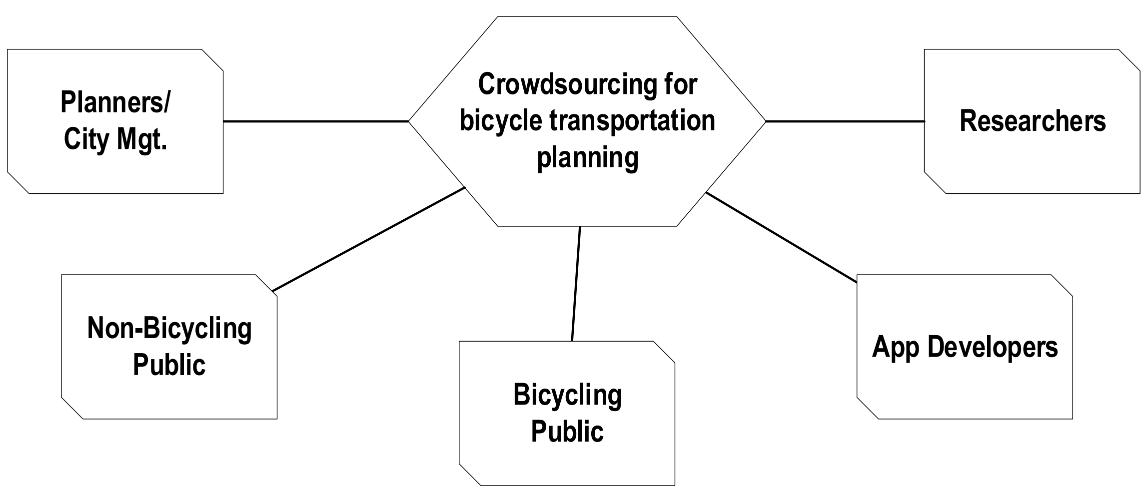

Figure 20: Relevant social groups of crowdsourcing for bicycle transportation planning

Differences between the technological frames of each group demonstrate the interpretive flexibility of crowdsourcing. The more similar their conceptions, the more firm the construct.

Second, constant comparison of the social groups' perspectives with case materials traces the artifact's social construction. As an artifact approaches 'closed-in hardness,' where participants use a technology with such frequency that imagining alternatives becomes difficult, people will perceive crowdsourcing as a strong solution for co-producing knowledge for bicycle transportation planning, rather than an equivocal approach to other techniques (Gidlund 2012; Hommels 2005). If this 'closed-in hardness' increases as crowdsourcing matures, it may exhibit characteristics of 'closing-out obduracy,' in which planners may think of crowdsourcing as a particular approach that cannot be adapted to a set of tasks beyond its commonly-recognized uses.

Third, I explain the social construction process in terms of the technological frames of the relevant social groups. This involves revisiting the results of interview and case materials through the social construction process. I then open these constructivist results through a pragmatic lens regarding how crowdsourcing appears to perform in the ongoing cases vis-à-vis the LASTR participation framework.

Limitations of the Social Construction of Technology Approach

For all of its strengths, the methods aligned with SCOT and its ontology have criticisms, including the definition and treatment of social groups, relativism, the social consequences of technological choice, and external issues of structure and culture (Winner 1993). SCOT's original emphasis on the producers of technological products as the focus of relevant social groups reinforced the marginalization of many social groups, generally excepting white males. By defining the socio-technical evolution of a product through its relevant social groups, researchers exclude the roles and impacts of those excluded from the construction of the artifact (Russell 1986). "As a result, SCOT can be seen as reinforcing racist stereotypes and supporting the constructed inferiority and marginalization of black people by building a program of investigation that obscures black Americans' ability to shape technology products" (Fouché 2006, 646). However, Fouché credited Pinch and Cline's reassessment of SCOT:

> The finer language that defines a relevant social group as a fluid assemblage of individuals who share a common meaning of an artifact opens up interpretive flexibility to acknowledge and consider a multitude of coexisting technological meanings for a variety of social groups and creates an opportunity to study how African Americans, and other marginalized peoples, create their own relevant social groups that decide which technologies work for them and how to use them (Fouché 2006, 646).

This opportunity for interpretive flexibility does not mitigate existing structural racism and other disparities, however (Klein and Kleinman 2002; Fouché 2006). Further, the interpretation of technology is limited to the voices gathered in the research process. Critique of ignorance of irrelevant social groups—such as people impacted by crowdsourced planning—can not be wholly mitigated in this study. Instead, this study reveals, mainly through interviews, some of the social groups suspected by experts to be impacted most. Impacts to these groups—low-income, elder, and women, in addition to structure and culture, should be the focus of the next stage of work on crowdsourcing for planning. Many more interviews and case materials are needed to examine this issue in depth, and particularly in other cases as well. However, this study at least partially addresses the consequences of choosing to crowdsource for planning through examination of case materials and interviews; in addition to some analysis of what integrating crowdsourcing in planning means in the conclusions of this and the final chapter.

Questioning the Smartness of Social Sensing

Some recent research conflates sensed data, big data, and crowdsourced data as part of an algorithmic approach to governance, commonly lumped together as 'smart city' approaches (Kamel Boulos and Al-Shorbaji 2014; Krivý 2016). These critiques are timely, questioning not only the expense of planning approaches driven by corporatized data services but the loss of human guidance on appropriate measures and ethical planning responses (Goodspeed 2015; Kitchin 2013). An empirical study of bicyclists self-tracking for transportation planning in Santiago de Chile, similar in some ways to this study, found "flaws in the GPS, uncertain trips, and playful re-interpretations" that lead to idiotic, rather than smart results (Tironi and Valderrama 2018, 13). The Santiago case had problems specific to their platform and application, but some of the critiques may apply to the use of Ride Report in Portland and Austin, such as the black-boxed algorithms for trips in the software. Further, the authors suggest that the apparent legitimacy of the participatory process was undercut by planners' lack of representative involvement and lack of demonstrated use of the data.

> "…the free labour of data-gathering provided by cyclists, which is supposedly legitimized by the good cause of making Santiago a more bike-friendly city, did not ensure active citizen participation or even real use of the data in urban planning, problematizing the promises of Smart Urbanism that we saw above" (Tironi and Valderrama 2018, 15).

The Santiago case does show that citizen empowerment is far from guaranteed in crowdsourcing. However, to propose that such a crowdsourcing technology causes this type of result in other applications is to reduce complex socio-technical processes to technological determinism (Næss 2016; Bijker 2009b). Viewed through a SCOT perspective, crowdsourcing for bicycle planning remains flexible, and each planning case iteration can improve upon previous efforts to the extent that the practitioners decide (Hommels, Peters, and Bijker 2007).

RESULTING SOCIOTECHNICAL REPRESENTATIONS

Deconstruction of Crowdsourcing for Bicycle Transportation Planning

Case materials in Portland and Austin describe the implementation of crowdsourcing with Ride Report as a pragmatic approach for people to contribute to improving bicycle planning. A Portland news release characterized partnering with the tech company as a "tool [to] help inform the planning and evaluation of bureau bicycle projects and programs" (Portland Bureau of Transportation 2018b). Figure 21 shows a screenshot from the city's news release, promoting use of the platform with a quote from Transportation Director Leah Treat: "I hope more people choose to use this locally-made app to track their bike rides so we can benefit from predictive analytics in shaping future routes" (Portland Bureau of Transportation 2018b).

Figure 21: Screenshot of the Ride Report dashboard for SW Naito Parkway, described as having "helped inform PBOT's Better Naito project evaluation" (Portland Bureau of Transportation 2018b). (Used with permission)

Similarly, the Austin Transportation Department developed a newsletter article to encourage the use of the app, inviting Austin bicyclists to "ping the City as you're biking, to report troublesome street conditions" (Austin Transportation Department 2016). Austin's article framed the platform as "crowdsourced feedback to help us improve biking routes in Austin and make them more 'high-comfort, low-stress' for riders young and old, novice to experienced'" (Austin Transportation Department 2016). Both of the cities' framing of Ride Report borrow concepts from the company's whitepaper (Ride Report 2016) but focus on civic-interested bicyclists to encourage the use of the app.

Planners, through interviews, defined crowdsourcing through the emphasis of online public participation in gathering data for planning. "Crowdsourcing is the act of using the Internet to get a lot of disparate and diverse information/ideas/resources to address a particular issue, generally done in a very public and transparent way" was one encompassing, if optimistic, definition. Others relayed complexities of the approach.

> I think I'd probably answer that in two ways. As an individual I would say that it's using widely based public knowledge and participation to gather information, and from the standpoint of a planner I would say that its using community based information to [provide] data on what may be an otherwise challenging data source, particularly among community groups or variables that don't have established collection methods.

Without specifying technologies, this definition suggested differing perspectives as a participant and as a working professional, emphasizing the role of filling holes for missing data, in addition to the idea of potentially supporting community groups, as opposed to only established planning organizations.

Bicyclists offered a range of responses, including "asking the crowd how to make something work best" and some suggested equivocality, such as "it's either creating data or answering questions by tapping into a large group of possibly anonymous people, usually online.” A bicyclist who had also worked as a community organizer and political consultant drew parallels with advocacy.

> … a lot of these questions about our democratic process are ultimately questions about "whose information, anecdotal data, and perspectives are valid and counted." This is true not only if you're knocking on a bunch of doors to see what the local neighborhood cares about as the top issues of the day but also at a grass tops level, when you're sending out a survey to your peer organizations. I think of crowd sourcing as attempting to harness the wisdom and intellect of a broadly defined group and assess what realm of knowledge currently exists about a specific targeted section of your demography.

Interviewed non-bicyclists offered relatively broad conceptions of crowdsourcing. “I'd loosely define it as a group of people who willingly, and sometimes eagerly, provide information for a common cause.” Another described it as a process of arriving at some defined outcome using input from the public to get there, generally with each person contributing a small amount (data, time, $, etc)”. The financial connection was also made through familiarity with *crowdfunding*, as “greater numbers of people / resources for more ideas, funding, support,” noting “gofundme is a good example…broad reach allows more people to be involved and lessens the burden on any one person."

Not surprisingly, app developers expressed nuance and optimism concerning crowdsourcing. One developer described how their approach to involved both technological and societal changes.

> I think it's a new thing we talk about for two reasons. One is the internet, and two is the rise of mass market consumer internet applications. So whereas in the past ‘crowdsourcing’ would be rare (a massive, well-funded study), now we can have massive data sets that are being generated at almost no cost as a by-product of consumer apps. What we are doing with [our crowdsourcing platform] is sort of in the middle. We've dramatically lowered the cost to collecting data, but the data isn't a by-product – it's the whole point of our business. When the data is purely a by-product, you have all kinds of problems that arise. The quality of the data can be bad (because it wasn't designed around the purpose used), you can have sampling bias, and of course there are massive privacy implications. So our

> approach is trying to leverage the main benefit (decreased costs) while preserving the quality and privacy of a traditional 'crowdsourced' study.

Another developer saw crowdsourcing as “using information passively or actively gathered by multiple people to improve products or services, extending the effectiveness and quality of information through user generated content (active or passive).” The attribute of passive or active data collection suggests a rift in concepts of participation, where developers have access to behavioral information that app users may not knowingly offer, as compared with actively provided information that might closer align with traditional forms of participation requiring purposeful input.

Researchers also addressed the notion of active and passive participation as crowdsourcing. Data might be gathered following the direction of the participant, or “potentially post-hoc style collection - the data is created and then we might use it after the fact for a purpose other than it was originally intended for,” reflecting a passive data collection technique. Researchers referred to issues of privacy and consent, but how crowdsourcing fit into involvement as a research participant was not clear to all of them. “With crowdsourcing I sort of assume that it would be individuals sharing their data, rather than the companies. But I'm not 100% on that." Interviewing a geographer, I referred to volunteered geographic information (VGI) as a related concept (Adams 2013), leading to a concern over the precision of terms which might overlap. “You mentioned VGI, which is interesting because it has ‘volunteering’ in it, but crowdsourcing comes from ‘outsourcing’ to the crowd, so there is some contradiction - it's not a perfect term, but it can be useful.” This distinction also relates to the concept of active or passive participation—researchers do not collectively agree on how to frame participants’ interaction with crowdsourcing platforms.

Tracing the Construction of Crowdsourcing

Planners referred to crowdsourcing in a variety of ways, most simply as "a data collection platform and a way to get people to use it," described by another as "people who are interested in a topic sharing their experiences in a common place." Responding to my question about "the parts that make up a crowdsourcing system," some thought of crowdsourcing as physical items, signified by objects (rather than actions) leading sentences.

> 1) large population of stakeholders, 2) tool for dissemination of information, e.g. an [online] map or survey, 2) entity that can analyze/process information into a useful outcome. 3) means of distributing the call to action or request for information (e.g. social media platforms).

Another response separates components including "a prompt, a semi-structured user interface to receive that input, database to store input…I feel like the keys are user input facilitated by some amount of digital automation". This respondent again distinguishes the issue of passive and active interaction: "crowdsourcing isn't fully passive data collection on the crowd's part, but it's also not manual data entry on the collector's end."

Others separated components according to what they afford planners to do.

> Off the cuff, my sense is you want a primary objective: getting more information from the public to help inform decisions. You want a technology that is easy to use. And you want to have a game plan on the front end on how you are going to evaluate the data. That said, Ride Report has been collecting the data without a specific objective and the volume of trips opens up a lot of possibilities. I would lastly say that a good crowd sourcing process has some plans to deal with bias and the under-representation of some voices.

Bicyclists focused more on the interaction aspect, similar to the last planner. One informant stressed the actions need to gain significant participation volumes.

> I would think you need some sort of marketing angle to grow the crowd, word of mouth or Instagram or whatever to attain a critical mass where the crowd is of a

> large enough size that it is useful in a particular region/function. Some sort of endpoint or phone app is obviously key, and some sort of infrastructure for the analytics or service to be provided/run on.

Non-bicyclists also tended to refer to either physical components of the system or the actions needed to develop an impactful crowdsourcing campaign.

> Hm. I would say the people contributing their information/resources, the information itself if it is something they are recording or creating, the channel/environment through which they are communicating it, the recipient, and some sort of feedback loop so that people see the results of aggregated data.

One non-bicyclist considered both the physical and interactions: "need a selling point to attract people to participate, then a user interface that is easy to use and nice to look at; reasons or new goals to maintain long term interest if that's your goal; reliable software/system because [of] short attention spans. A reason to get engaged, and also, user trust is important".

App developers that provided detailed responses included similar components of crowdsourcing.

> 1) People, 2) A problem area or problem set that needs an answer, 3) Some kind of stakeholder that wants an answer to that problem, 4) A means to corral the opinions of people on how to answer that problem (e.g. an app could be one method), 5) Delivery of the collected data to the stakeholders, and 6) some kind of perceived value or benefit to the people who have an opinion about [the problem] needing an answer.

Another response reflected almost exactly these same categories using slightly different terms, with the addition of a way "to make sense of the data you need some way of aggregating and analyzing it," recognizing a translation role needed for practicing planners to use the data effectively. Importantly, this suggests an issue of complexity, recognizing the number of participants and structures of data involved may exceed traditional planner training.

Researchers, as a group, were less settled in their definitions of the parts of crowdsourcing. One made a distinct separation between the “infrastructure parts”—which I previously referred to as driven by nouns, and the “people and the process”—which I distinguished as action-oriented descriptions. This researcher saw crowdsourcing as involving three phases: first development of the platform, then deployment which would include recruitment and retention of participants, and third “reporting and that is an iterative cycle,” emphasizing a need for feedback outside of the crowdsourcing process to achieve the desired result. Another researcher took an approach bookended by people, enumerating a “crowd that generates the data, a physical sensor that captures the data, a logger that stores the data, and an analyst who tries to make sense of it all.” Each of these definitions across the relevant social groups shares components and characteristics, but enough variance exists that show these groups to see parts of crowdsourcing differently—the concept is still under construction.

Tracing the Problems and Solutions of Crowdsourcing

Considering these and other interview results, in addition to case materials and literature, this section identifies three critical problems with crowdsourcing—inequality, complexity, and low participation—and relationships with potential solutions.

Inequity is an issue stemming from concerns with power through resources of time and money. Interviewees most often mentioned the issue as part of my questioning about how crowdsourcing had changed over time, suggesting it is emerging as a critical problem. The most prevalent concern by far is that low-income or other marginalized groups may be least likely to participate, leading to exacerbate existing inequalities in transportation service provision. “Higher income people tend to have more time to be engaged on these topics.” The City of Portland is experimenting with new ways to reach out to east Portland communities through incentivized recruitment, but have not yet completed the work to enable evaluation of results. Others are applying sample weighting techniques from traditional survey methodologies to scale up under-represented groups (Turner et al. 2018). One informant described a problem that crowdsourcing could be used to counter public interests or input through other means, suggesting the platform's data might provide evidence to support the status quo. In this case, planners should contextualize both the input and the argument in a more extensive evaluation framework, without automatically trusting processes driven by planning agencies or their directing governments. Figure 22 summarizes these three approaches to dealing with the problem of inequity in crowdsourcing.

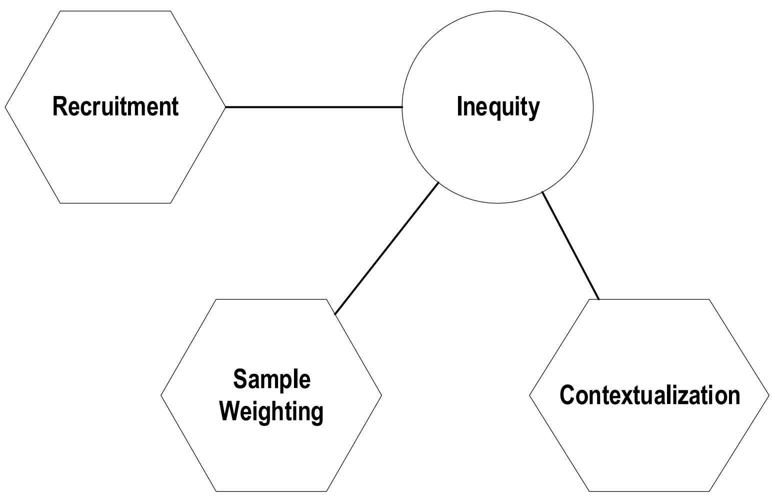

Figure 22: Inequity as a problem for crowdsourcing

Complexity is another issue with crowdsourcing, which planners, app developers, and researchers work through in several ways. Crowdsourcing adds new tasks and timelines to a planning process, and the transparency of the process can show problems such as a lack of participation or errors in data. In most public participation processes, these issues build on top of existing engagement requirements to add complexity, rather than solving problems for planners. In response, app developers such as Ride Report have developed dashboards in an attempt to offer a simple, quick interface to query crowdsourced data. Most include temporal filters by date or time of day, built on a mapping platform to offer reasonably complete control over the visualization of the data. Researchers, including college professors, also have a role in training planners with techniques that help address the added complexity. GIS and statistical software techniques support processing the data, in addition to qualitative analysis and data mining methods can help work with large text corpora from crowdsourcing projects. Further, project management tools such as work breakdown structures and communication strategies may be needed to deal with workflow impacts from integrating crowdsourcing into planning processes. Figure 23 uses the same approach as the previous diagram to connect solutions to the problem of complexity in crowdsourcing.

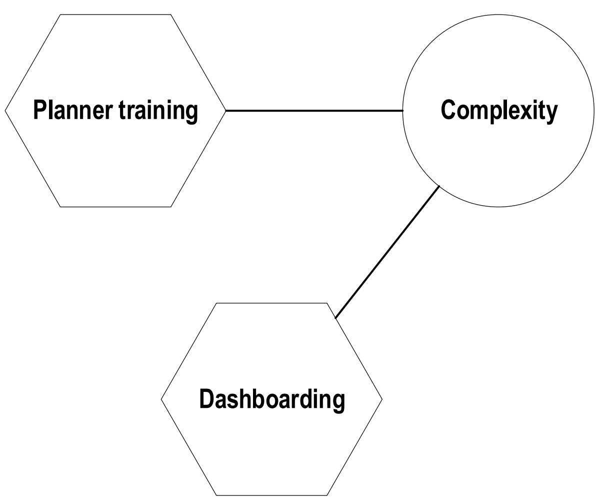

Figure 23: Complexity as a problem for crowdsourcing

Low participation was also a consistent issue mentioned in crowdsourcing—the word itself implying a requirement for broad involvement. The most obvious solution is recruitment, which could involve either targeted messaging or the use of incentives (Griffin 2019; Ferster et al. 2017). Contextualization offers another approach, in which planners consider participation levels with the perspective of issues that may help explain differences in use, such as densities of population or bicycle infrastructure (Conrow et al. 2018; Griffin and Jiao 2015a), in addition to cultural interest and communication (Smith and Treem 2017). A third approach is to choose platforms that already have high existing use, even if another platform might more directly address the needed planning challenge. For instance, use of the Strava platform is widespread in Texas, enabling analysis of bicycle trip volumes where Ride Report has not been introduced (Turner et al. 2018). This option may become more practical with the development of additional crowdsourcing platforms or with future data products from apps employing passive sensing of activities, such as the Apple Health app.

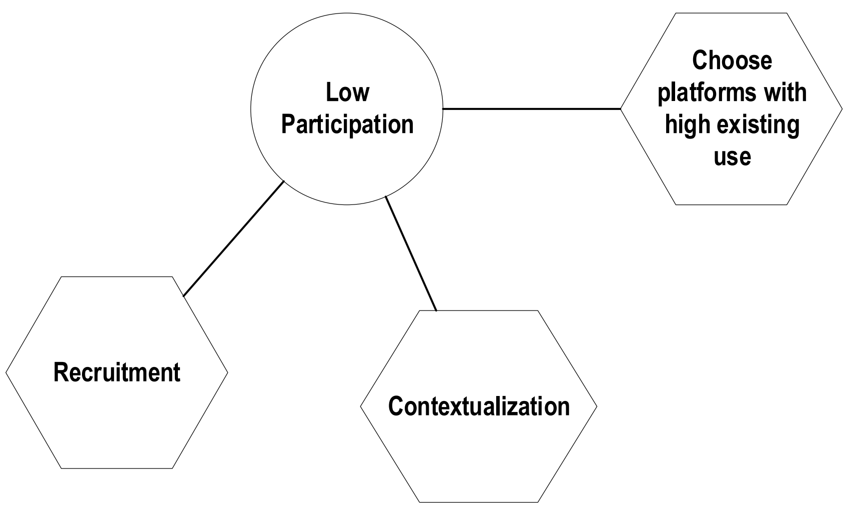

Figure 24: Low participation as a problem for crowdsourcing

Combined with the relevant social groups, each of these problems and their concomitant solutions interlink to show key areas of development in crowdsourcing for bicycle transportation planning. Figure 25 shows their connections between shared problems, such as planners struggling with inequity and complexity, and contextualization as a possible solution for both inequity and low participation.

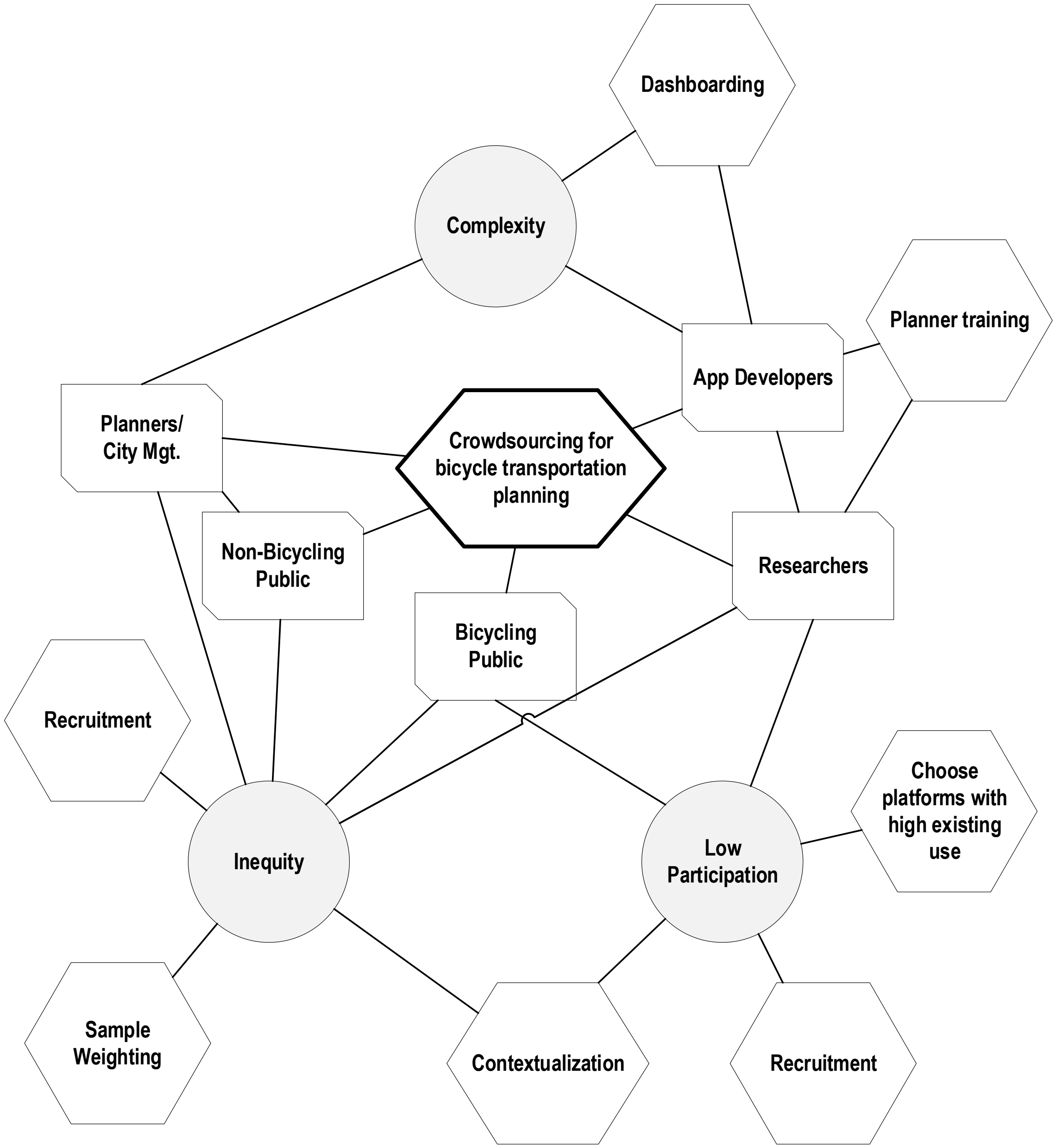

Figure 25: Evolution of problems in crowdsourcing (circles) through relevant social groups (rectangles) and solutions (hexagons), adapted from Bijker 1995.

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Technological Frames of Relevant Social Groups

Case materials and interviews show overlap and differences in how the relevant social groups understand crowdsourcing as a technology for bicycle transportation planning. To further describe differences between groups, I use case materials and interview responses to a question regarding how crowdsourcing has influenced the transportation planning process.

Planners/City Management

The City of Austin promotes the use of Ride Report to crowdsource information about bicycle routes. They publicize the benefits for the city as providing information about bicycling from the public and suggesting its use for prioritizing projects. “The City is gaining the first-ever view of Austin’s biking network that shows where people are biking, and their reported level of stress (both streets and trails),” notes the city’s website (City of Austin 2018). To explain how the information will be used, the site describes “Ride Report feedback will help to inform how the City prioritizes investments in the bicycle network – every “not great” rating tells the City where dollars may be needed, and best spent” (City of Austin 2018). The city’s aspirational language is not yet supported by planning outcomes, however. A planner responded that “the influence is probably just beginning to really take hold in the government sector,” adding that “I think you’ll see outcomes for specific projects where the technology has been leveraged.” Another planner went further, stating “I think that it's seen as a cool new engagement tool. But I don't think it has really reached maturity and formalization in the formal process”. Perhaps a practical approach forward is for planners to cross between the disciplines of planning and app development.

> When I think deeply about Ride Report, as a bicycle and mobility planning professional it seriously makes me want to be a planner working to embed

> planning needs, thinking, analytics into these types of platforms. There is an amazing amount of potential to marry very rich, nearly real time data, with best practice planning practices to drive real world results.

One interviewee described a case outside of the Ride Report applications, where "crowdsourcing has already changed planning." The District of Saanich, in British Columbia, crowdsources bicycling incidents through a partnership with University of Victoria researchers' BikeMaps.org platform (DeRosa 2017). "It does allow cities to be more proactive in how we look at problem areas," said Harley Machielse, Saanich's director of engineering. "Instead of being reactionary, which is a traditional method in looking at ICBC [Insurance Corporation of British Columbia] crash data, this type of information allows us to be on the proactive side" (DeRosa 2017).

Bicyclists suggested opportunities for advancement, but a sense that planning as a field has not yet benefitted from crowdsourcing.

> My gut feeling is that crowdsourcing has had more of an influence on transportation in recent history and will continue to trend upwards. And I think it is limited by what we discussed before: exposure, trust, and technology. On the technology point, I think we're only now getting to a place where people who are passionate about this stuff are also people that can build a platform for it. Technologists are breaking away from tech companies and tackling civic problems. I think we'll see more of that. I hope we do.

Part of the implication in this response is that planners do not necessarily have the skillset to develop crowdsourcing platforms to address their needs directly, but that technologists are gaining interest in applications that give back to real communities.

Non-Bicyclists mentioned a range of considerations as to how crowdsourcing impacts planning. Optimistically, one informant described crowdsourcing as offering a "broader reach" which "probably allows more integration across cities and regions and better statewide planning." Another reflected an "impression that it is something that is really hard to do right but that people want to do it even if they don't know how the info they collect will fit in to the planning process, which is still very political." The more pessimistic perspective was that "a tool like this can be used by a planner or politician to say that current infrastructure is sufficient." Non-bicyclists share an understanding that the information is part of a more extensive process of information gathering and decision-making, but the framing of crowdsourcing's impact offers little consensus.

App Developers, who might have the most invested in the concept of crowdsourcing as a tool for planning, appear to concede nonetheless that the approach has not solidified for the field. "I think we are still in the early days of this," offered one developer, who stressed the use of crowdsourcing during outreach as "a great way to both educate and engage ether public so they can more easily be participants in data collection." Though not mentioned by many, this perspective on social learning through crowdsourcing suggests the potential for evaluating more direct outcomes on learning or longer-term engagement. This fundamentally conforms to another developer who does not "think cities are using it effectively in planning. Yet". To this programmer, planners are not yet trained to know how to integrate crowdsourcing in their processes, in order to be impactful. Only one project showed results from using the data in a publicized case, as of this writing. Portland planners used Ride Report to show the impacts of a seasonally-implemented protected bike lane, called the Better Naito project between the city's downtown and the Willamette River (Portland Bureau of Transportation 2018a).

Researchers see more potential than practice, to date, as well. One researcher claimed a pessimistic stance, seeing "decision-making in most cases ultimately coming down to politics." However, the same researcher noted application in Seattle (WA), where Strava data was used to estimate "safety performance functions, ultimately suing the results in their prioritization process." Considered more broadly, some researchers relayed cases beyond bicycle trip trackers that crowdsourced input for planning, ultimately opening up questions about transportation planning that may not be addressable with traditional data.

> I think we can ask new questions about more specific issues people have with transport - a crowdsourcing effort in Phoenix comes to mind where an interest group used Open Street Map to generate a map of where people were having specific barriers to biking. I think to get a city-wide view of those barriers would be very difficult through conventional mediums and would be a daunting or impossible task for something like a charrette but it was very simple to go online and set a marker and describe a problem you had with that area.

SOCIOTECHNICAL CONCLUSIONS

Following a review of the reasons and methods for tracing developments such as crowdsourcing through SCOT and its limitations, this concluding section returns to the original question of this chapter. Do implementations of crowdsourcing for planning tend to reflect the publics of interest, or just the interested publics? Put another way, does the social construction of crowdsourcing influence the representativeness of geographic communities? Further, how might the applications impact the real or perceived representation of communities and potential for social learning in the planning process? This chapter used a review of case materials and interviews with five relevant social groups to respond to these questions.

1. Crowdsourcing can lead to biased representation or mislead planners in a way that counters efforts to improve equity. However, results suggest the technology itself is not to blame for this risk, but that planners and technologists have a responsibility to develop participation methods that improve conditions for current and future generations. Specifically, the AICP Code of Ethics charges planners with "seek[ing] social justice by working to expand choice and opportunity for all persons, recognizing a special

responsibility to plan for the needs of the disadvantaged and to promote racial and economic integration" (AICP 2016).

2. The social construction of technology (SCOT) approach to gain an understanding of an ongoing and evolving technology shows that crowdsourcing has not approached "closed-out hardness" by any relevant social group—the approach and artifact remain flexibly interpreted. This means that the initial applications of crowdsourcing in bicycle transportation planning are closer to applied experiments than practice cases. Performed a few years earlier or in the future, one might expect very different results. Rather than support or dismiss crowdsourcing as an approach in terms of (mis)representation or other metrics, researchers and planners should work to identify the case conditions in which the method might improve equitable and sustainable outcomes to improve quality of life in future communities.
3. Evaluating representation in crowdsourcing is a moving target, rather than a definitive hit or miss, through this dissertation's LASTR framework. Though Chapter 5 showed some consistency in the geographies of participation between the two case cities, more in-depth analysis of experiences in crowdsourcing demonstrate that other cities could certainly have different experiences. However, this chapter showed no evidence suggesting the technology intrinsically excludes populations, but cities and planners have responsibility for addressing problems of inequality, complexity, and low participation, and they can use this research as a guide.
4. Social learning is possible through crowdsourcing, as shown through interview evidence. Informants reported social learning directly, but fostering extensive knowledge about a planning process online may also recruit new

participants, and potentially encourage them to ask questions using data developed by their peers.

Crowdsourcing continues to evolve through the actions of planners, developers, and communities, and the concept can still be considered an amalgamation of projects and objects—flexibly interpreted with opportunities to improve planning. The final chapter of this dissertation returns to the opportunities and limits of co-producing information for planning.

Chapter 7: Conclusions

This dissertation builds understanding for theory and practice of crowdsourcing for urban planning through cases in Portland (OR), and Austin (TX) focused on bicycle transportation. Through literature review, quantitative, mixed, and qualitative methods, this study shows how crowdsourcing includes both prospects and problems as a co-productive form of participation in planning. This chapter offers a brief review of findings in this study to summarize results in a way to support future theory-building and practice. After a quick overview of findings through the LASTR framework, this chapter reviews opportunities and limitations for co-production, the obduracy of crowdsourcing as a sociotechnical ensemble, and then specifies overall contributions to urban planning.

This study advances a new framework for evaluating participation in planning for a digital age, including legitimacy, accessibility, social learning, transparency, and representativeness. Taken together, the LASTR window is a metaphor and a practice—an approach to consider both the immediate impacts of the work of planners and publics, in addition to a reference for considering the implementation of a plan through medium and long-term impact. An approach can be considered legitimate if planners show the public how their input will be used, and follow through their words. Accessibility is concerned not only with the geography of participation, but whether people can digitally or physically engage with the process. Social learning represents encouragement of participants to gain knowledge likely to be useful beyond the present issue at hand, under the notion that people's time should be respected as individuals, and as conduits for others in their homes and communities to build continuous and impactful engagement. A transparent process offers insight on both immediate use of information for decision-making, in addition to feedback and reporting how participants impact the implementation of projects over time. Digital access is a cornerstone for transparency in a contemporary civic context. Representativeness refers to the relative match between people involved in the process and the communities that stand to be impacted by a planning process in the present and future.

IMPLEMENTING THE LASTR EVALUATION WINDOW FOR PUBLIC PARTICIPATION

The window of legitimacy, accessibility, social learning, transparency, and representation is a rubric for evaluating co-productive participation in planning. Recognizing that few studies show the comprehensive evaluation of participation influences and outputs, this framework can be used to guide evaluation within the resources and scope available for a given project. Though this dissertation shows diverse methods to evaluate co-productive planning, most transportation agencies are likely limited by time and know-how for timely evaluation of projects. Either the depth of analysis or the breadth of LASTR components may be changed to suit a given planning context.

As a hypothetical, but a plausible example, consider a medium-sized metropolitan planning organization (MPO) responsible for developing a comprehensive, cooperative, and continuing planning process for a region. The MPO might invite the public to contribute by using a smartphone platform that integrates data on participants' bicycling trips with their comments on desired improvements, for example. To provide ongoing evaluation of the process before fully integrating results, the MPO could survey participants using the LASTR framework as a guide for developing questions. Legitimacy might be assessed through questions related to a perceived likelihood of implementing public suggestions, or a Likert-scale (disagree—agree) response to perceived legitimacy, perhaps including participants' previous participatory transportation planning experiences. Accessibility questions could target ease-of-use regarding the app, including concerns of potentially using participants' smartphone data plans. Social learning questions might include both factual questions to test knowledge, in addition to subjective elements that allow self-reporting of new knowledge gained through using the platform. Transparency could be evaluated by asking whether participants could view new information used in plan development through the process. Representation questions could include demographic and geographic information, in addition to open-ended questions about how to pull in other communities to participate. The survey could be as brief as five or ten questions and include only a sample of all participants, or researchers could be involved to improve the analysis and robustness. A brief report targeted toward agency decision-makers could help frame the real and perceived quality of the co-produced information to inform planning decisions, in addition to serving as a reference for continuous improvement of participatory planning. This hypothetical is only one plausible approach to applying the LASTR framework for evaluating co-productive planning, and future researchers could develop more robust approaches to evaluate new developments in crowdsourcing, machine learning, or human-centered participation outputs and outcomes—the next section re-centers on the findings of this dissertation for practice and later research.

SUMMARY OF FINDINGS

Through analysis of literature, two case studies of crowdsourcing for bicycle planning, and 33 interviews, this dissertation contributes findings regarding co-productive planning theory, planning for bicycle safety, geographies of participation to inform megaregional planning, and the social construction of crowdsourcing. This section re-summarizes each of the main findings through the LASTR framework.

Legitimacy Findings

Safety exploration in the fourth chapter showed that bicycle volumes crowdsourced through the Ride Report platform were significantly associated with crash risk, strengthening its potential role as a legitimate approach to transportation planning. This finding could be related to a civic-orientation and a high level of bicycling skill of its users in the case study sites, which may not generalize to different contexts. Conversely, the crowdsourced route comfort ratings had no significant relationship with bicycle crash risk. The association of crowdsourced bicycle volume with safety risk partially supports the safety-in-numbers hypothesis (Elvik and Bjørnskau 2017). The crowdsourced bicycle volume data may not adequately represent the bicycling population, and therefore, the actual risk of any person bicycling on a given segment.

Megaregion-scale participation poses a challenge for planning, and the third chapter of this dissertation analyzed findings concerning the geographies of participation for both crowdsourcing cases. Analysis of the spatial extent of in-person meetings and crowdsourced contributions showed that the areas of crowdsourced involvement were spatially more extensive in both cases, which may support the legitimacy of megaregional planning efforts. However, this study did not evaluate the impact of crowdsourcing on actual outcomes, which must be assessed following completion of projects. Further, equity measures involving population, income, and race did not meet statistical significance, suggesting the geographies of participation via crowdsourcing may not necessarily introduce sociodemographic equities, at least viewed through associating the location of participation and households.

Accessibility Findings

Accessibility, as presented in this dissertation, involved the ability of the public to participate based on location, time, and skills related to language and technology. This study only focused on the locational aspect, finding that crowdsourcing approaches do not necessarily increase the geographic impact of participation, but such online approaches may nonetheless expand access to the process. Beyond the spatial analysis, interviewees reported challenges with recruiting and sustaining participation in crowdsourcing efforts, and case evidence to date shows little impact in terms of plans changed through this crowdsourced information to date. However, interviews also suggest that the practice of crowdsourcing for bicycle transportation planning is still evolving. Beyond locational access, further research should integrate aspects of time, language, and technical skills.

Social Learning Findings

This study defined social learning as the gaining or sharing of knowledge or skills between participants in a planning process. Conceptually, crowdsourcing breaks down complexity of planning processes into a set of tasks that members of the public can complete with little or no direct involvement by planners, providing an experience that could support learning through doing. Further, interview informants reported learning about transportation issues through participation in crowdsourcing. Social learning was not directly related to the core research questions of this study, but constitutes an important area for further research on participation with crowdsourcing, and a useful outcome for planning in practice.

Transparency Findings

Transparency, as defined in Chapter 1, deals with the ability of people outside an organizational process to be able to find and answer questions about how planning decisions are made. The online map resulting from use of the Ride Report platform shown in Figure 3 supports real-time visualization of crowdsourcing. This study also suggests that transparency can show problems in a planning process, such as a lack of participation or errors in data. In this way, transparency may be a strong contributor to legitimacy—a positive reinforcement between aspects of this evaluation framework. Similar to social learning, this dissertation provides opportunities for further research on the aspect of transparency in public planning. As suggested in the section in Chapter 5 on Hacking the System, and supported by interview data, current proprietary platforms offer limited transparency to how public input translates to crowdsourced information on the platform. Development of fully open platforms could support additional transparency in the future, but no such platform exists at present to fully address the issues in this study. In truthfulness, the notion of transparency should be considered only as a gradient of opacity—so *translucency* might be a more appropriate term for evaluating online participation.

Representation Findings

A sociotechnical analysis of interviews in the sixth chapter yielded three major findings regarding representation. First, the study confirmed that crowdsourcing can lead to biased representation, or can mislead planners in a way that counters efforts to improve equity. Researchers are, at the time of this writing, beginning to address biases of representation in crowdsourced data by adjusting travel volume estimates with actual counts (Dadashova et al. 2018). However, each crowdsourced data source and implementation context may require different adjustments, which may or may not prove practical. Hence, planners must continue to work with crowdsourced data suspiciously—and to design approaches to avoid or mitigate representation biases where possible. Second, the Social Construction of Technology (SCOT) approach shows that crowdsourcing as a concept or technology remains flexible, as shown by interviews with the five relevant social groups in this study—planners/city management, app developers, researchers, bicycling public, and non-bicycling public. Therefore, research and practice on this topic soon may yield different results, and the combined interpretations could show an evolution of how crowdsourcing is constructed over time. A related issue is that crowdsourcing's representation of communities is not static, but should be seen as a moving target. This dissertation showed some consistency in the geographies of participation between the two case cities, but other analyses of crowdsourcing suggest that other cities could undoubtedly have different experiences.

CO-PRODUCTIVE OPPORTUNITIES

Crowdsourcing has much to offer in terms of the LASTR framework. In many ways, the components support each other. For instance, the transparency of Ride Report's public online map shows that their participation makes a difference, at least in terms of the data going into a process. When cities describe clearly how input will be used in planning, this adds to the legitimacy of the approach. Resulting data also shows where communities were not involved, suggesting how representativeness can be improved. Depending on the level of engagement of participants and planners, social learning may occur, and the data collection role in the present case studies form a logical basis for beginning the education of participants. There are many reasons to be enthusiastic about the prospects of crowdsourcing in planning, and this dissertation shows only two implementations of a worldwide phenomenon.

CO-PRODUCTIVE LIMITATIONS

However, crowdsourcing still is held back by many of the same structural forces plaguing involvement. Technology does not by itself create new opportunities, nor connections between power structures and the people affected by them. Taken at its worst, people seeking to make a positive difference may be unwittingly providing private information that could be used against their interests. Such a case would be worse than tokenism on Arnstein's ladder (Arnstein 1969), but it might not necessarily raise red flags for unwitting co-producers of the crowdsourcing opportunity.

THE OBDURACY OF CROWDSOURCING PUBLIC PARTICIPATION

This study shows that crowdsourcing is quite flexibly interpreted between different relevant social groups. Interviews, in particular, with 33 people from five different backgrounds or associations showed divergence in the construct of crowdsourcing not only between groups but within groups. This lack of obduracy of crowdsourcing in planning contexts leaves space for change—not necessarily for the better—but rather showing that planners need to engage with technologists and others to guide the use of technology to advance social good.

CONTRIBUTIONS TO PLANNING THEORY, EDUCATION, AND PRACTICE

This dissertation extended approaches from SCOT to the incorporation of digital technologies in urban planning. This constructivist, embedded, and pragmatic approach not only further connected urban planning to science and technology studies but also showed the value of combined ontologies. Planners are faced with the dual realities of a socially-constructed practice field, in addition to the expectations of managers, elected officials, and the public at large to have a substantive impact from their work. In this way, planners have to balance between the pressure to show on-ground results in the context of socially-constructed truths—many realities and interpretations lie beyond the control of a planning team.

Instructors can improve urban planning pedagogy concerning urban informatics, addressing digital biases, and use of mixed-methods to align with real-world practice.

Educators can guide planners-in-training not to accept a lack of data for addressing vexxing problems. As shown in this dissertation, planners can crowdsource missing information such as bicycle route volumes, and I encourage educators to explore new ways of sensing urban contexts and co-producing knowledge. Identifying biases is not the primary goal of this study, but sufficient evidence exists from previous works and this study's interview results to determine that addressing bias in crowdsourcing is key for representing communities. As suggested by one informant, we must start with an assumption of bias when using digital media as a source for planning decisions. Third, urban planning educators can broaden and deepen students' critical thinking through mixed-methods approaches in course assignments and major projects. Just as crowdsourced data in this dissertation are compared and contrasted with rich interviews, working planners must combine knowledge gleaned from quantitative sources while working with the subjective and political understandings and challenges through public involvement, colleagues, and leaders. Thus, this dissertation contributes to a socially-constructed pathway for gaining knowledge suitable for urban planning decisions.

Practically, this dissertation showed that crowdsourced data could have a strong relationship to safety. Indeed, the volume data solves an immediate and pervasive problem for planners of not being able to normalize crashes according to risk levels (e.g., Graves et al. 2014)—crowdsourced traffic volumes make this possible. Additionally, geographic analysis shows that crowdsourcing may cover a larger area of participation than is commonly used in practice. This finding has implications for megaregional planning. First, the larger area of interaction may bridge adjacent jurisdictions with a single dataset for solving planning problems. Second, and more radical, is that the very practice of ignoring and exceeding jurisdictional boundaries may have the impact of forcing officials to interact in service to communities beyond their direct electorate. In this way, crowdsourcing might potentially 'hack' the very system that supported its development. Finally, the advancement of the LASTR framework previously described suggests a more comprehensive approach to evaluating urban planning, relevant for advancing digital civics to improve the lives of present and future generations.

Needed Research Areas

This dissertation addressed initial explorations in crowdsourced planning information regarding safety for bicycling, geographies of participation, and the social construction of crowdsourcing, but left three key topics largely un-addressed: equity issues stemming from biased participation, compensation for labor in co-production, and control through mobile communication.

Marginalized and disenfranchised communities, notably including low-income groups and women bicycling, are likely under-represented in crowdsourced bicycling data (Blanc and Figliozzi 2017; Griffin and Jiao 2015a). Therefore, reliance on crowdsourced data could logically further existing biases towards high-income bicyclists and men, as the rate of women bicycling in the US lags behind Europe (Rosenbloom and Pleissis-Fraissard 2010). Bias in crowdsourced data necessitates identification and mitigation for marginalized groups, including gender, income, race, and other groups, in addition to the intersections of these groups.

As suggested in Chapter 2, labor compensation is an issue for urban planning to the extent that planning organizations leverage work from participatory crowds (Deng, Joshi, and Galliers 2013; Goodspeed 2016b). If participants replace some of the labor of planners, are there justice issues in (non)payment of both parties (participants and planners)? How might this re-frame participatory planning, including issues of both agency (who controls the work) and outcomes, dealing with participants as simultaneous workers and customers of the planning product?

Additionally, the use of mobiles owned and used by participants in a framework controlled by planning organizations suggests research questions related to control (Stephens 2018). How are hierarchical control boundaries negotiated between planners and publics in co-productive planning? What happens when participants agree on their core values, but discord results in challenges to the planning process, similar to Stephens' notion of *concertive control*? Mobile technology owned and operated by participants pushes the boundaries of traditional planning work, in addition to other issues of co-production, each meriting further study.

Appendix

INTERVIEWEE INVITATION

Message
[SUBJECT] Consent to Participate in Internet Research, "Sociotechnical Co-production of Planning Information …"

Identification of Investigator and Purpose of Study

You are invited to participate in a research study, entitled "**Sociotechnical Co-production of Planning Information: Opportunities and Limits of Crowdsourcing for the Geography and Planning of Bicycle Transportation**." The study is being conducted by Ph.D. Candidate Greg Griffin of The University of Texas at Austin, 310 Inner Campus Drive B7500 Austin, TX 78712-1009, 512-609-0474, gregpgriffin@utexas.edu.

The purpose of this research study is to examine opportunities and limits for crowdsourced information in transportation planning. Your participation in the study will contribute to a better understanding of how crowdsourcing is understood and perceived by different social groups. You are free to contact the investigator at the above address and phone number to discuss the study. You must be at least 18 years old, speak English, have access to the Internet, and have some knowledge or experience with crowdsourcing platforms for transportation planning to participate.

If you agree to participate:

- The interview will take approximately **45 minutes** of your time.
- The interview will take place online using text-based conferencing, and includes questions on your perceptions and experience with crowdsourcing for transportation planning.
- You will be compensated with a gift card worth **$15**.

Risks/Benefits/Confidentiality of Data

There are no known risks for participating. There will be no costs for participating, nor will you benefit from participating. Your name and email address will be kept during the data collection phase for tracking purposes only. A limited number of research team members will have access to the data during data collection. Identifying information will be stripped from the final dataset.

Participation or Withdrawal

Your participation in this study is voluntary. You may decline to answer any question and you have the right to withdraw from participation at any time. Withdrawal will not affect your relationship with The University of Texas in any way. If you do not want to participate either simply stop participating or close the online window.

If you do not want to receive any more reminders, you may email us at gregpgriffin@utexas.edu.

Contacts

If you have any questions about the study or need to update your email address contact the researcher Greg Griffin at 512-609-0474 or send an email to gregpgriffin@utexas.edu. This study has been reviewed by The University of Texas at Austin Institutional Review Board and the study number is **2017-05-0127.**

Questions about your rights as a research participant.
If you have questions about your rights or are dissatisfied at any time with any part of this study, you can contact, anonymously if you wish, the Institutional Review Board by phone at (512) 471-8871 or email atorsc@uts.cc.utexas.edu.

If you agree to participate, **respond to this email with a date and time** that is convenient to you. The researcher will reply with a specific online appointment and web address.

Thank you.
[signature]

SEMI-STRUCTURED INTERVIEW GUIDE

Note: Bulleted items are "probes" only used if needed to help spur responses if interviewee hesitates or is unsure how to respond, and may help tailor questioning to the interviewee's experience.

QUESTIONS

1. What does crowdsourcing mean to you?

2. Which specific crowdsourcing platforms have you experienced?
    - Ride Report
    - Strava
    - Waze
    - Shareabouts

3. What are the parts that make up a crowdsourcing system?

4. Please describe any ways that the crowdsourcing data does not represent the entire population for transportation planning.
    - Socioeconomic
    - Geographic
    - Representation of information

5. Do you think crowdsourcing, as used here in Austin [or Portland], has influenced transportation planning?

6. How has crowdsourcing for transportation planning changed over time?
    - Public use
    - Programming
    - Hardware
    - Staff use

7. Overall, how do you think crowdsourcing has influenced the transportation planning process?
    - Process
    - Geographic scale
    - Outcomes

8. Is there anything else that I have not asked about that you would like to add?

INTERVIEW CODEBOOK

INSTRUCTIONS FOR QUALITATIVE CODING IN THIS WORKBOOK

1. Go to the first question worksheet "Q1", and read the entire entry for the first interviewee. Each row is one interviewee, and each question is a different spreadsheet.
2. Review the codes in columns to the right of the text entry, and code a "1" if the code topic is present in the response. Code a “0” if the topic is not present.

TABLE 17. Structural Codebook

Code	Description	Inclusion Criteria	Exclusion Criteria
LEGITIMACY	degree to which a public planning process is designed to effect real outcomes	“legit” word stem use, or synonyms: Real Impactful	Sarcasm
ACCESSIBILITY	the ability of members of the public to involve themselves in a planning process	Refers to: Meeting location Digital inequality Understanding of materials Public knowledge of engagement opportunity	Concerns access to anything besides an aspect of the planning *process*, like: Taking a bus to work Accessing internet for shopping
SOCIAL LEARNING	Gaining or sharing knowledge or skills between participants in a planning process	Learning from, or sharing with others online or in-person	Individual learning from personal observation or study
TRANSPARENCY	Ability of people outside an organizational process to be able to find and	Either helps or hinders understanding of planning.	Landscape visibility or city wayfinding

	answer questions about how decisions are made	Could include the openness of software or data.	
REPRESENTATION	Two meanings: 1) ways that data or information, such as in crowdsourcing, characterizes the phenomena of interest 2) differences and similarities between a group of interest, and the larger population of a community	Refers to either crowdsourced data vs. actual thing, or relationship between participants and population	Political representation, e.g. elected officials
ROUTE QUALITY	This code refers to the specific use of crowdsourced data for understanding transportation segments.	Crowdsourced information relating to good, bad, or neutral aspects of an actual or digital transportation route for any travel mode.	Non-crowdsourced information, such as an individual's experience on a given street Transportation risk (SAFETY)
SAFETY	Personal safety of transportation system users	Crashes Collisions Accidents Infrastructure impacting safety Use of data for safety	Security from criminal acts Perception of road compatibility (ROUTE QUALITY)
GEOGRAPHIC DIFFERENCES	Larger, smaller, or displaced coverage	Crowdsourced data as covering a different area than traditional sources	Time shift of data (REPRESENTATION)

3. Repeat this process for the Q2 through Q8 for the remaining interviews (rows).

4. Email gregpgriffin@utexas.edu the coded spreadsheet, and include any notes or questions on the work.

VARIABLE DESCRIPTIONS USED IN CHAPTER 4

Dependent Variable:

ACpKBKT: Annual Crashes per 1,000 Bicycle Kilometers Traveled

Independent Variables:

Name	**Description**	**Source**
CONSTANT	intercept value for the regression equation	Derived by author's calculation
Rating	Ride Report bicycle segment quality ranging from 0-1, with 1 representing 100% of users rated the route using that segment great.	Bicyclists through Ride Report (Knock Software 2017)
AACBKT	Ride Report trip volumes, calculated as Average Annual Crowdsourced Bicycle Kilometers Traveled	Ride Report (Knock Software 2017)
BNA_FT_SEG_STR	Level of Traffic Stress rating, 1=low stress, 3=high stress	People for Bikes Bicycle Network Analysis (People for Bikes 2017)
Built Environment and Demographic variables below were all spatially joined as an average of each block group intersecting the street segments buffered 15m.		
Density independent variables		
Avg_PCT_AO0	Percent of zero-car households, using 2006-2010 American Community Survey	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
Avg_D1B	Gross population density (people per acre) using 2010 Census	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
Avg_D1C	Gross employment density (jobs per acre), using Census 2010 Longitudinal Employer-Household Dynamics	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
Avg_D1D	Gross activity density (employment + housing units) on unprotected land	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
Diversity independent variables		
Avg_D2A_JPHH	Jobs to Household Balance (total	Smart Location

	employment / housing units)	Database version 2.0 (Ramsey and Bell 2014b)
Avg_NonWhitePer	Percent non-white race calculated by Census block group	2012-2016 American Community Survey data
Avg_MedHHIncome	Median household income from 2012-2016 American Community Survey data by Census block group	2012-2016 American Community Survey data
Avg_D2C_TRIPEQ	Equillibrium index of trip productions and attractions (1= perfectly balanced by block group)	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
Design independent variables		
Avg_D3aao	Street network density as auto-oriented links per square mile	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
Avg_D3amm	Street network density as multi-modal links per square mile	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
Avg_D3bao	Street network density as auto-oriented intersections per square mile	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
Avg_D3bmm4	Street network density as multi-modal intersections having four or more legs per square mile	Smart Location Database version 2.0 (Ramsey and Bell 2014b)
AvgBi_SEG_STR	Level of traffic stress by segment (1=low stress, 3=high stress)	Bicycle Network Analysis (People for Bikes 2017)
AvgBi_INT_STR	Level of traffic stress by intersection (1=low stress, 3=high stress)	Bicycle Network Analysis (People for Bikes 2017)

Level of Traffic Stress Rating, from Bicycle Network Analysis (People for Bikes 2017)

Default segment assumptions

Functional class	Speed	Number of lanes	Parkin g	Parking lane width	Buffered bike lane width	Bike lane width (with parking)	Bike lane width (no parking)	Roadway width
Primary	40	2	Y	8 ft	6	5	4	N/A
Secondary	40	2	Y	8 ft	6	5	4	N/A
Tertiary	30	1	Y	8 ft	6	5	4	N/A
Unclassified	25	1	Y	N/A	N/A	N/A	N/A	27 ft
Residential	25	1	Y	N/A	N/A	N/A	N/A	27 ft

Default signal control assumptions*

Street classes	Signaliz ed
Primary-Primary	Y
Primary-Secondary	Y
Primary-Tertiary	N
Primary-Residential	N
Secondary-Secondary	Y
Secondary-Tertiary	N
Secondary-Residential	N
Tertiary-Tertiary	Y
Tertiary-Residential	N
Residential-Residential	N

*Uncontrolled intersections assume a low stress crossing for travel along the higher-order roadway
(e.g. If traveling on secondary and crossing a residential, it is low stress. If traveling on residential and crossing a secondary, the stress is governed by the characteristics of the secondary roadway.)

Stress on segments (except residential or unclassified class)

Facility type	Speed	Number of lanes	Parking	Facility width	Stress
Cycle track	-------------------	-------------------	-------------------	----------->	Low
Buffered bike lane	> 35	> 1	-------------------	----------->	High
		1	-------------------	----------->	High
	35	> 1	-------------------	----------->	High
		1	Yes	----------->	High
			No	----------->	Low
	30	> 1	Yes	----------->	High
			No	----------->	Low
		1	-------------------	----------->	Low
	<= 25	-------------------	-------------------	----------->	Low
Bike lane without parking	>30	-------------------	-------------------	----------->	High
	25-30	> 1	-------------------	----------->	High
		1	-------------------	----------->	Low
	<= 20	> 2	-------------------	----------->	High
		<= 2	-------------------	----------->	Low
Bike lane with parking	-------------------	-------------------	---------------------->	>= 15 ft	*Treat as buffered lane*
				13-14 ft	*Treat as bike lane without parking*
				< 13 ft	*Treat as shared lane*
Shared lane	<= 20	1	-----------------------	----------->	Low
		> 1	-----------------------	----------->	High
	> 20	-------------------	-----------------------	----------->	High

Stress at intersections

Intersection control	Number of crossing lanes	Crossing speed limit	Median island	Stress
None/yield to cross traffic	> 4	-----------------------------	--------------------->	High
	4	>30	--------------------->	High
		30	Yes	Low
			No	High
		<= 25	--------------------->	Low
	< 4	> 30	Yes	Low
			No	High
		<= 30	--------------------->	Low
RRFB	> 4	-----------------------------	--------------------->	High
	4	>= 40	--------------------->	High
		35	Yes	Low
			No	High
		<= 30	--------------------->	Low
	< 4	> 35	Yes	Low
			No	High
		<= 35	--------------------->	Low
Signalized, HAWK, four way stop, or priority based on class	----------------------------------	-----------------------------	--------------------->	Low

Stress on segments

Facility type	Speed	Number of lanes	Parking	Road width	Stress
Cycle track	-----------------------	-----------------------	-----------------------	------------------>	*Treat as tertiary*
Buffered bike lane	-----------------------	-----------------------	-----------------------	------------------>	*Treat as tertiary*
Combined bike / parking lane	-----------------------	-----------------------	-----------------------	------------------>	*Treat as tertiary*
Bike lane	-----------------------	-----------------------	-----------------------	------------------>	*Treat as tertiary*
Shared lane	>=30	-----------------------	-----------------------	------------------>	*Treat as tertiary*
	25	>1	-----------------------	------------------>	*Treat as tertiary*
		1	One side or none	>= 19 ft	Low
				18 ft	High
				< 18 ft	High
			Both sides	>= 27 ft	Low
				26 ft	High
				< 26 ft	High
	<= 20	>1	-----------------------	------------------>	*Treat as tertiary*
		1	One side or none	>= 19 ft	Low
				18 ft	Low
				< 18 ft	Low
			Both sides	>= 27 ft	Low
				26 ft	Low
				< 26 ft	Low

PORTLAND, CLASSIC OLS MODEL

```
>>10/07/18 13:42:57
REGRESSION
----------
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            :  PDXBuffer15mMergedSLD6_PT_ratingOK
Dependent Variable  :  logACPKBKT  Number of Observations:23316
Mean dependent var  :    -20.6161  Number of Variables   :   17
S.D. dependent var  :     7.76553  Degrees of Freedom    :23299

R-squared           :    0.026719  F-statistic           :     39.9764
Adjusted R-squared  :    0.026051  Prob(F-statistic)     :           0
Sum squared residual:1.36847e+006  Log likelihood        :    -80558.9
Sigma-square        :      58.735  Akaike info criterion :      161152
S.E. of regression  :     7.66387  Schwarz criterion     :      161289
Sigma-square ML     :     58.6921
S.E of regression ML:     7.66108
```

Variable	Coefficient	Std.Error	t-Statistic	Probability
CONSTANT	-26.1597	0.780322	-33.5243	0.00000
rating	0.43629	0.408832	1.06716	0.28591
AACBKT	0.00886191	0.00100673	8.80269	0.00000
Avg_NonWhitePer	2.98684	0.509631	5.86078	0.00000
Avg_MedHHIncome	1.48473e-005	2.40082e-006	6.18425	0.00000
Avg_PCT_AO0	-0.153658	0.478671	-0.32101	0.74854
Avg_D1B	0.0476597	0.0177156	2.69027	0.00715
Avg_D1C	0.0531208	0.0221869	2.39425	0.01666
Avg_D1D	-0.0492987	0.0217404	-2.26761	0.02337
Avg_D2A_JPHH	-0.000155585	0.000119415	-1.30289	0.19267
Avg_D2C_TRIPEQ	0.0992299	0.275605	0.360044	0.71932
Avg_D3aao	0.0468026	0.0270505	1.73019	0.08363
Avg_D3amm	0.393787	0.0303561	12.9723	0.00000
Avg_D3bao	-0.00727577	0.0159562	-0.455984	0.64810
Avg_D3bmm4	-0.0140867	0.00325993	-4.32116	0.00002
AvgBi_SEG_STR	1.10935	0.0890257	12.461	0.00000
AvgBi_INT_STR	0.177525	0.573186	0.309716	0.75690

```
REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   121.354171
TEST ON NORMALITY OF ERRORS
TEST                  DF           VALUE              PROB
Jarque-Bera            2        70380.5190          0.00000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                  DF           VALUE              PROB
Breusch-Pagan test    16         1863.8021          0.00000
Koenker-Bassett test  16          445.2507          0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHT MATRIX : PDXBuffer15mMergedSLD6_PT_ratingOK
   (row-standardized weights)
TEST                          MI/DF        VALUE          PROB
Moran's I (error)             0.5014     164.5193        0.00000
Lagrange Multiplier (lag)       1       26743.2320        0.00000
```

```
Robust LM (lag)                  1          34.6505        0.00000
Lagrange Multiplier (error)      1       26876.2655        0.00000
Robust LM (error)                1         167.6840        0.00000
Lagrange Multiplier (SARMA)      2       26910.9160        0.00000
============================== END OF REPORT ================================
```

PORTLAND, SPATIAL ERROR MODEL

```
>>10/07/18 13:50:14
REGRESSION
----------
SUMMARY OF OUTPUT: SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set            : PDXBuffer15mMergedSLD6_PT_ratingOK
Spatial Weight      : PDXBuffer15mMergedSLD6_PT_ratingOK
Dependent Variable  :  logACPKBKT  Number of Observations:23316
Mean dependent var  :  -20.616082  Number of Variables   :   17
S.D. dependent var  :    7.765526  Degrees of Freedom    :23299
Lag coeff. (Lambda) :    0.866409

R-squared           :    0.547485  R-squared (BUSE)      : -
Sq. Correlation     : -            Log likelihood        :-73226.051812
Sigma-square        :     27.2882  Akaike info criterion :      146486
S.E of regression   :     5.22381  Schwarz criterion     :      146623
```

Variable	Coefficient	Std.Error	z-value	Probability
CONSTANT	-20.3576	0.985611	-20.6548	0.00000
rating	0.0861275	0.375449	0.229399	0.81856
AACBKT	0.00587833	0.000717108	8.19728	0.00000
Avg_NonWhitePer	0.077534	1.09697	0.0706798	0.94365
Avg_MedHHIncome	-4.892e-006	4.7529e-006	-1.02927	0.30336
Avg_PCT_AO0	-1.19731	1.13357	-1.05622	0.29087
Avg_D1B	0.0120164	0.0499201	0.240713	0.80978
Avg_D1C	0.000916451	0.0634977	0.0144328	0.98848
Avg_D1D	-0.00328049	0.0626112	-0.0523946	0.95821
Avg_D2A_JPHH	-6.16708e-005	0.000172602	-0.357301	0.72087
Avg_D2C_TRIPEQ	-0.181559	0.47423	-0.38285	0.70183
Avg_D3aao	-0.00511299	0.0599535	-0.0852826	0.93204
Avg_D3amm	0.180254	0.0681686	2.64424	0.00819
Avg_D3bao	0.0198793	0.0368236	0.539851	0.58930
Avg_D3bmm4	-0.0048555	0.00750049	-0.647358	0.51740
AvgBi_SEG_STR	0.946707	0.100507	9.41931	0.00000
AvgBi_INT_STR	-1.86464	0.589988	-3.16047	0.00158
LAMBDA	0.866409	0.0043238	200.382	0.00000

```
REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                                 DF      VALUE        PROB
Breusch-Pagan test                   16      1705.5480    0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX : PDXBuffer15mMergedSLD6_PT_ratingOK
TEST                                 DF      VALUE        PROB
Likelihood Ratio Test                 1     14665.7184    0.00000
============================== END OF REPORT ================================
```

AUSTIN, CLASSIC OLS MODEL

```
>>10/07/18 10:32:48
REGRESSION
----------
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            :  ATX15mbufferRR16to18crashes14to15ACS_SLD_BNAratingOK_PT
Dependent Variable  :  lnACp1kBKT  Number of Observations: 6310
Mean dependent var  :    -20.4941  Number of Variables   :   17
S.D. dependent var  :     7.99569  Degrees of Freedom    : 6293

R-squared           :    0.041361  F-statistic           :     16.9696
Adjusted R-squared  :    0.038924  Prob(F-statistic)     :           0
Sum squared residual:      386720  Log likelihood        :    -21938.1
Sigma-square        :     61.4524  Akaike info criterion :     43910.2
S.E. of regression  :     7.83916  Schwarz criterion     :       44025
Sigma-square ML     :     61.2868
S.E of regression ML:     7.82859

-----------------------------------------------------------------------------
       Variable      Coefficient      Std.Error    t-Statistic   Probability
-----------------------------------------------------------------------------
          CONSTANT      -18.6843        1.34758       -13.8651     0.00000
            rating      -2.94892       0.873016       -3.37785     0.00073
            AACBKT     0.0112251     0.00779818        1.43945     0.15008
Avg_Per..012_16ACS  -0.000204407     0.00633245     -0.0322792     0.97324
Avg_med..ncome2016 -1.63764e-005    4.84142e-006      -3.38257     0.00072
       Avg_PCT_AO0     -0.404934        1.29806      -0.311954     0.75529
           Avg_D1B    -0.0269478      0.0265984       -1.01314     0.31104
           Avg_D1C     -0.264897      0.0756102       -3.50345     0.00046
           Avg_D1D      0.260724      0.0703174        3.70781     0.00021
      Avg_D2A_JPHH       0.05277      0.0271953        1.94041     0.05237
   Avg_D2C_TRIPEQ       -1.95804       0.595128       -3.29012     0.00101
        Avg_D3aao     -0.0792602       0.108206      -0.732496     0.46394
        Avg_D3amm      0.0603868      0.0857991       0.703817     0.48149
        Avg_D3bao      0.0454024      0.0556351       0.816075     0.41453
       Avg_D3bmm4     -0.0511455      0.0180097       -2.83989     0.00453
  Avg_BiDi_SEG_STR       2.19251       0.165919        13.2143     0.00000
  Avg_BiDi_INT_STR       -1.8025       0.811523       -2.22113     0.02638
-----------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   231.575305
TEST ON NORMALITY OF ERRORS
TEST                  DF           VALUE             PROB
Jarque-Bera            2        15798.5011           0.00000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                  DF           VALUE             PROB
Breusch-Pagan test    16           965.1563          0.00000
Koenker-Bassett test  16           253.2449          0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHT MATRIX : ATX15mbufferRR16to18crashes14to15ACS_SLD_BNAratingOK_PT
   (row-standardized weights)
TEST                          MI/DF        VALUE          PROB
Moran's I (error)             0.4083       70.8107        0.00000
Lagrange Multiplier (lag)       1        4789.5719        0.00000
```

Robust LM (lag)	1	8.3726	0.00381
Lagrange Multiplier (error)	1	4879.7670	0.00000
Robust LM (error)	1	98.5676	0.00000
Lagrange Multiplier (SARMA)	2	4888.1395	0.00000

============================== END OF REPORT ================================

AUSTIN, SPATIAL ERROR MODEL

```
>>10/07/18 10:34:04
REGRESSION
----------
SUMMARY OF OUTPUT: SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set            : ATX15mbufferRR16to18crashes14to15ACS_SLD_BNAratingOK_PT
Spatial Weight      : ATX15mbufferRR16to18crashes14to15ACS_SLD_BNAratingOK_PT
Dependent Variable  :  lnACp1kBKT  Number of Observations: 6310
Mean dependent var  :  -20.494116  Number of Variables   :   17
S.D. dependent var  :    7.995689  Degrees of Freedom    : 6293
Lag coeff. (Lambda) :    0.806731

R-squared           :    0.443574  R-squared (BUSE)      : -
Sq. Correlation     : -            Log likelihood        :-20593.493295
Sigma-square        :     35.5729  Akaike info criterion :       41221
S.E of regression   :      5.9643  Schwarz criterion     :     41335.7
```

Variable	Coefficient	Std.Error	z-value	Probability
CONSTANT	-21.4842	1.67488	-12.8273	0.00000
rating	-1.97091	0.974834	-2.02179	0.04320
AACBKT	0.0151507	0.00643688	2.35374	0.01859
Avg_Per..012_16ACS	0.0117053	0.0110125	1.06292	0.28782
Avg_med..ncome2016	-3.83446e-006	8.28741e-006	-0.462684	0.64359
Avg_PCT_AO0	-1.73648	2.43425	-0.713354	0.47563
Avg_D1B	-0.0825337	0.0529925	-1.55746	0.11936
Avg_D1C	-0.426809	0.144108	-2.96172	0.00306
Avg_D1D	0.412685	0.134536	3.06746	0.00216
Avg_D2A_JPHH	0.103701	0.0528401	1.96254	0.04970
Avg_D2C_TRIPEQ	-1.04498	0.913555	-1.14386	0.25268
Avg_D3aao	-0.0322896	0.160917	-0.20066	0.84096
Avg_D3amm	0.12286	0.15525	0.791372	0.42873
Avg_D3bao	0.00319657	0.085957	0.037188	0.97034
Avg_D3bmm4	-0.0616377	0.0325568	-1.89323	0.05833
Avg_BiDi_SEG_STR	1.74563	0.190887	9.14482	0.00000
Avg_BiDi_INT_STR	-0.799816	0.886357	-0.902363	0.36686
LAMBDA	0.806731	0.0104794	76.9828	0.00000

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	16	877.2170	0.00000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX :
ATX15mbufferRR16to18crashes14to15ACS_SLD_BNAratingOK_PT

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	2689.2290	0.00000

============================== END OF REPORT ================================

References

Adams, David. 2013. “Volunteered Geographic Information: Potential Implications for Participatory Planning.” *Planning Practice and Research* 28 (4): 464–69. https://doi.org/10.1080/02697459.2012.725549.

Afzalan, Nader, and Brian Muller. 2018. “Online Participatory Technologies: Opportunities and Challenges for Enriching Participatory Planning.” *Journal of the American Planning Association* 84 (2): 162–77. https://doi.org/10.1080/01944363.2018.1434010.

Afzalan, Nader, and Thomas Sanchez. 2017. “Testing the Use of Crowdsourced Information: Case Study of Bike-Share Infrastructure Planning in Cincinnati, Ohio.” *Urban Planning* 2 (3): 33. https://doi.org/10.17645/up.v2i3.1013.

Afzalan, Nader, Thomas W. Sanchez, and Jennifer S. Evans-Cowley. 2017. “Creating Smarter Cities: Considerations for Selecting Online Participatory Tools.” *Cities* 67 (April): 21–30. https://doi.org/10.1016/j.cities.2017.04.002.

AICP. 2016. “Code of Ethics and Professional Conduct.” 2016. https://www.planning.org/ethics/ethicscode/.

Akar, Gulsah, Chris Flynn, and Mi Namgung. 2012. “Travel Choices and Links to Transportation Demand Management Case Study at Ohio State University.” *Transportation Research Record: Journal of the Transportation Research Board*, no. 2319: 77–85. https://doi.org/http://dx.doi.org/10.3141/2319-09.

Albrechts, Louis. 2012. “Reframing Strategic Spatial Planning by Using a Coproduction Perspective.” *Planning Theory* 12 (1): 46–63. https://doi.org/10.1177/1473095212452722.

Alexander, E. R. 2001. “The Planner-Prince: Interdependence, Rationalities and Post-Communicative Practice.” *Planning Theory & Practice* 2 (3): 311–24. https://doi.org/10.1080/14649350120096848.

Alinsky, Saul D. 1972. *Rules for Radicals*. 1989 Ed. New York: Vintage Books.

Alliance for Bicycling and Walking. 2016. “Bicycling and Walking in the United States 2016 Benchmarking Report.” *Bicycling and Walking in the United States 2016 Benchmarking Report*. Washington, D.C.

Allmendinger, Phil, and Graham Haughton. 2012. “Post-Political Spatial Planning in England: A Crisis of Consensus?” *Transactions of the Institute of British Geographers* 37 (1): 89–103. https://doi.org/10.1111/j.1475-5661.2011.00468.x.

Allmendinger, Philip. 2002. “Towards a Post-Positivist Typology of Planning Theory.” *Planning Theory* 1 (1): 77–99.

Allmendinger, Philip, and Mark Tewdwr-Jones. 2002. “The Communicative Turn in Urban Planning: Unravelling Paradigmatic, Imperialistic and Moralistic

Dimensions." *Space and Polity* 6 (1): 5–24. https://doi.org/10.1080/13562570220137871.

Álvarez Sánchez, Diego, David Pardo Gimilio, and Jorge Isnardo Altamirano. 2015. "Crowdsourcing: A New Way to Citizen Empowerment." In *Advances in Crowdsourcing*, 73–86. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-18341-1_6.

Anastasiu, Irina. 2019. "Unpacking the Smart City Through the Lens of the Right to the City: A Taxonomy as a Way Forward in Participatory City-Making." In *The Hackable City*, 239–60. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-13-2694-3_13.

Andersen, Michael. 2015. "How Was Your Ride? Portland Mobile Startup Hopes to Gather 5,000 Answers Every Week." BikePortland.Org. 2015. https://bikeportland.org/2015/07/13/ride-portland-mobile-startup-hopes-gather-5000-answers-every-week-145847.

Anselin, Luc. 2018a. "Contiguity-Based Spatial Weights." 2018. https://geodacenter.github.io/workbook/4a_contig_weights/lab4a.html#queen-contiguity.

———. 2018b. "GeoDa 1.12 on Github." 2018. http://geodacenter.github.io/.

Anselin, Luc, Anil K. Bera, Raymond Florax, and Mann J. Yoon. 1996. "Simple Diagnostic Tests for Spatial Dependence." *Regional Science and Urban Economics* 26 (1): 77–104. https://doi.org/10.1016/0166-0462(95)02111-6.

Anselin, Luc, Ibnu Syabri, and Youngihn Kho. 2006. "GeoDa: An Introduction to Spatial Data Analysis." *Geographical Analysis* 38 (1): 5–22. https://doi.org/10.1111/j.0016-7363.2005.00671.x.

Appadurai, Arjun. 2012. "Why Enumeration Counts." *Environment and Urbanization* 24 (2): 639–41. https://doi.org/10.1177/0956247812447511.

Arie, Yossef, and Gustavo S. Mesch. 2016. "The Spatial and Social Network Dimensions of Mobile Communication: A Test of the Social Stratification and Social Diversification Hypotheses." *Communication Research* 43 (5): 713–34. https://doi.org/10.1177/0093650215573961.

Arnstein, Sherry R. 1969. "A Ladder Of Citizen Participation." *Journal of the American Institute of Planners* 35 (4): 216–24.

Ashton, Philip, Rachel Weber, and Matthew Zook. 2017. "The Cloud, the Crowd, and the City: How New Data Practices Reconfigure Urban Governance?" *Big Data & Society* 4 (1): 205395171770671. https://doi.org/10.1177/2053951717706718.

Austin Transportation Department. 2014. "2014 Austin Bicycle Plan Appendices." Austin, TX.

———. 2016. “Austin Mobility News: Nov. 14, 2016.” 2016. https://us3.campaign-archive.com/?u=da7c8480d321984a479109412&id=5e49835d30&e=6bef06a6f1.

Bailey, Keiron, Ted Grossardt, and John Ripy. 2015. “High-Performance Public Involvement.” *Transportation Research Record: Journal of the Transportation Research Board* 2499 (October): 45–53. https://doi.org/10.3141/2499-07.

Barrington-Leigh, Christopher, and Adam Millard-Ball. 2017. “The World’s User-Generated Road Map Is More than 80% Complete.” *PLoS ONE* 12 (8): 1–20. https://doi.org/10.1371/journal.pone.0180698.

Barta, Kristen, and Gina Neff. 2016. “Technologies for Sharing: Lessons from Quantified Self about the Political Economy of Platforms.” *Information Communication and Society* 19 (4): 518–31. https://doi.org/10.1080/1369118X.2015.1118520.

Battista, Geoffrey A., and Kevin Manaugh. 2017. “My Way or the Highway? Framing Transportation Planners’ Attitudes in Negotiating Professional Expertise and Public Insight.” *Transportation*, November. https://doi.org/10.1007/s11116-017-9833-8.

Bennett, W. Lance. 2008. “Changing Citizenship in the Digital Age.” In *Civic Life Online□: Learning How Digital Media Can Engage Youth*, edited by W. Lance Bennett, 72:1–206. MIT Press. https://doi.org/-.

Bergai, Jenni. 2018. “States Step Up on Net Neutrality.” *Planning*, April 2018.

Bhatia, Rajiv, and Megan Wier. 2011. “‘Safety in Numbers’ Re-Examined: Can We Make Valid or Practical Inferences from Available Evidence?” *Accident Analysis and Prevention* 43 (1): 235–40. https://doi.org/10.1016/j.aap.2010.08.015.

Bijker, Wiebe E. 1995. *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. Boston, MA: MIT Press. https://doi.org/10.2307/2077312.

———. 2009a. “How Is Technology Made?-That Is the Question!” *Cambridge Journal of Economics* 34 (1): 63–76. https://doi.org/10.1093/cje/bep068.

———. 2009b. “Social Construction of Technology.” In *A Companion to the Philosophy of Technology*, 88–94. https://doi.org/10.1002/9781444310795.ch15.

Bike Austin. 2016. “@bikeaustin Twitter.” 2016. https://twitter.com/bikeaustin/status/764220077138964480.

Black, Laura W. 2012. “Blog, Chat, Edit, Text, or Tweet? Using Online Tools to Advance Adult Civic Engagement.” *New Directions for Adult and Continuing Education* 2012 (135): 71–79. https://doi.org/10.1002/ace.20028.

Blanc, Bryan, and Miguel Figliozzi. 2017. “Safety Perceptions , Roadway Characteristics and Cyclists ’ Demographics□: A Study of the of Crowdsourced Smartphone

Bicycle Safety Data." *96th Annual Meeting of the Transportation Research Board*, no. July.

Blank, Grant, Mark Graham, and Claudio Calvino. 2018. "Local Geographies of Digital Inequality." *Social Science Computer Review* 36 (1): 82–102. https://doi.org/10.1177/0894439317693332.

Bloch, Matthew. 2018. "Mapshaper." 2018. http://mapshaper.org/.

Brabham, Daren C. 2009. "Crowdsourcing the Public Participation Process for Planning Projects." *Planning Theory* 8 (3): 242–62. https://doi.org/10.1177/1473095209104824.

———. 2010. "Crowdsourcing as a Model for Problem Solving: Leveraging the Collective Intelligence of Online Communities for Public Good." Dissertation, University of Utah.

———. 2013. *Crowdsourcing*. Cambridge, MA: MIT Press.

Brooks, Michael P. 2002. *Planning Theory for Practitioners*. Chicago: Planners Press, American Planning Association.

Brown, Greg. 2012. "An Empirical Evaluation of the Spatial Accuracy of Public Participation GIS (PPGIS) Data." *Applied Geography* 34 (May): 289–94. https://doi.org/10.1016/j.apgeog.2011.12.004.

———. 2017. "A Review of Sampling Effects and Response Bias in Internet Participatory Mapping (PPGIS / PGIS / VGI)." *Transactions in GIS* 21 (1): 39–56. https://doi.org/10.1111/tgis.12207.

Brown, Greg, and Marketta Kyttä. 2014. "Key Issues and Research Priorities for Public Participation GIS (PPGIS): A Synthesis Based on Empirical Research." *Applied Geography* 46 (January): 122–36. https://doi.org/10.1016/j.apgeog.2013.11.004.

Bryson, John, Kathryn S. Quick, Carissa Schively Slotterback, and Barbara C. Crosby. 2012. "Designing Public Participation Process." *Public Administration Review* 73 (1): 23–34. https://doi.org/10.111/j.1540-6210.2012.02678.x.Designing.

Burby, Raymond J. 2003. "Making Plans That Matter: Citizen Involvement and Government Action." *Journal of the American Planning Association* 69 (1): 33–49. https://doi.org/10.1080/01944360308976292.

Burd, Gene. 2008. "The Mediated Metropolis as Medium and Message." *International Communication Gazette* 70 (3–4): 209–22. https://doi.org/10.1177/1748048508089948.

Callahan, Kathe, and Kloby Kathryn. 2009. "Moving Toward Outcome-Oriented Performance Measurement Systems." *Managing for Performance and Results Series Moving Toward Outcome-Oriented Performance Measurement Systems*.

Callahan, Kathe, and Kathryn Kloby. 2007. "Collaboration Meets the Performance Measurement Challenge." *The Public Manager*, no. Summer: 9–13.

Carpenter, Andrew. 2016. "New Trip-Tracking App Seeks to Help Planners and Advocates - Mobility Lab." Mobility Lab. 2016. https://mobilitylab.org/2016/03/01/new-app-seeks-to-help-planners/.

Castells, Manuel. 2007. "Communication, Power and Counter-Power in the Network Society." *International Journal of Communication* 1 (June 2006): 29. https://doi.org/10.1080/13691180903390885.

———. 2013. *Communication Power*. 2nd ed. Oxford: Oxford University Press.

Cervero, Robert, and Kara Kockelman. 1997. "Travel Demand and the 3Ds: Density, Diversity, and Design." *Transportation Research Part D: Transport and Environment* 2 (3): 199–219.

Chen, Peng, Jiangping Zhou, and Feiyang Sun. 2017. "Built Environment Determinants of Bicycle Volume: A Longitudinal Analysis." *Journal of Transport and Land Use* 10 (1): 655–74. https://doi.org/10.5198/jtlu.2017.892.

City of Austin. 2014. "2014 Austin Bicycle Plan." Austin, TX.

———. 2018. "Ride Report App and Bicycle Comfort Map." 2018. http://www.austintexas.gov/department/ride-report.

City of Austin Transportation Department. 2016. "@AustinBikePed Twitter." 2016. https://twitter.com/AustinBikePed/status/753581111498989569.

City of Melbourne. 2017. "Future Melbourne□:: Creating the Plan." 2017. http://participate.melbourne.vic.gov.au/future/creating-future-melbourne-2026-plan.

City of Portland Oregon. 2010. *Portland Bicycle Plan for 2030*. Portland, OR: City of Portland.

City of Seattle. 2015a. "Key Proposal: Increase the Diversity of Housing Types in Lower Density Residential Zones, Including Single-Family Zones." 2015. https://seattle2035.consider.it/Housing?results=true.

———. 2015b. "Seattle 2035 Twitter." 2015. https://twitter.com/Seattle2035/status/697486442528788480.

———. 2016. "Seattle 2035 Comprehensive Plan." 2016. http://www.seattle.gov/dpd/cityplanning/completeprojectslist/comprehensiveplan/documents/default.htm.

Clark, Benjamin Y., and Jeffrey L. Brudney. 2018. "Citizen Representation in City Government-Driven Crowdsourcing." *Computer Supported Cooperative Work (CSCW)*, April. https://doi.org/10.1007/s10606-018-9308-2.

Clark, Benjamin Y, Jeffrey L Brudney, Morten Jakobsen, and Simon Calmar Andersen. 2013. "Coproduction of Government Services and the New Information Technology: Investigating the Distributional Biases." *Public Administration Review* 73 (5): 704–13. https://doi.org/10.1111/puar.12092.Coproduction.

Collins, Harry, and Trevor J. Pinch. 1998. *The Golem at Large*. Canto 2014. Cambridge: Cambridge University Press.

Conrow, Lindsey, Elizabeth Wentz, Trisalyn Nelson, and Christopher Pettit. 2018. "Comparing Spatial Patterns of Crowdsourced and Conventional Bicycling Datasets." *Applied Geography* 92 (December 2017): 21–30. https://doi.org/10.1016/j.apgeog.2018.01.009.

Consider.It. 2015. "Seattle 2035 Comprehensive Plan | Consider.It Engagement." 2015. https://seattle2035.consider.it/.

Cooper, Caren, and Ashwin Balakrishnan. 2013. "Citizen Science Perspectives on E-Participation in Urban Planning." In *Citizen E-Participation in Urban Governance*, edited by Carlos Nunes Silva, 172–97. IGI Global. https://doi.org/10.4018/978-1-4666-4169-3.ch010.

Cope, Meghan, and Sarah Elwood. 2009. *Qualitative GIS*. Edited by Meghan Cope and Sarah Elwood. *Qualitative GIS*. London: SAGE Publications Ltd. https://doi.org/10.4135/9780857024541.

Cui, Yuchen, Sabyasachee Mishra, and Timothy F. Welch. 2014. "Land Use Effects on Bicycle Ridership: A Framework for State Planning Agencies." *Journal of Transport Geography* 41 (2014): 220–28. https://doi.org/10.1016/j.jtrangeo.2014.10.004.

Curtin, G. G. 2010. "Free the Data!: E-Governance for Megaregions." *Public Works Management and Policy* 14 (3): 307–26. https://doi.org/10.1177/1087724X09359352.

Dadashova, Bahar, Greg P. Griffin, Subasish Das, Shawn Turner, and Madison Graham. 2018. "Guide for Seasonal Adjustment and Crowdsourced Data Scaling." College Station, Texas.

Daft, Richard L., and Robert H. Lengel. 1986. "Organizational Information Requirements, Media Richness and Structural Design." *Management Science* 32 (5): 554–71.

Davis, J., J. Arderiu, H. Lin, Z. Nevins, S. Schuon, O. Gallo, and Ming-Hsuan Yang. 2010. "The HPU." In *Computer Vision and Pattern Recognition Workshop on Advancing Computer Vision with Human in the Loop*. https://doi.org/10.1109/CVPRW.2010.5543192.

DeLuca, Kevin Michael, Elizabeth Brunner, and Ye Sun. 2016. "Weibo, WeChat, and the Transformative Events of Environmental Activism in China." *International Journal of Communication* 10: 19.

Deng, Xuefei (Nancy), K. D. Joshi, and Robert D. Galliers. 2013. "The Duality of Empowerment and Marginalization in Microtask Crowdsourcing: Giving Voice To the Less Powerful Through Value Sensitive Design." *MIS Quarterly* 40 (2): 1–19. https://doi.org/10.1074/jbc.M800868200.

DeRosa, Katie. 2017. "Saanich Using Bike 'Hot Spots' to Map out Transportation Plan." *Times Colonist*, January 11, 2017.

DeSanctis, Gerardine, and Marshall Scott Poole. 1994. "Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory." *Organization Science* 5 (2): 121–47. https://doi.org/doi: 10.2307/2635011.

Dewar, M., and D. Epstein. 2007. "Planning for 'Megaregions' in the United States." *Journal of Planning Literature* 22 (2): 108–24. https://doi.org/10.1177/0885412207306615.

Dewey, John. 1927. *The Public and Its Problems*. 1991 print. Athens, Ohio: Swallow Press.

DiGioia, Jonathan, Kari Edison Watkins, Yanzhi Xu, Michael Rodgers, and Randall Guensler. 2017. "Safety Impacts of Bicycle Infrastructure: A Critical Review." *Journal of Safety Research* 61: 105–19. https://doi.org/10.1016/j.jsr.2017.02.015.

DiMaggio, P, and Eszter Hargittai. 2001. "From the 'Digital Divide' to 'Digital Inequality': Studying Internet Use as Penetration Increases." *Center for Arts and Cultural Policy Studies, Princeton University* 15: 1–23. https://doi.org/10.1002/bem.20484.

Douay, Nicolas. 2018. *Urban Planning in the Digital Age*. Hoboken, New Jersey: Wiley.

Dumbaugh, Eric, and Wenhao Li. 2011. "Designing for the Safety of Pedestrians, Cyclists, and Motorists in Urban Environments." *Journal of the American Planning Association* 77 (1): 69–88. https://doi.org/10.1080/01944363.2011.536101.

Elliott, Mark. 2012. "Collaborating with the Crowd." 2012. https://www.slideshare.net/mark.elliott/planning-institute-of-australia-nsw-presentation.

Elvik, Rune. 2013. "Can a Safety-in-Numbers Effect and a Hazard-in-Numbers Effect Co-Exist in the Same Data?" *Accident Analysis and Prevention* 60: 57–63. https://doi.org/10.1016/j.aap.2013.08.010.

———. 2017. "Exploring Factors Influencing the Strength of the Safety-in-Numbers Effect." *Accident Analysis and Prevention* 100: 75–84. https://doi.org/10.1016/j.aap.2016.12.013.

Elvik, Rune, and Torkel Bjørnskau. 2017. “Safety-in-Numbers: A Systematic Review and Meta-Analysis of Evidence.” *Safety Science* 92 (0349): 274–82. https://doi.org/10.1016/j.ssci.2015.07.017.

Esri. 2017. “How Directional Distribution (Standard Deviational Ellipse) Works—Help | ArcGIS Desktop.” 2017. http://desktop.arcgis.com/en/arcmap/latest/tools/spatial-statistics-toolbox/h-how-directional-distribution-standard-deviationa.htm.

Evan, William M. 1965. “Toward a Theory of Inter-Organizational Relations.” *Management Science* 11 (10): B217–30.

Evans-Cowley, Jennifer S., and Greg P. Griffin. 2012. “Microparticipation with Social Media for Community Engagement in Transportation Planning.” *Transportation Research Record: Journal of the Transportation Research Board* 2307 (1): 90–98. https://doi.org/10.3141/2307-10.

Evans-Cowley, Jennifer S., and Justin Hollander. 2010. “The New Generation of Public Participation: Internet-Based Participation Tools.” *Planning Practice and Research* 25 (3): 397–408. https://doi.org/10.1080/02697459.2010.503432.

Evans-Cowley, Jennifer S., and Joseph Kitchen. 2011. *E-Government PAS Report 564*. Chicago: IL: American Planning Association.

Evers, David, and Jochem de Vries. 2013. “Explaining Governance in Five Mega-City Regions: Rethinking the Role of Hierarchy and Government.” *European Planning Studies* 21 (4): 536–55. https://doi.org/10.1080/09654313.2012.722944.

Ewing, Reid, and Robert Cervero. 2001. “Travel and the Built Environment: A Synthesis.” *Transportation Research Record: Journal of the Transportation Research Board* 1780 (1): 87–114. https://doi.org/10.3141/1780-10.

Ewing, Reid, and Shima Hamidi. 2014. “Longitudinal Analysis of Transit’s Land Use Multiplier in Portland (OR).” *Journal of the American Planning Association* 80 (February 2015): 1–15. https://doi.org/10.1080/01944363.2014.949506.

Ewing, Reid, Guang Tian, J. P. Goates, Ming Zhang, Michael J. Greenwald, Alex Joyce, John Kircher, and William Greene. 2015. “Varying Influences of the Built Environment on Household Travel in 15 Diverse Regions of the United States.” *Urban Studies* 52 (13): 2330–48. https://doi.org/10.1177/0042098014560991.

Faghih-Imani, Ahmadreza, and Naveen Eluru. 2015. “Analysing Bicycle-Sharing System User Destination Choice Preferences: Chicago’s Divvy System.” *Journal of Transport Geography* 44 (2015): 53–64. https://doi.org/10.1016/j.jtrangeo.2015.03.005.

Fainstein, Susan S. 2010. *The Just City*. *International Journal of Urban Sciences*. Vol. 18. Ithaca, NY: Cornell University Press. https://doi.org/10.1080/12265934.2013.834643.

Federal Highway Administration. 2018. "DOT Public Involvement Reference Tool." 2018. http://www.fhwa.dot.gov/planning/public_involvement/reference_tool/.

Ferster, Colin, Trisalyn Nelson, Karen Laberee, Ward Vanlaar, and Meghan Winters. 2017. "Promoting Crowdsourcing for Urban Research: Cycling Safety Citizen Science in Four Cities." *Urban Science* 1 (2): 21. https://doi.org/10.3390/urbansci1020021.

Figliozzi, Miguel, and Bryan Blanc. 2015. "Evaluating the Use of Crowdsourcing as a Data Collection Method for Bicycle Performance Measures and Identification of Facility Improvement Needs." Salem, OR.

Finlay, Jessica M., and Jay A. Bowman. 2016. "Geographies on the Move: A Practical and Theoretical Approach to the Mobile Interview." *The Professional Geographer* 0124 (October): 1–12. https://doi.org/10.1080/00330124.2016.1229623.

Fischler, Raphaël. 2000. "Communicative Planning Theory: A Foucauldian Assessment." *Journal of Planning Education and Research* 19 (4): 358–68. https://doi.org/10.1177/0739456X0001900405.

Flyvbjerg, Bent. 1998a. "Empowering Civil Society: Habermas, Foucault and the Question of Conflict." In *Cities for Citizens*, edited by Mike Douglass and John Friedmann. Chichester, UK: John Wiley & Sons.

———. 1998b. *Rationality and Power*. Chicago, IL: The University of Chicago Press.

———. 2004. "Phronetic Planning Research: Theoretical and Methodological Reflections." *Planning Theory & Practice* 5 (3): 283–306. https://doi.org/10.1080/1464935042000250195.

———. 2012. "Why Mass Media Matter to Planning Research: The Case of Megaprojects." *Journal of Planning Education and Research* 32 (2): 169–81. https://doi.org/10.1177/0739456X12441950.

Forester, John. 1980. "Critical Theory and Planning Practice." *Journal of the American Planning Association* 46 (3): 275–86. https://doi.org/10.1080/01944368008977043.

———. 1988. *Planning in the Face of Power*. Berkeley, CA: University of California Press.

———. 2001. "An Instructive Case-Study Hampered by Theoretical Puzzles: Critical Comments on Flyvbjerg's Rationality and Power." *International Planning Studies* 6 (3): 263–70. https://doi.org/10.1080/713672905.

———. 2015. "What Kind of Research Might Help Us Become Better Planners?" *Planning Theory & Practice* 16 (2): 145–48. https://doi.org/10.1080/14649357.2015.1028711.

Fouché, Rayvon. 2006. "Say It Loud, I ' m Black and I' m Proud: African Americans, American Artifactual Culture , and Black Vernacular Technological Creativity." *American Quarterly* 58 (3): 639–61.

Fredericks, Joel, and Marcus Foth. 2013. "Augmenting Public Participation: Enhancing Planning Outcomes through the Use of Social Media and Web 2.0." *Australian Planner* 50 (3): 244–56. https://doi.org/10.1080/07293682.2012.748083.

Friedmann, John. 1987. *Planning in the Public Domain*. Princeton, NJ: Princeton University Press.

Fuentes-Bautista, Martha, and Nobuya Inagaki. 2012. "Bridging the Broadband Gap or Recreating Digital Inequalities?" In *Inequity in the Technolpolis□: Race, Class, Gender, and the Digital Divide in Austin*, edited by Joseph Straubhaar, Jeremiah Spence, Zeynep Tufekci, and Roberta G. Lentz, 193–222. Austin, TX: University of Texas Press.

Furth, Peter G., Maaza C. Mekuria, and Hilary Nixon. 2016. "Network Connectivity for Low-Stress Bicycling." *Transportation Research Record: Journal of the Transportation Research Board* 2587 (January): 41–49. https://doi.org/10.3141/2587-06.

Gabrys, Jennifer. 2014. "Programming Environments: Environmentality and Citizen Sensing in the Smart City." *Environment and Planning D: Society and Space* 32 (1): 30–48. https://doi.org/10.1068/d16812.

Geels, Frank W., Benjamin K. Sovacool, Tim Schwanen, and Steve Sorrell. 2017. "Sociotechnical Transitions for Deep Decarbonization." *Science* 357 (6357): 1242–44. https://doi.org/10.1126/science.aao3760.

Geller, Roger. 2009. "Four Types of Cyclists." 2009. https://www.portlandoregon.gov/transportation/44597?a=237507.

Giddens, Anthony. 1984. *The Constitution of Society: Outline of the Theory of Structuration*. Cambridge: Polity press.

Gidlund, Katarina L. 2012. "'Demand Driven Development of Public e-Services.'" In *Lecture Notes in Computer Science*, 7443 LNCS:66–77. Berlin: Springer. https://doi.org/10.1007/978-3-642-33489-4_6.

Goddard, Tara, Kimberly Barsamian Kahn, and Arlie Adkins. 2015. "Racial Bias in Driver Yielding Behavior at Crosswalks." *Transportation Research Part F: Traffic Psychology and Behaviour* 33: 1–6. https://doi.org/10.1016/j.trf.2015.06.002.

Goodspeed, Robert. 2015. "Smart Cities: Moving beyond Urban Cybernetics to Tackle Wicked Problems." *Cambridge Journal of Regions, Economy and Society* 8 (1): 79–92. https://doi.org/10.1093/cjres/rsu013.

———. 2016a. “Sketching and Learning: A Planning Support System Field Study.” *Environment and Planning B: Planning and Design* 43 (3): 444–63. https://doi.org/10.1177/0265813515614665.

———. 2016b. “Digital Knowledge Technologies in Planning Practice: From Black Boxes to Media for Collaborative Inquiry.” *Planning Theory & Practice* 17 (4): 577–600. https://doi.org/10.1080/14649357.2016.1212996.

———. 2016c. “The Death and Life of Collaborative Planning Theory.” *Urban Planning* 1 (4): 1–5. https://doi.org/10.17645/up.v1i4.715.

Goodspeed, Robert, Christian Spanring, and Timothy Reardon. 2012. “Crowdsourcing as Data Sharing.” In *Proceedings of the 6th International Conference on Theory and Practice of Electronic Governance - ICEGOV ’12*, 460. https://doi.org/10.1145/2463728.2463819.

Graves, Janessa M, Barry Pless, Lynne Moore, Avery B Nathens, Garth Hunte, and Frederick P Rivara. 2014. “Public Bicycle Share Programs and Head Injuries.” *American Journal of Public Health* 104 (8): e106-11. https://doi.org/10.2105/AJPH.2014.302012.

Griffin, Greg P. 2014. “Geographic Specificity and Positionality of Public Input in Transportation: A Rural Transportation Planning Case from Central Texas.” *Urban, Planning and Transport Research* 2 (1): 407–22. https://doi.org/10.1080/21650020.2014.969442.

———. 2018. “The Civic Organization and the Digital Citizen: Communicating Engagement in a Networked Age , by Chris Wells.” *Journal of Urban Affairs* 40 (2): 301–2. https://doi.org/10.1080/07352166.2017.1338895.

———. 2019. “Co-Producing Mobility: Lessons from Ridesharing for a More Just and Sustainable Autonomous Future.” In *Disruptive Transport: Driverless Cars, Transport Innovation and the Sustainable City of Tomorrow*, edited by William W. Riggs. New York: Routledge.

Griffin, Greg P., Steven Hankey, Ralph Buehler, and Safety through Disruption University Transportation Center (Safe-D). 2017. “Street Noise Relationship to Vulnerable Road User Safety.” 2017. https://www.vtti.vt.edu/utc/safe-d/index.php/projects/street-noise-relationship-to-vulnerable-road-user-safety/.

Griffin, Greg P., and Junfeng Jiao. 2015a. “Crowdsourcing Bicycle Volumes: Exploring the Role of Volunteered Geographic Information and Established Monitoring Methods.” *URISA Journal* 27 (1): 57–66.

———. 2015b. “Where Does Bicycling for Health Happen? Analysing Volunteered Geographic Information through Place and Plexus.” *Journal of Transport & Health* 2 (2): 238–47. https://doi.org/10.1016/j.jth.2014.12.001.

———. 2018. “Can Crowdsourcing Support Co-Productive Transportation Planning in Megaregion? Evidence from Local Practice.” Austin, TX.

———. 2019a. “Crowdsourcing Bike Share Station Locations.” *Journal of the American Planning Association* 85 (1): 35–48. https://doi.org/10.1080/01944363.2018.1476174.

———. 2019b. “The Geography and Equity of Crowdsourced Public Participation for Active Transportation Planning.” *Transportation Research Record: Journal of the Transportation Research Board* in press (January). https://doi.org/10.1177/0361198118823498.

Griffin, Greg P., Alexandra R. Radtke, Madison Metsker-Galarza, Gretchen Stoeltje, Tina Geiselbrecht, Ben Ettelman, and Chris Simek. 2018. “A Phased Logic Model Approach to Public Involvement Performance Measurement.” *97th Annual Meeting of the Transportation Research Board*.

Griffin, Greg P., Chris Simek, Meg Mulhall, and Safety through Disruption University Transportation Center (Safe-D). 2017. “Sources and Mitigation of Bias in Big Data for Transportation Safety.” 2017. https://www.vtti.vt.edu/utc/safe-d/index.php/projects/sources-and-mitigation-of-bias-in-big-data-for-transportation-safety/.

Griffin, Greg P., Gretchen Stoeltje, Tina Geiselbrecht, Chris Simek, Ben Ettelman, and Madison Metsker-Galarza. 2018. *Performance Measures for Public Participation Methods*. Austin, TX: Texas A&M Transportation Institute.

Grossardt, Ted, and Keiron Bailey. 2018. *Transportation Planning and Public Participation*. Amsterdam: Elsevier. https://doi.org/10.1016/B978-0-12-812956-2.00001-3.

Grossardt, Ted, Keiron Bailey, and Joel Brumm. 2003. “Structured Public Involvement: Problems and Prospects for Improvement.” *Transportation Research Record: Journal of the Transportation Research Board* 1858 (January): 59–102. https://doi.org/10.3141/1858-13.

Gudowsky, Niklas, and Ulrike Bechtold. 2013. “The Role of Information in Public Participation.” *Journal of Public Deliberation* 9 (1): 387–94.

Gumpert, G., and S. J. Drucker. 2008. “Communicative Cities.” *International Communication Gazette* 70 (3–4): 195–208. https://doi.org/10.1177/1748048508089947.

Guyadeen, Dave, and Mark Seasons. 2018. “Evaluation Theory and Practice: Comparing Program Evaluation and Evaluation in Planning.” *Journal of Planning Education and Research* 38 (1): 98–110. https://doi.org/10.1177/0739456X16675930.

Habermas, Jürgen. 1962. *The Structural Transformation of the Public Sphere*. First MIT. Cambridge, MA: MIT Press.

———. 1984. *The Theory of Communicative Action, Volume 1, Reason and the Rationalization of Society*. Edited by Thomas McCarthy. English Tr. Boston: Beacon Press.

———. 1987. *The Theory of Communicative Action, Volume 2, Lifeworld and System: A Critique of Functionalist Reason (3rd English Tr. by Thomas McCarthy of 1981 Theorie Des Kommunikativen Handelns, Band 2: Zur Kritik Der Funktionalistischen Vernunf)*. 3rd Englis. Vol. 2. Boston: Beacon Press.

———. 1990. *Moral Consciousness and Communicative Action*. English tr. Cambridge, MA: Polity press.

Habermas, Jürgen, and Maeve Cooke. 1998. *On the Pragmatics of Communication*. Cambridge, MA: MIT Press.

Haklay, Mordechai (Muki). 2013. "Neogeography and the Delusion of Democratisation." *Environment and Planning A* 45 (1): 55–69. https://doi.org/10.1068/a45184.

Hall, Peter. 2002. *Cities of Tomorrow*. 3rd ed. Oxford: Blackwell.

Hamre, Andrea, and Ralph Buehler. 2014. "Commuter Mode Choice and Free Car Parking, Public Transportation Benefits, Showers/Lockers, and Bike Parking at Work: Evidence from the Washington, DC Region." *Journal of Public Transportation* 17 (2): 67–91.

Harris, Christopher G. 2011. "Dirty Deeds Done Dirt Cheap: A Darker Side to Crowdsourcing." *Proceedings - 2011 IEEE International Conference on Privacy, Security, Risk and Trust and IEEE International Conference on Social Computing, PASSAT/SocialCom 2011*, 1314–17. https://doi.org/10.1109/PASSAT/SocialCom.2011.89.

Haughton, G., and A. While. 1999. "From Corporate City to Citizens City?: Urban Leadership After Local Entrepreneurialism in the United Kingdom." *Urban Affairs Review* 35 (1): 3–23. https://doi.org/10.1177/10780879922184266.

Healey, Patsy. 1997. *Collaborative Planning: Shaping Places in Fragmented Societies*. London: Macmillan.

———. 1999. "Institutionalist Analysis, Communicative Planning, and Shaping Places." *Journal of Planning Education and Research* 19 (2): 111–21. https://doi.org/10.1177/0739456X9901900201.

———. 2003. "Collaborative Planning in Perspective." *Planning Theory* 2 (2): 101–23. https://doi.org/10.1177/14730952030022002.

———. 2008. "The Pragmatic Tradition in Planning Thought." *Journal of Planning Education and Research* 28 (3): 277–92. https://doi.org/10.1177/0739456X08325175.

Hermida, Alfred, Seth C. Lewis, and Rodrigo Zamith. 2014. "Sourcing the Arab Spring: A Case Study of Andy Carvin's Sources on Twitter during the Tunisian and Egyptian Revolutions." *Journal of Computer-Mediated Communication* 19 (3): 479–99. https://doi.org/10.1111/jcc4.12074.

Hewson, Claire. 2014. "Qualitative Approaches in Internet-Mediated Research: Opportunities, Issues, Possibilities." In *The Oxford Handbook of Qualitative Research Methods*, edited by Patricia Leavy, 423–54. Oxford: Oxford University Press.

Hewson, Claire, Carl Vogel, and Dianna Laurent. 2016. "Internet Mediated Research: State of the Art." In *Internet Research Methods*, 33–69. Thousand Oaks, CA: SAGE Publications.

Hillier, Jean. 2002. "Direct Action and Agonism in Democratic Planning Practice." In *Planning Futures: New Directions for Planning Theory*, edited by Philip Allmendinger and Mark Tewdwr-Jones, 110–36. London: Routledge.

Hoch, Charles. 2007. "Pragmatic Communicative Action Theory." *Journal of Planning Education and Research* 26 (3): 272–83. https://doi.org/10.1177/0739456X06295029.

———. 2018. "Neo-Pragmatist Planning Theory." In *The Routledge Handbook of Planning Theory*, edited by Michael Gunder, Ali Madanipour, and Vanessa Watson, 118–29. New York: Routledge. https://doi.org/10.1177/1473095207087526.

Hoch, Charles, Moira Zellner, Dan Milz, Josh Radinsky, and Leilah Lyons. 2015. "Seeing Is Not Believing: Cognitive Bias and Modelling in Collaborative Planning." *Planning Theory & Practice* 16 (3): 319–35. https://doi.org/10.1080/14649357.2015.1045015.

Hochmair, Hartwig H. 2014. "Assessment of Bicycle Service Areas around Transit Stations." *International Journal of Sustainable Transportation* 9 (November 2014): 15–29. https://doi.org/10.1080/15568318.2012.719998.

Hoffmann, Melody L. 2016. *Bike Lanes Are White Lanes: Bicycle Advocacy and Urban Planning*. Lincoln, NE: University of Nebraska Press.

Hollander, Justin B. 2011. "Approaching an Ideal: Using Technology to Apply Collaborative Rationality to Urban Planning Processes." *Planning Practice and Research* 26 (5): 587–96. https://doi.org/10.1080/02697459.2011.627001.

Hommels, Anique. 2005. "Studying Obduracy in the City: Toward a Productive Fusion between Technology Studies and Urban Studies." *Science, Technology & Human Values* 30 (3): 323–51. https://doi.org/10.1177/0162243904271759.

Hommels, Anique, Peter Peters, and Wiebe E. Bijker. 2007. "Techno Therapy or Nurtured Niches? Technology Studies and the Evaluation of Radical

Innovations." *Research Policy* 36 (7): 1088–99. https://doi.org/10.1016/j.respol.2007.04.002.

Hoskins, Guy T. 2013. "Meet the Habermasses: Charting the Emergence of a Social Media-Enabled Public Sphere in New Democracies." *International Journal of Technology, Knowledge and Society* 9.

Hunn, Alexander, and Lisa Loftus-Otway. 2018. "Assessing Changes to Federal and State Law for Megaregion Planning. Part 1: Defining Federal Constitutional Powers for Megaregion Planning: Recommendations for Transportation Policy." Austin, TX.

Huxley, Margo. 2000. "The Limits to Communicative Planning." *Journal of Planning Education and Research* 19 (4): 369–77. https://doi.org/10.1177/0739456X0001900406.

Huxley, Margo, and Oren Yiftachel. 2000. "New Paradigm or Old Myopia? Unsettling the Communicative Turn in Planning Theory." *Journal of Planning Education and Research* 19 (4): 333–42. https://doi.org/10.1177/0739456X0001900402.

Innes, Judith E. 1995. "Planning Theory's Emerging Paradigm: Communicative Action and Interactive Practice." *Journal of Planning Education and Research* 14 (3): 183–89. https://doi.org/10.1177/0739456X9501400307.

———. 1998. "Information in Communicative Planning." *Journal of the American Planning Association* 64 (1): 52. https://doi.org/10.1080/01944369808975956.

Innes, Judith E., and David E. Booher. 2000. "Indicators for Sustainable Communities: A Strategy Building on Complexity Theory and Distributed Intelligence." *Planning Theory & Practice* 1 (2): 173–86. https://doi.org/10.1080/14649350020008378.

———. 2004. "Reframing Public Participation: Strategies for the 21st Century." *Planning Theory & Practice* 5 (4): 419–36. https://doi.org/10.1080/1464935042000293170.

———. 2010. *Planning with Complexity: An Introduction to Collaborative Rationality for Public Policy*. New York: Routledge.

Innes, Judith E., David E. Booher, and Sarah Di Vittorio. 2011. "Strategies for Megaregion Governance -- Collaborative Dialogue, Networks, and Self-Organization." *Journal of the American Planning Association* 77 (1): 55–67. https://doi.org/10.1080/01944363.2011.533640.

Jacobsen. 2003. "Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling." *Injury Prevention* 9 (3): 205–9. https://doi.org/10.1136/ip.9.3.205.

Jacobsen, and P L Jacobsen. 2003. "Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling." *Injury Prevention* 9 (3): 205–9. https://doi.org/10.1136/ip.9.3.205.

Jacobsen, David R. Ragland, and Charles Komanoff. 2015. "Safety in Numbers for Walkers and Bicyclists: Exploring the Mechanisms." *Injury Prevention* 21 (4): 217–20. https://doi.org/10.1136/injuryprev-2015-041635.

James, William. 1904. "Lecture II What Pragmatism Means." 1904. http://www.marxists.org/reference/subject/philosophy/works/us/james.htm.

Jankowski, Piotr, Michał Czepkiewicz, Marek Młodkowski, Michał Wójcicki, and Zbigniew Zwolinski. 2016. "Scalability in Participatory Planning: A Comparison of Online PPGIS Methods with Faceto- Face Meetings." *International Conference on GIScience Short Paper Proceedings* 1. https://doi.org/10.21433/B3118NH5943S.

Jankowski, Piotr, Michał Czepkiewicz, Marek Młodkowski, and Zbigniew Zwoliński. 2016. "Geo-Questionnaire: A Method and Tool for Public Preference Elicitation in Land Use Planning." *Transactions in GIS* 20 (6): 903–24. https://doi.org/10.1111/tgis.12191.

Jankowski, Piotr, Michał Czepkiewicz, Marek Młodkowski, Zbigniew Zwoliński, and Michał Wójcicki. 2017. "Evaluating the Scalability of Public Participation in Urban Land Use Planning: A Comparison of Geoweb Methods with Face-to-Face Meetings." *Environment and Planning B: Urban Analytics and City Science*, July. https://doi.org/10.1177/2399808317719709.

Jasanoff, Sheila. 2017. "Science and Democracy." In *The Handbook of Science and Technology Studies*, edited by Ulrike Felt, Rayvon Fouché, Clark Miller, and Laurel Smith-Doerr, 4th Ed., 259–88. Cambridge, MA: MIT Press.

Jeffres, Leo W. 2010. "The Communicative City: Conceptualizing, Operationalizing, and Policy Making." *Journal of Planning Literature* 25 (2): 99–110. https://doi.org/10.1177/0885412210369455.

Johnson, Peter A., and Renee E. Sieber. 2012. "Motivations Driving Government Adoption of the Geoweb." *GeoJournal* 77 (5): 667–80. https://doi.org/10.1007/s10708-011-9416-8.

Kahila-Tani, Maarit, Anna Broberg, Marketta Kyttä, and Taylor Tyger. 2016. "Let the Citizens Map—Public Participation GIS as a Planning Support System in the Helsinki Master Plan Process." *Planning Practice & Research* 31 (2): 195–214. https://doi.org/10.1080/02697459.2015.1104203.

Kam, Katie A., Joel L. Meyer, Jennifer C. Duthie, and Hamza Khan. 2018. "Mapping GPS Data and Assessing Mapping Accuracy." In *Bicycle Urbanism□ Reimagining Bicycle Friendly Cities*, edited by Rachel Berney, 199–212. New York: Routledge. https://doi.org/10.4324/9781315569338.

Kamel Boulos, Maged N, and Najeeb M Al-Shorbaji. 2014. "On the Internet of Things, Smart Cities and the WHO Healthy Cities." *International Journal of Health Geographics* 13 (1): 10. https://doi.org/10.1186/1476-072X-13-10.

Kang, Cecilia. 2018. “Washington Governor Signs First State Net Neutrality Bill.” *The New York Times*, March 5, 2018.

Karner, Alex, and Richard A. Marcantonio. 2018. “Achieving Transportation Equity: Meaningful Public Involvement to Meet the Needs of Underserved Communities.” *Public Works Management & Policy* 23 (2): 105–26. https://doi.org/10.1177/1087724X17738792.

Kazmer, Michelle M., and Bo Xie. 2008. “Qualitative Interviewing in Internet Studies: Playing with the Media, Playing with the Method.” *Information, Communication & Society* 11 (2): 257–78. https://doi.org/10.1080/13691180801946333.

Kelty, Christopher M. 2008. *Two Bits: The Cultural Significance of Free Software*. Durham, NC: Duke University Press.

Kitchin, Rob. 2013. “The Real-Time City? Big Data and Smart Urbanism.” *GeoJournal* 79 (1): 1–14. https://doi.org/10.1007/s10708-013-9516-8.

Klein, Hans K., and Daniel Lee Kleinman. 2002. “The Social Construction of Technology: Structural Considerations.” *Science, Technology & Human Values* 27 (1): 28–52. https://doi.org/10.1177/016224390202700102.

Knock Software. 2017. “Ride Report.” 2017. https://ride.report/.

Kramer, Jeff, Domenico Pontoriero, Melissa McCarville, and Kristine Williams. 2013. “Public Involvement Performance Measurement Tool.” *Compendium of Transportation Research Board 2013 Annual Meeting*.

Kriplean, Travis. 2012. “Encouraging Reflective Discussion on the Web.” University of Washington.

Kriplean, Travis, Caitlin Bonnar, Alan Borning, Bo Kinney, and Brian Gill. 2014. “Integrating On-Demand Fact-Checking with Public Dialogue.” *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing - CSCW ’14*, 1188–99. https://doi.org/10.1145/2531602.2531677.

Kriplean, Travis, Jonathan Morgan, Deen Freelon, Alan Borning, and Lance Bennett. 2012. “Supporting Reflective Public Thought with ConsiderIt.” *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work - CSCW ’12*, 265. https://doi.org/10.1145/2145204.2145249.

Krivý, Maroš. 2016. “Towards a Critique of Cybernetic Urbanism: The Smart City and the Society of Control.” *Planning Theory*. https://doi.org/10.1177/1473095216645631.

Kwan, Mei-Po. 2012. “The Uncertain Geographic Context Problem.” *Annals of the Association of American Geographers* 102 (5): 958–68. https://doi.org/10.1080/00045608.2012.687349.

Lakhani, Karim R., Hila Lifshitz - Assaf, and Michael Tushman. 2013. "Open Innovation and Organizational Boudaries: Task Decomposition, Knowledge Distribution and the Locus of Innovation." In , edited by Anna Grandori, 355–82. Cheltenham, UK: Edward Elgar. https://doi.org/10.2139/ssrn.1980118.

Latour, Bruno. 1990. "Technology Is Society Made Durable." *The Sociological Review* 38 (1_suppl): 103–31. https://doi.org/10.1111/j.1467-954X.1990.tb03350.x.

———. 1996. *Aramis, or the Love of Technology*. Cambridge, MA: Harvard University Press.

Laurian, Lucie, Jan Crawford, Maxine Day, Peter Kouwenhoven, Greg Mason, Neil Ericksen, and Lee Beattie. 2010. "Evaluating the Outcomes of Plans: Theory, Practice, and Methodology." *Environment and Planning B: Planning and Design* 37 (4): 740–57. https://doi.org/10.1068/b35051.

Lavy, Brendan L., Erin D. Dascher, and Ronald R. Hagelman. 2016. "Media Portrayal of Gentrification and Redevelopment on Rainey Street in Austin, Texas (USA), 2000–2014." *City, Culture and Society* 7 (4): 197–207. https://doi.org/10.1016/j.ccs.2016.08.001.

Lease, Matthew, and Omar Alonso. 2014. *Crowdsourcing and Human Computation, Introduction*. Edited by Reda Alhajj and Jon Rokne. *Encyclopedia of Social Network Analysis and Mining*. New York, NY: Springer New York. https://doi.org/10.1007/978-1-4614-6170-8.

Lee, Jae Seung, P. Christopher Zegras, and Eran Ben-Joseph. 2013. "Safely Active Mobility for Urban Baby Boomers: The Role of Neighborhood Design." *Accident Analysis and Prevention* 61: 153–66. https://doi.org/10.1016/j.aap.2013.05.008.

Legacy, Crystal. 2010. "Investigating the Knowledge Interface between Stakeholder Engagement and Plan-Making." *Environment and Planning A* 42 (11): 2705–20. https://doi.org/10.1068/a43164.

Legacy, Crystal, Alan March, and Clare M. Mouat. 2014. "Limits and Potentials to Deliberative Engagement in Highly Regulated Planning Systems: Norm Development within Fixed Rules." *Planning Theory & Practice* 15 (1): 26–40. https://doi.org/10.1080/14649357.2013.866264.

Lentz, R.G., and Michael D. Oden. 2001. "Digital Divide or Digital Opportunity in the Mississippi Delta Region of the US." *Telecommunications Policy* 25 (5): 291–313. https://doi.org/10.1016/S0308-5961(01)00006-4.

Leszczynski, Agnieszka. 2017. "Digital Methods I." *Progress in Human Geography*, June, 030913251771177. https://doi.org/10.1177/0309132517711779.

Levin, Janet. 2004. "Functionalism." August 24, 2004. http://plato.stanford.edu/entries/functionalism/.

Levine, Jonathan, Joe Grengs, Qingyun Shen, and Qing Shen. 2012. “Does Accessibility Require Density or Speed?” *Journal of the American Planning Association* 78 (2): 157–72. https://doi.org/10.1080/01944363.2012.677119.

Lewis, Jennifer, and J. Scott Lane. 2007. “Public Outreach in Pedestrian Plan for Durham, North Carolina: Effectiveness in a Diverse Community.” *Transportation Research Record: Journal of the Transportation Research Board* 1994: 138–46. https://doi.org/10.3141/1994-18.

Lin, Yanliu, and Stan Geertman. 2015. “Smart Governance, Collaborative Planning and Planning Support Systems: A Fruitful Triangle?” In *Planning Support Systems and Smart Cities*, edited by Stan Geertman, Joseph Ferreira, Robert Goodspeed, and John Stillwell, 261–77. Springer International Publishing. https://doi.org/10.1007/978-3-319-18368-8_14.

Linders, Dennis. 2012. “From E-Government to We-Government: Defining a Typology for Citizen Coproduction in the Age of Social Media.” *Government Information Quarterly* 29 (4): 446–54. https://doi.org/10.1016/j.giq.2012.06.003.

Love to Ride. 2018. “Austin Bike Challenge 2018 - Biketober.” 2018. https://www.lovetoride.net/austin?locale=en-US.

Lowry, Michael B. 2010. “Online Public Deliberation for a Regional Transportation Improvement Decision.” *Transportation* 37 (1): 39–58. https://doi.org/10.1007/s11116-009-9219-7.

Lupton, Deborah, and Christine Heyes Labond. 2018. “Personal Data Contexts, Data Sense, and Self-Tracking Cycling.” *International Journal of Communication* 12: 647–65.

Mandarano, L. 2015. “Civic Engagement Capacity Building: An Assessment of the Citizen Planning Academy Model of Public Outreach and Education.” *Journal of Planning Education and Research* 35 (2): 174–87. https://doi.org/10.1177/0739456X14566869.

Margerum, Richard D. 2002a. “Collaborative Planning: Building Consensus and Building a Distinct Model for Practice.” *Journal of Planning Education and Research* 21 (3): 237–53. https://doi.org/10.1177/0739456X0202100302.

———. 2002b. “Collaborative Planning.” *Journal of Planning Education and Research* 21 (3): 237–53. https://doi.org/10.1177/0739456X0202100302.

———. 2011. “The Translation to Practice.” In *Beyond Consensus Improving Collaborative Planning and Management*, 259–87. Boston: MIT Press.

Marler, Will. 2018. “Mobile Phones and Inequality: Findings, Trends, and Future Directions.” *New Media & Society* 20 (9): 3498–3520. https://doi.org/10.1177/1461444818765154.

Matsaganis, Matthew D. 2016. “Multi- and Mixed-Methods Approaches to Urban Communication Research: A Synthesis and the Road Ahead.” *International Journal of Communication* 10: 1331–50.

Mattingly, Meghan, P. Sriraj, Eric Welch, and Barbara Bhojraj. 2010. “Measuring and Assessing Perceptions of Success in a Transit Agency’s Stakeholder Involvement Program.” *Transportation Research Record: Journal of the Transportation Research Board* 2174 (December): 89–98. https://doi.org/10.3141/2174-13.

McAndrews, Carolyn, and Justine Marcus. 2015. “The Politics of Collective Public Participation in Transportation Decision-Making.” *Transportation Research Part A: Policy and Practice* 78: 537–50. https://doi.org/10.1016/j.tra.2015.06.014.

McConnell, Christopher Lee. 2014. “Digital Inclusion and Techno-Capital in Austin , Texas.” The University of Texas at Austin.

McFarlane, Colin. 2011. *Learning the City*. Oxford, UK: Wiley-Blackwell. https://doi.org/10.1002/9781444343434.

McLean, Anthony, Harriet Bulkeley, and Mike Crang. 2015. “Negotiating the Urban Smart Grid: Socio-Technical Experimentation in the City of Austin.” *Urban Studies* 53 (October 2014): 3246–63. https://doi.org/10.1177/0042098015612984.

McNeil, Nathan, Jennifer Dill, John MacArthur, Joseph Broach, and Steven Howland. 2017. “Breaking Barriers to Bike Share: Insights on Equity.” Portland, OR.

Mead, George Herbert. 1934. *Mind, Self & Society*. Definitive. Chicago: University of Chicago Press.

Menghini, G., N. Carrasco, N. Schüssler, and K.W. Axhausen. 2010. “Route Choice of Cyclists in Zurich.” *Transportation Research Part A: Policy and Practice* 44 (9): 754–65. https://doi.org/10.1016/j.tra.2010.07.008.

Minner, Jennifer S. 2015. “Recoding Embedded Assumptions: Adaptation of an Open Source Tool to Support Sustainability, Transparency and Participatory Governance.” In *Planning Support Systems and Smart Cities*, 409–25. Lecture Notes in Geoinformation and Cartography. Cham, Switzerland: Springer. https://doi.org/10.1007/978-3-319-18368-8_22.

Mitra, Raktim, and Ron N. Buliung. 2012. “Built Environment Correlates of Active School Transportation: Neighborhood and the Modifiable Areal Unit Problem.” *Journal of Transport Geography* 20 (1): 51–61. https://doi.org/10.1016/j.jtrangeo.2011.07.009.

Movability Austin. 2018. “It’s Bike Month!” 2018. http://movabilityaustin.org/2018/05/its-bike-month/.

Mumford, Lewis. 1964. “Authoritarian and Democratic Technics.” *Technology and Culture* 5 (1): 1–8.

Murthy, Dhiraj, Alison B. Powell, Ramine Tinati, Nick Anstead, Leslie Carr, Susan J. Halford, and Mark Weal. 2016. "Bots and Political Influence: A Sociotechnical Investigation of Social Network Capital." *International Journal of Communication* 10: 20.

Nabatchi, Tina, and Matt Leighninger. 2015. *Public Participation for 21st Century Democracy*. Hoboken, New Jersey: John Wiley & Sons.

Næss, Petter. 2016. "Built Environment, Causality and Urban Planning." *Planning Theory & Practice* 9357 (February 2016): 1–20. https://doi.org/10.1080/14649357.2015.1127994.

Nakatsu, R. T., E. B. Grossman, and C. L. Iacovou. 2014. "A Taxonomy of Crowdsourcing Based on Task Complexity." *Journal of Information Science* 40 (6): 823–34. https://doi.org/10.1177/0165551514550140.

Nelson, Arthur C. 2017. "Megaregion Projections 2015 to 2045 with Transportation Policy Implications." *Transportation Research Record: Journal of the Transportation Research Board* 2654 (January): 11–19. https://doi.org/10.3141/2654-02.

Noveck, Beth Simone. 2003. "Designing Deliberative Democracy in Cyberspace: The Role of the Cyber-Lawyer." *Boston University Journal of Science and Technology Law* 9 (1).

O'Cathain, Alicia. 2010. "Assessing the Quality of Mixed Methods Research: Toward a Comprehensive Framework." In *SAGE Handbook of Mixed Methods in Social & Behavioral Research*, 2nd:531–56. Thousand Oaks, CA: SAGE Publications, Inc. https://doi.org/10.4135/9781506335193.n21.

O'Connor, Henrietta, Clare Madge, Robert Shaw, and Jane Wellens. 2008. "Internet-Based Interviewing." In *The SAGE Handbook of Online Research Methods*, edited by Nigel Fielding, Raymond M Lee, and Grant Blank, 271–89. London: SAGE Publications, Ltd. https://doi.org/10.4135/9780857020055.

Ogra, Aurobindo, and Robert Ndebele. 2014. "The Role of 6Ds: Density, Diversity, Design, Destination, Distance, and Demand Management in Transit Oriented Development (TOD)." *Neo-International Conference on Habitable Environments*, 539–46.

Orlikowski, Wanda J., and Susan V. Scott. 2015. "The Algorithm and the Crowd: Considering the Materiality of Service Innovation." *MIS Quarterly* 39 (1): 201–16.

Ortiz, J. A., and A. H. Tapia. 2008. "Keeping Promises: Municipal Communities Struggle to Fulfill Promises to Narrow the Digital Divide with Municipal-Community Wireless Networks." *Journal of Community Informatics* 4 (1): 1–20.

Ory, Marcia G. 2015. “Physical Activity Impacts of a Planned Activity-Friendly Community: The What, Where, When and Why of Environmental Approaches to Obesity Prevention.” 2015. https://projectreporter.nih.gov/project_info_description.cfm?aid=9325464&icde=37729040.

Ose, Solveig Osborg. 2016. “Using Excel and Word to Structure Qualitative Data.” *Journal of Applied Social Science* 10 (2): 147–62. https://doi.org/10.1177/1936724416664948.

Ostrom, Elinor. 1996. “Crossing the Great Divide: Coproduction, Synergy, and Development.” *World Development* 24 (6): 1073–87. https://doi.org/10.1016/0305-750X(96)00023-X.

Pak, Burak, Alvin Chua, and Andrew Vande Moere. 2017. “FixMyStreet Brussels: Socio-Demographic Inequality in Crowdsourced Civic Participation.” *Journal of Urban Technology*, April, 1–23. https://doi.org/10.1080/10630732.2016.1270047.

Papacharissi, Zizi. 2014. *Affective Publics*. Oxford: Oxford University Press.

Pearce, Katy E., and Ronald E. Rice. 2013. “Digital Divides From Access to Activities: Comparing Mobile and Personal Computer Internet Users.” *Journal of Communication* 63 (4): 721–44. https://doi.org/10.1111/jcom.12045.

Peckett, Haley, and William M Lyons. 2012. “Evolving Role of Metropolitan Planning Organizations in Transportation Planning for Megaregions.” *Transportation Research Record: Journal of the Transportation Research Board*, no. 2307: 43–51. https://doi.org/10.3141/2307-05.

People for Bikes. 2017. “Bike Network Analysis Methodology.” 2017. https://bna.peopleforbikes.org/#/methodology.

Pettigrew, Thomas F, and Linda R Tropp. 2006. “A Meta-Analytic Test of Intergroup Contact Theory.” *Journal of Personality and Social Psychology* 90 (5): 751–83. https://doi.org/10.1037/0022-3514.90.5.751.

Pew Research Center. 2016. “13% of Americans Don’t Use the Internet. Who Are They?” 2016. http://www.pewresearch.org/fact-tank/2016/09/07/some-americans-dont-use-the-internet-who-are-they/.

———. 2018. “Demographics of Internet and Home Broadband Usage in the United States.” 2018. http://www.pewinternet.org/fact-sheet/internet-broadband/.

Piatkowski, Daniel, Wesley Marshall, and Nader Afzalan. 2017. “Can Web-Based Community Engagement Inform Equitable Planning Outcomes? A Case Study of Bikesharing.” *Journal of Urbanism: International Research on Placemaking and Urban Sustainability* 10 (3): 296–309. https://doi.org/10.1080/17549175.2016.1254672.

Pina, Vicente, Lourdes Torres, and Sonia Royo. 2017. "Comparing Online with Offline Citizen Engagement for Climate Change: Findings from Austria, Germany and Spain." *Government Information Quarterly* 34 (1): 26–36. https://doi.org/10.1016/j.giq.2016.08.009.

Portland Bureau of Transportation. 2018a. "Better Naito Returns for 2018; New Report Shows Almost 400k Trips Taken by People Biking during 2017 Season." 2018. https://www.portlandoregon.gov/transportation/article/675539.

———. 2018b. "News Release□: PBOT Partners with Portland Startup Ride Report for Bicycle Data Collection." 2018. https://www.portlandoregon.gov/transportation/article/680761.

Radil, Steven M., and Matthew B. Anderson. 2019. "Rethinking PGIS: Participatory or (Post)Political GIS?" *Progress in Human Geography* 43 (2): 195–213. https://doi.org/10.1177/0309132517750774.

Radil, Steven M., and Junfeng Jiao. 2016. "Public Participatory GIS and the Geography of Inclusion." *The Professional Geographer* 68 (2): 202–10. https://doi.org/10.1080/00330124.2015.1054750.

Ramsey, Kevin, and Alexander Bell. 2014a. *Smart Location Database*. Washington, D.C.: U.S. EPA Office of Sustainable Communities.

———. 2014b. "Smart Location Database Version 2.0 User Guide." 2014. https://edg.epa.gov/data/PUBLIC/OP/SLD.

Rauchfleisch, A., and M. Kovic. 2016. "The Internet and Generalized Functions of the Public Sphere: Transformative Potentials From a Comparative Perspective." *Social Media + Society* 2 (2): 1–15. https://doi.org/10.1177/2056305116646393.

Ride Report. 2016. "Ride Report Whitepaper." 2016. https://static.ride.report/static/promosite/assets/whitepaper.ef1622d2516d.pdf.

———. 2018a. "Ride Report Austin." 2018. https://ride.report/austin.

———. 2018b. "Ride Report Portland." 2018. https://ride.report/portland.

Riggs, William, and Kayla Gordon. 2017. "How Is Mobile Technology Changing City Planning? Developing a Taxonomy for the Future." *Environment and Planning B: Urban Analytics and City Science* 44 (1): 100–119. https://doi.org/10.1177/0265813515610337.

Rose, Gillian. 1997. "Situating Knowledges: Positionality, Reflexivities and Other Tactics." *Progress in Human Geography* 21 (3): 305–20. https://doi.org/10.1191/030913297673302122.

Rosenblat, Alex, and Luke Stark. 2016. "Algorithmic Labor and Information Asymmetries: A Case Study of Uber's Drivers." *International Journal of Communication* 10: 27.

Rosenbloom, Sandra, and Maryvonne Pleissis-Fraissard. 2010. "Women's Travel in Developed and Developing Countries Two Versions of the Same Story?" In *Women's Issues in Transportation: Summary of the 4th International Conference, Volume 1: Conference Overview and Plenary Papers*. https://doi.org/10.17226/22901.

Ross, Catherine, Myungje Woo, and Fangru Wang. 2016. "Megaregions and Regional Sustainability." *International Journal of Urban Sciences* 20 (3): 299–317. https://doi.org/10.1080/12265934.2016.1189846.

Rowe, G., and L. J. Frewer. 2000. "Public Participation Methods: A Framework for Evaluation." *Science, Technology & Human Values* 25 (1): 3–29. https://doi.org/10.1177/016224390002500101.

Russell, Stewart. 1986. "The Social Construction of Artefacts: A Response to Pinch and Bijker." *Social Studies of Science* 16 (2): 331–46. https://doi.org/10.1177/0306312786016002008.

Saelens, Brian E., James F. Sallis, and Lawrence D. Frank. 2003. "Environmental Correlates of Walking and Cycling: Findings From the Transportation, Urban Design, and Planning Literatures." *Annals of Behavioral Medicine* 25 (2): 80–91.

Sager, Tore. 2013. *Reviving Critical Planning Theory*. New York: Routledge.

Saldaña, Johnny. 2016. *The Coding Manual for Qualitative Researchers*. Third Edit. Thousand Oaks, CA: SAGE Publications.

Sallis, James F., Robert B. Cervero, William Ascher, Karla A. Henderson, M. Katherine Kraft, and Jacqueline Kerr. 2006. "An Ecological Approach to Creating Active Living Communities." *Annual Review of Public Health* 27 (1): 297–322. https://doi.org/10.1146/annurev.publhealth.27.021405.102100.

Sanchez, Thomas W., and Marc Brenman. 2013. "Public Participation, Social Equity, and Technology in Urban Governance." In *Citizen E-Participation in Urban Governance*, 35–48. IGI Global. https://doi.org/10.4018/978-1-4666-4169-3.ch003.

Sando, Thobias, Renatus Mussa, John Sobanjo, and Lisa Spainhour. 2010. "Quantification of the Accuracy of Low Priced GPS Receivers for Crash Location." *Journal of the Transportation Research Forum* 44 (2): 19–32. https://doi.org/10.5399/osu/jtrf.44.2.821.

Sandoval, Gerardo. 2007. "Catalytic Gaze: Co-Evolutionary Adaptation in an Emerging New Mesoamerican Neighborhood in Los Angeles." https://doi.org/10.1146/annurev.ps.44.020193.001211.

Schafran, Alex. 2013. "Rethinking Mega-Regions: Sub-Regional Politics in a Fragmented Metropolis." *Regional Studies* 48 (4): 1–16. https://doi.org/10.1080/00343404.2013.834043.

Schrock, Andrew R. 2016. "Civic Hacking as Data Activism and Advocacy: A History from Publicity to Open Government Data." *New Media & Society* 18 (4): 581–99. https://doi.org/10.1177/1461444816629469.

Schweitzer, Lisa A. 2014. "Planning and Social Media: A Case Study of Public Transit and Stigma on Twitter." *Journal of the American Planning Association* 80 (3): 218–38. https://doi.org/10.1080/01944363.2014.980439.

Schweitzer, Lisa A., and Nader Afzalan. 2017. "Four Reasons Why AICP Needs an Open Data Ethic." *Journal of the American Planning Association* 83 (2): 161–67. https://doi.org/10.1080/01944363.2017.1290495.

Seltzer, Ethan, and Dillon Mahmoudi. 2013. "Citizen Participation, Open Innovation, and Crowdsourcing: Challenges and Opportunities for Planning." *Journal of Planning Literature* 28 (1): 3–18. https://doi.org/10.1177/0885412212469112.

Shane, Scott. 2017. "The Fake Americans Russia Created to Influence the Election." *New York Times*, September 7, 2017.

Showers, Eric, Nathan Tindall, and Todd Davies. 2015. "Equality of Participation Online Versus Face to Face: Condensed Analysis of the Community Forum Deliberative Methods Demonstration." In *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, edited by Efthimios Tambouris, Panos Panagiotopoulos, Øystein Sæbø, Konstantinos Tarabanis, Maria A. Wimmer, Michela Milano, and Theresa Pardo, 9249:53–67. Springer International Publishing. https://doi.org/10.1007/978-3-319-22500-5_5.

Siddiqui, Chowdhury, Mohamed Abdel-Aty, and Keechoo Choi. 2012. "Macroscopic Spatial Analysis of Pedestrian and Bicycle Crashes." *Accident Analysis and Prevention* 45: 382–91. https://doi.org/10.1016/j.aap.2011.08.003.

Sieber, Renee E, and Peter A Johnson. 2015. "Civic Open Data at a Crossroads: Dominant Models and Current Challenges." *Government Information Quarterly* 32 (3): 308–15. https://doi.org/10.1016/j.giq.2015.05.003.

Singleton, Patrick A., and Kelly J. Clifton. 2014. "Exploring Synergy in Bicycle and Transit Use." *Transportation Research Record: Journal of the Transportation Research Board* 2417 (1): 92–102. https://doi.org/10.3141/2417-10.

Slotterback, Carissa Schively, Bryan Runck, David G. Pitt, Len Kne, Nicholas R. Jordan, David J. Mulla, Cindy Zerger, and Michael Reichenbach. 2016. "Collaborative Geodesign to Advance Multifunctional Landscapes." *Landscape and Urban Planning* 156 (December): 71–80. https://doi.org/10.1016/j.landurbplan.2016.05.011.

Smith, William Roth. 2017. "Communication, Sportsmanship, and Negotiating Ethical Conduct on the Digital Playing Field." *Communication & Sport* 5 (2): 160–85. https://doi.org/10.1177/2167479515600199.

Smith, William Roth, and Jeffrey Treem. 2017. "Striving to Be King of Mobile Mountains: Communication and Organizing Through Digital Fitness Technology." *Communication Studies* 68 (2): 135–51. https://doi.org/10.1080/10510974.2016.1269818.

Söderström, Ola, Till Paasche, and Francisco Klauser. 2014. "Smart Cities as Corporate Storytelling." *City* 18 (3): 307–20. https://doi.org/10.1080/13604813.2014.906716.

Soules, Marshall. 2007. "Jürgen Habermas and the Public Sphere." 2007. http://www.media-studies.ca/articles/habermas.htm.

Spence, Jermiah, Joseph Straubhaar, Zynep Tufekci, Alexander Cho, and Dean Graber. 2012. "Structuring Race in the Cultural Geography of Austin." In *Inequity in the Technolopolis: Race, Class, Gender, and the Digital Divide in Austin*, edited by Joseph Straubhaar, Jermiah Spence, Zynep Tufekci, and Roberta G. Lentz, 33–62. Austin, TX: University of Texas Press.

Sprecher, Susan. 2014. "Initial Interactions Online-Text, Online-Audio, Online-Video, or Face-to-Face: Effects of Modality on Liking, Closeness, and Other Interpersonal Outcomes." *Computers in Human Behavior* 31 (1): 190–97. https://doi.org/10.1016/j.chb.2013.10.029.

Star, S. L., and J. R. Griesemer. 1989. "Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social Studies of Science* 19 (3): 387–420. https://doi.org/10.1177/030631289019003001.

Stephens, Keri K. 2007. "The Successive Use of Information and Communication Technologies at Work." *Communication Theory* 17 (4): 486–507. https://doi.org/10.1111/j.1468-2885.2007.00308.x.

———. 2018. *Negotiating Control*. New York: Oxford University Press. https://doi.org/10.1093/oso/9780190625504.001.0001.

Stephens, Keri K., and Ashley K. Barrett. 2016. "Communicating Briefly." *International Journal of Business Communication* 53 (4): 398–418. https://doi.org/10.1177/2329488414525463.

Stewart, Anson F, P Christopher Zegras, Phil Tinn, and Jeffrey L. Rosenblum. 2018. "Tangible Tools for Public Transportation Planning: Public Involvement and Learning for Bus Rapid Transit Corridor Design." *Transportation Research Record: Journal of the Transportation Research Board*, September. https://doi.org/10.1177/0361198118797462.

Stewart, Leo G., Ahmer Arif, and Kate Starbird. 2018. "Examining Trolls and Polarization with a Retweet Network." *Proceedings of WSDM Workshop on Misinformation and Misbehavior Mining on the Web (MIS2).*, 6. https://doi.org/https://doi.org/10.475/123_4.

Sui, Daniel, Michael Goodchild, and Sarah Elwood. 2013. "Volunteered Geographic Information, the Exaflood, and the Growing Digital Divide." In *Crowdsourcing Geographic Knowldegde: Volunteered Geographic Information in Theory and Practice*, edited by Daniel Sui, Sarah Elwood, and Michael Goodchild, 1–14. New York, NY: Springer.

Tewdwr-Jones, Mark, and Philip Allmendinger. 2002. "Conclusion: Communicative Planning, Collaborative Planning and the Post-Positivist Planning Theory Landscape." In *Planning Futures: New Directions for Planning Theory*, edited by Philip Allmendinger and Mark Tewdwr-Jones. London: Routledge.

Texas Department of Transportation. 2014. "Roadway Design Manual." *Roadway Design Manual*.

Thorpe, Amelia. 2017. "Rethinking Participation, Rethinking Planning." *Planning Theory and Practice* 18 (4): 566–82. https://doi.org/10.1080/14649357.2017.1371788.

Timothy Nyerges. 2005. "Scaling-Up as a Grand Challenge for Public Participation GIS." Directions Magazine. 2005. http://www.directionsmag.com/entry/scaling-up-as-a-grand-challenge-for-public-participation-gis/123341.

Tironi, Martín, and Matías Valderrama. 2018. "Unpacking a Citizen Self-Tracking Device: Smartness and Idiocy in the Accumulation of Cycling Mobility Data." *Environment and Planning D: Society and Space* 36 (2): 294–312. https://doi.org/10.1177/0263775817744781.

Tobler, W. R. 1970. "A Computer Movie Simulating Urban Growth in the Detroit Region." *Economic Geography* 46 (Supplement: Proceedings. International Geographical Union. Commission on Quantitative Methods (Jun., 1970)): 234–40.

Tocqueville, Alexis de. 2002. *Democracy in America*. Edited by trans. Henry Reeve. The Pennsylvania State University.

Trapenberg Frick, Karen. 2016. "Citizen Activism, Conservative Views & Mega Planning in a Digital Era." *Planning Theory & Practice* 17 (1): 93–118. https://doi.org/10.1080/14649357.2015.1125520.

Triplett, Kimberly L. (Stephenson), and Glenn S. Johnson. 2011. "Environmental Justice and Transportation: An Analysis of Public Involvement at Pennsylvania Department of Transportation." *Race, Gender & Class* 18 (3–4): 348–71.

Turner, Shawn, Robert Benz, Joan Hudson, Greg P. Griffin, Phil Lasley, Bahar Dadashova, and Subasish Das. 2018. "Improving the Amount and Availability of Pedestrian and Bicyclist Count Data in Texas." Austin, TX.

U.S. Department of Housing and Urban Development. 2018. "Income Limits." 2018. https://www.huduser.gov/portal/datasets/il.html#2016.

United States Council on Environmental Quality. 2005. *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act*. United States of America.

United States Department of Justice. 1964. "Title VI of the 1964 Civil Rights Act." 1964. http://www.justice.gov/crt/about/cor/coord/titlevistat.php.

US Census Bureau. 2018. "TIGER/Line® with Selected Demographics." 2018. https://www.census.gov/geo/maps-data/data/tiger-data.html.

Vreugdenhil, Roger, and Stewart Williams. 2013. "White Line Fever: A Sociotechnical Perspective on the Contested Implementation of an Urban Bike Lane Network." *Area* 45 (3): 283–91. https://doi.org/10.1111/area.12029.

Walther, Joseph B. 2016. "Social Information Processing Theory." In *The International Encyclopedia of Interpersonal Communication,* edited by Charles R. Berger and Michael E. Roloff. John Wiley & Sons. https://doi.org/10.1002/9781118540190.wbeic0192.

Watson, Vanessa. 2003. "Conflicting Rationalities: Implications for Planning Theory and Ethics." *Planning Theory & Practice* 4 (4): 395–407. https://doi.org/10.1080/1464935032000146318.

———. 2014. "Co-Production and Collaboration in Planning – The Difference." *Planning Theory & Practice* 15 (1): 62–76. https://doi.org/10.1080/14649357.2013.866266.

Weber, Andrew. 2016. "What's Your Best Bike Route in Austin? This New App Aims to Find Out." KUT. 2016. http://www.kut.org/post/whats-your-best-bike-route-austin-new-app-aims-find-out.

Wechsler, Dietmar. 2014. "Crowdsourcing as a Method of Transdisciplinary Research—Tapping the Full Potential of Participants." *Futures* 60 (August): 14–22. https://doi.org/10.1016/j.futures.2014.02.005.

Wee, Bert Van, Karst Geurs, and Caspar Chorus. 2013. "Information, Communication, Travel Behavior and Accessibility." *Journal of Transport and Land Use* 6 (3): 1. https://doi.org/10.5198/jtlu.v6i3.282.

Wells, Chris. 2015. *The Civic Organization and the Digital Citizen: Communicating Engagement in a Networked Age*. New York: Oxford University Press.

Whittemore, Andrew H. 2014. "Phenomenology and City Planning." *Journal of Planning Education and Research* 34 (3): 301–8. https://doi.org/10.1177/0739456X14536989.

Wilson, Matthew, Karen Robson, and Elsamari Botha. 2017. "Crowdsourcing in a Time of Empowered Stakeholders: Lessons from Crowdsourcing Campaigns." *Business Horizons* 60 (2): 247–53. https://doi.org/10.1016/j.bushor.2016.11.009.

Wilson, Patricia A. 1997. "Building Social Capital: A Learning Agenda for the Twenty-First Century." *Urban Studies* 34 (512): 745–60. https://doi.org/10.1080/0042098975808.

Winner, Langdon. 1993. "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology." *Science, Technology, & Human Values* 18 (3): 362–78. https://doi.org/10.1177/016224399301800306.

Xu, Chen, David W Wong, and Chaowei Yang. 2013. "Evaluating the 'Geographical Awareness' of Individuals: An Exploratory Analysis of Twitter Data." *Cartography and Geographic Information Science* 40 (2): 103–15. https://doi.org/10.1080/15230406.2013.776212.

Yin, Robert K. 2014. *Case Study Research Design and Methods*. Thousand Oaks, CA: SAGE.

Yu, Haitao, Junfeng Jiao, Eric Houston, and Zhong Ren Peng. 2018. "Evaluating the Relationship between Rail Transit and Industrial Agglomeration: An Observation from the Dallas-Fort Worth Region, TX." *Journal of Transport Geography* 67 (January): 33–52. https://doi.org/10.1016/j.jtrangeo.2018.01.008.

Yuill, Robert S. 1971. "The Standard Deviational Ellipse; An Updated Tool for Spatial Description." *Geografiska Annaler. Series B, Human Geography* 53 (1): 28. https://doi.org/10.2307/490885.

Zhang, Hongyu, and Jacek Malczewski. 2017. "Quality Evaluation of Volunteered Geographic Information." In *Volunteered Geographic Information and the Future of Geospatial Data*, 19–46. IGI Global. https://doi.org/10.4018/978-1-5225-2446-5.ch002.

Zhang, Ming, and Nishant Kukadia. 2005. "Metrics of Urban Form and the Modifiable Areal Unit Problem." *Transportation Research Record: Journal of the Transportation Research Board* 1902: 71–79. https://doi.org/10.3141/1902-09.

Zhang, Ming, and Wenjia Zhang. 2018. "When Context Meets Self-Selection: The Built Environment–Travel Connection Revisited." *Journal of Planning Education and Research*, February. https://doi.org/10.1177/0739456X18755495.

Zhang, Shanqi. 2019. "Public Participation in the Geoweb Era: Defining a Typology for Geo-Participation in Local Governments." *Cities* 85 (November 2018): 38–50. https://doi.org/10.1016/j.cities.2018.12.004.

Zolnik, Edmund J., and Ellen K. Cromley. 2008. "Poisson Multilevel Methodology of Bicycle Levels of Service for Road Networks." *Transportation Research Record: Journal of the Transportation Research Board* 2031: 1–8. https://doi.org/10.3141/2031-01.

Vita

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