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Closing the Gap or Widening the Divide: The Impacts of Technology-Enabled Coproduction on Equity in Public Service Delivery

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Abstract: *This article investigates how 311 systems affect distributional equity in public service delivery. Many local governments in the United States have adopted interactive 311 platforms to engage citizens in coproduction. Using a novel household-level data set on 311 service requests and power service restoration in the City of Tallahassee, Florida, after Hurricane Michael in 2018, the authors examine possible disparities between racial minority groups and nonminorities in making power service restoration requests via 311. The article further analyzes how coproduction participation through 311 affects distributional equity in power restoration. The findings show that minority groups are more likely to utilize these smart technologies to submit requests for essential services after disasters, as they may have greater needs but less political capital to reach out to the government. Their utilization of e-governance technologies has helped them gain more attention from the government, which narrows the equity gap in service delivery.*

Evidence for Practice

- E-governance technologies provide "digital capital" to historically disadvantaged groups to change the distributional disparities in public service delivery.
- Since the internet and smartphones have become more prevalent, interactive 311 service platforms supported by these technologies provide an alternative and convenient channel for disadvantaged citizens to interact with the government and participate in coproduction.
- Minority groups are more likely to utilize smart technologies to submit service requests when they have greater needs for specific services.
- By making service requests, minority neighborhoods can obtain faster service delivery, which can narrow the equity gap in service delivery.
- Increasing minority communities' awareness and acceptance of e-governance technologies is an important initial step to facilitate the utilization of this "digital capital."

In pursuit of smart governance, governments have adopted various information and communication technologies (ICTs) over the past two decades. The rapid diffusion of Web 2.0 and mobile technologies has provided alternative channels for public agencies to collaborate with citizens in the production of public services. This technology-enabled coproduction is also referred to as "e-governance" (we use these two terms interchangeably hereafter) (Dawes 2008; Dunleavy et al. 2006; Meijer 2015; Meijer and Bolívar 2016). One popular e-governance technology adopted at the local level is the two-way 311 platform, which allows citizens to report nonemergency service issues to governments through a web portal or mobile app. Compared with traditional 311 hotlines, the web portal and mobile app allow citizens to make nonemergency service requests to the government with geocoded addresses and photos, submit comments, and monitor the entire process of service delivery (Tang et al. 2019).

These features supported by e-governance technologies have great potential to transform the coproduction process (Sorrentino, Sicilia, and Howlett 2018) First, internet and mobile technologies enable ubiquitous coproduction from any location at any time, which can lower coproduction costs and encourage greater participation (Linders 2012). Second, government-to-citizen and citizen-to-citizen interactivity supported by these e-governance platforms can foster a sense of community among all stakeholders (Meijer 2011; Sorrentino, Sicilia, and Howlett 2018). Moreover, the real-time and location-specific service request information provided by citizens can help governments improve service efficiency and effectiveness (Tang et al. 2019).

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Despite the benefits of e-governance technologies, their potential negative effects are noted by scholars and practitioners. One vital issue is equity (Sorrentino, Sicilia, and Howlett 2018). The existing literature has focused on disparities in coproduction participation and provided inconclusive findings. Several studies report that citizens with low socioeconomic status (SES) and racial minorities are less likely to coproduce through 311 (Pak, Chua, and Moere 2017; Thomas and Streib 2003), which might exacerbate existing disparities in public service provision between disadvantaged and advantaged citizens (Bovaird 2007; Rosentraub and Sharp 1981). In contrast, other studies report that 311 service apps encourage disadvantaged citizens to participate in coproduction because of their low cost and convenience (Clark, Brudney, and Jang 2013; Tang et al. 2019), potentially reducing disparities. However, empirical research to examine the ultimate impacts of these e-governance technologies on equity in service outcomes is rare (Clark et al. 2020). Particularly, we know relatively little about local governments incorporate 311 requests information in their service delivery decision-making and how this process influences the distribution of public services to different groups.

To fill this knowledge gap, we investigate how technology-enabled coproduction affects distributional equity in service delivery. Specifically, we ask, *does 311-based coproduction benefit historically disadvantaged groups or increase existing equity gaps in service delivery*? We define "historically disadvantaged groups" as racial groups that have been subjected to prejudice in American society based on the U.S. Code of Federal Regulations (https://gov.ecfr.io/cgi-bin/ECFR?page=browse). Except for non-Hispanic whites, all other racial groups are designated as socially disadvantaged groups. Following the service distribution literature, we define "service delivery" as getting municipal service to citizen customers (Jones 1977; Jones et al. 1978; Sharp 1980). To test our research question, we use the City of Tallahassee, the capital city of Florida, to examine how citizen coproduction via 311 affects the distributional equity in service restoration after disasters.

Tallahassee, like many local governments in the United States and Europe, utilizes a two-way 311 platform that it dubs "DigiTally," which can be accessed online and through a mobile app (Figure A1). In the fall of 2018, Hurricane Michael resulted in citywide power outages and service disruptions in Tallahassee. Power service was one of the critical services that the city government was trying to recover. Citizens can report power outages through DigiTally, which helped the municipal utility accurately locate power outages, track restoration progress, and allocate resources to fix the power issues throughout the city. Given that nearly all households had power outages, this extreme case gives us a unique opportunity to observe citywide service delivery equity.

We utilize a novel household-level data set that combines big data from smart meters to accurately capture household-level power outage status, all service request data from DigiTally, and census data (Feiock and Xu 2019). This fine-grained data set allows us to identify the SES of each household, which overcomes the data limitation of previous studies using census block group data (Clark, Brudney, and Jang 2013). We also use interviews with city government officials who are involved in DigiTally management and power restoration to buttress and add nuance to our regression results. We find that historically disadvantaged groups are more likely to report power outages through DigiTally compared with nonminority households. City government prioritizes service delivery to communities with higher service demands; the power outage map on DigiTally is one tool that it uses to identify service demands in different communities. A higher level of 311 service requests from minority households helps them get faster service delivery, which narrows the equity gap in power restoration between minorities and nonminority households.

Our study adds theoretical and practical contributions and offers new insights into coproduction in the digital age. Extending the technology-enabled coproduction literature (Clark, Brudney, and Jang 2013; Clark et al. 2020), our study sheds light on how local governments utilize 311 requests data in service delivery decision-making and how it can reshape the distributional equity. The Tallahassee case suggests that 311 has provided a new coproduction channel for historically disadvantaged groups that lack the economic or political capital to participate in traditional coproduction. Minority groups often have greater needs for certain types of public services than citizens with high SES (Jones 1977; Nabatchi, Sancino, and Sicilia 2017; Sharp 1980, 1984; Thomas 1982; Verba and Nie 1987). Since access to smartphones and the internet has become almost ubiquitous (O'Brien 2016; Tang et al. 2019), historically disadvantaged groups are more likely to utilize 311 apps or websites to report their service needs when they have less political capital to reach out to the government. Their utilization of e-governance technologies can help them gain more attention from the government, which bridges the equity gap in service delivery.

Literature Review: Coproduction and Its New Trends in the Digital Age

Coproduction in Public Service Delivery

Coproduction has seen a global resurgence in government practice and research in recent years (Nabatchi, Sancino, and Sicilia 2017; Yang and Schachter 2012). As originally formulated by Elinor Ostrom and colleagues (Ostrom 1972, 1996; Ostrom and Ostrom 1977; Parks et al. 1981), "coproduction" is defined as "the process through which inputs used to provide a good or service are contributed by individuals who are not 'in' the same organization" (Ostrom 1996, 1073). Later studies identify three broad types of coproduction of public services: (1) citizen requests for assistance from public agencies, (2) assistance provided by citizens in public service delivery, and (3) interaction between citizens and public agencies to adjust each other's service expectations and actions (Whitaker 1980).

Coproduction can provide different values to transform public service delivery (Nabatchi, Sancino, and Sicilia 2017). Early research emphasized its instrumental values to improve the efficiency and effectiveness of public services (Alford 1998; Levine and Fisher 1984; Ostrom 1996). More recent work considers coproduction as a way to provide long-term interaction between government and citizens (Alford 2009; Bovaird 2007; Brandsen and Honingh 2016; Joshi and Moore 2004), which supports normative values such as democratic governance, social capital, and accountability (Jakobsen and Andersen 2013; Kim and Lee 2012; Meijer 2011; Ostrom 1996).

Technology-Enabled Coproduction in the Digital Age

In this article, we focus on the first of the three types of coproduction identified by Whitaker (1980): citizen service requests. Citizen service requests provide necessary information to local governments concerning service needs and shortfalls (Whitaker 1980). In the traditional service delivery model, citizens are viewed as passive customers waiting for governments to discover nonemergency service issues and fix them. Adopting the coproduction model, many local governments encourage citizens to report their service requests, which helps governments identify and solve problems timely.

In the digital age, coproduction through reporting service needs has received increased attention (Clark et al. 2020; Meijer 2015; Pak, Chua, and Moere 2017; Sjoberg, Mellon, and Peixoto 2017; Tang et al. 2019). Local governments around the world have adopted smart ICTs to support two-way 311 service request platforms and engage citizens in coproduction. These smart technologies can transform the coproduction process as they enable ubiquitous coproduction, enhance transparency and interactivity, and generate real-time and location-specific service request data to improve decision-making (Linders 2012; Meijer 2011; Sjoberg, Mellon, and Peixoto 2017; Sorrentino, Sicilia, and Howlett 2018; Tang and Ho 2019).

Despite the transformative potential, limited empirical studies have been conducted on service delivery outcomes from technology-enabled coproduction (Clark and Guzman 2017; Hartmann, Mainka, and Stock 2017; Nam and Pardo 2014; Schwester, Carrizales, and Holzer 2009). Thus far, one stream of research has studied the intermediate outcome of technology-enabled coproduction—citizen participation (Chatfield and Reddick 2018; Clark, Brudney, and Jang 2013; O'Brien 2016; O'Brien et al. 2017), particularly the disparities in coproduction participation on 311 among different SES and racial groups. Empirical studies on 311 participation in various cities in the United States and Europe show mixed findings. Evidence from citizen participation in the web-based 311 service platform in Brussels suggests that this coproduction platform marginalized low-income and racial minority communities because of the digital divide (Pak, Chua, and Moere 2017). In contrast, recent 311 studies on Boston and San Francisco do not find significant differences in 311 participation across different SES and racial groups (Clark, Brudney, and Jang 2013; Clark and Brudney 2018). Moreover, the emergence of 311 apps can bridge the digital divide because of their convenience for coproduction (Clark, Brudney, and Jang 2013).

Still, little is known about how technology-enabled coproduction affects the ultimate distributional equity in service delivery. To the best of our knowledge, there has been only one study to empirically examine whether governments respond differently to 311 requests made by different SES and racial groups in 15 U.S. cities (Clark et al. 2020). However, it does not investigate how service departments incorporate 311 request data in service delivery decision-making and how this process affects citywide service distribution across different demographic groups.

To address this intellectual gap, we draw on the local service distribution literature and the coproduction literature to explain how technology-enabled coproduction affects distributional equity in service delivery in the following section.

Theoretical Framework: Technology-Enabled Coproduction and Service Delivery Equity

Studies on local service distribution focus on "the level of municipal services provided to different groups in the metropolis" (Jones et al. 1978; Sharp 1980, 1982). Previous findings have revealed that public service delivery may be biased against historically disadvantaged groups. With the development of e-governance technologies, the coproduction literature argues that technology-enabled coproduction can improve the effectiveness and efficiency of service delivery. Extending these two streams of research, we develop theories to investigate how these two factors interact to influence the distributional outcome of service delivery. Figure 1 illustrates the theoretical framework.

Disparities in Public Service Delivery

To investigate how technology-enabled coproduction changes the distributional equity in service delivery, the first question to examine is whether disparities exist without the use of e-governance technologies. Studies on local service distribution reveal that historically disadvantaged communities experience difficulties receiving public services compared with affluent nonminority communities. With limited fiscal and political resources, disadvantaged neighborhoods often have inadequate electricity and water infrastructure, unmaintained roads and public spaces, and dismal public school systems (Goldsmith and Blakely 2010; Lichter, Parisi, and Taquino 2012; Sampson 2009).

Such disparities in service delivery are exacerbated during disasters, as power, water, solid waste management, and transportation systems are all crippled (Peacock, Dash, and Zhang 2007; Tatsuki

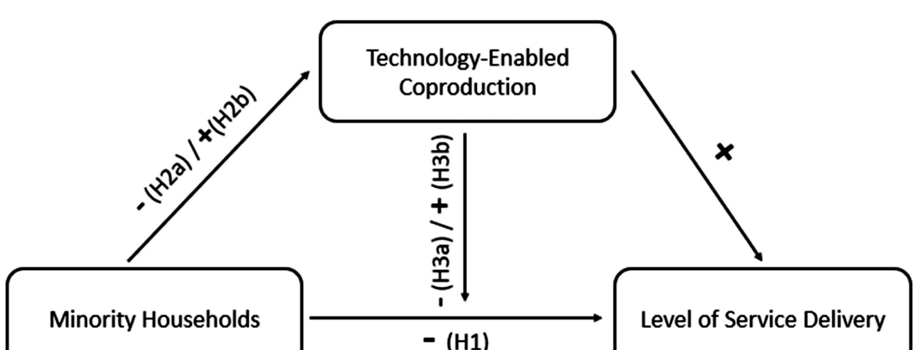

Figure 1 Theoretical Framework

and Hayashi 2002; Zhang and Peacock 2009). Affected citizens all seek access to these basic public services simultaneously. Neighborhoods with better infrastructure or stronger political capital may be able to capture these finite resources before others (Olshansky, Hopkins, and Johnson 2012). In contrast, historically disadvantaged populations disproportionately reside in old neighborhoods with concentrated poverty (Lichter, Parisi, and Taquino 2012; Sampson 2009), and they are often marginalized from local political and economic decisions (Olshansky, Lewis, and Johnson 2012). Empirical evidence from Hurricane Katrina indicates that governments' emergency response tended to aid more affluent nonminority communities over poor minority communities (Elliott and Pais 2006; Turner and Zedlewski 2006). After Hurricane Hermine, a lawsuit was filed against the Tallahassee Utility, claiming that the city utility showed favoritism toward certain affluent communities during power service restoration (Burlew 2017). Based on these historical practices and evidence before the widespread adoption of 311, we expect that similar disparities exist in disaster recovery for citizens who do not participate in technology-enabled coproduction.

Hypothesis 1: Without participating in technology-enabled coproduction, historically disadvantaged groups are more likely to experience slower service delivery.

Disparities in E-Governance Participation?

The ability of e-governance technologies to break the divide between citizens and the government and distributional equity in services depends on citizens' utilization of these tools. Whether technologies increase socioeconomic inequality in citizen coproduction participation has long been debated (Bimber 2001; Clark, Brudney, and Jang 2013; DiMaggio et al. 2001; Krueger 2002; Norris 2010).

Pessimistic scholars argue that technological innovations will exacerbate unequal participation in coproduction because of variation among individuals in terms of their access to ICTs, their understanding of digital devices, and their use of ICTs (i.e., the "digital divide") (Best and Krueger 2005; Norris 2001; Van Deursen and Van Dijk 2011). Previous studies reported that minority and low-SES populations in the United States had limited access, experience, or training to use new ICTs, which limited their ability to fully participate in e-governance (Nash 2011; Schradie 2011). Some minority groups are less likely to coproduce via 311 platforms because of education or language barriers (Pak, Chua, and Moere 2017). From this perspective, we hypothesize the following:

Hypothesis 2a: Historically disadvantaged groups are less likely to participate in technology-enabled coproduction.

In contrast, the more optimistic position argues that innovation in ICTs reduces the costs of e-governance technologies, which encourages historically disadvantaged groups to get involved in public life (Dimitrova and Chen 2006; Krueger 2002; Norris 2001; Ward, Gibson, and Lusoli 2003; Weber, Loumakis, and Bergman 2003). This "mobilizing effect" has been supported by empirical evidence, which suggests that the internet increased political participation among people who are less likely to participate through traditional channels (Nam 2012). Recent studies have found that access to smartphones is not a significant barrier for historically disadvantaged groups to participate in coproduction. Instead, citizens consider mobile apps to outperform other digital platforms by affording them a more convenient way to interact with the local government with reduced costs and effort (O'Brien et al. 2017; Tang et al. 2019). Clark, Brudney, and Jang (2013) suggest that smartphone apps may help bridge the digital divide between affluent communities and low-income communities compared with 311 hotlines and web portals.

In addition to the reduced costs and convenience of Web 2.0 and mobile technologies, variation in service needs between the historically disadvantaged groups and affluent nonminority communities can motivate minorities to use e-governance tools. Minority groups often have greater needs for critical public services, and this gap becomes more conspicuous during disasters (Jones 1977; Jones et al. 1978; Olshansky 2005; Olshansky, Lewis, and Johnson 2012; Thomas 1982; Thomas and Melkers 1999). With better financial capacity, affluent residents have more alternatives to adapt to natural disasters, such as evacuation. With limited alternatives, disadvantaged groups can only stay at home or in shelters. These disadvantaged groups have higher needs for power restoration and debris removal, yet they have less political capital to influence government decision-making (Lichter, Parisi, and Taquino 2012). With limited political power, e-governance platforms become a crucial resource that minorities can mobilize to interact with the government and convey their service needs. Following this optimistic perspective, we hypothesize the following:

Hypothesis 2b: Historically disadvantaged groups are more likely to participate in technology-enabled coproduction.

Technology-Enabled Coproduction and Equity in Service Delivery

To examine how technology-enabled coproduction affects the distributional outcome of service delivery, it is important to understand how local governments incorporate these citizen inputs from 311 into service delivery routines. Based on the literature on e-governance and service delivery rules, we propose two layers of interaction that help predict the distributional outcome.

At the individual level, citizens who submit service requests via 311 are more likely to get faster service delivery compared with citizens who do not participate in 311, all other things being equal. With citizen participation, coproduction can improve the efficiency and effectiveness of public service delivery (Bovaird 2007; Brudney and England 1982; Parks et al. 1981; Thomas 2013). Technology innovation for coproduction, such as 311 mobile apps and web platforms, allows citizens to submit service requests immediately with location information and photos to illustrate the service issues (Tang et al. 2019). These advantageous features of 311 platforms can help governments identify service problems more accurately and allocate resources to solve these problems faster. Therefore, if minority households citizens are more likely to submit service requests using 311 (hypothesis 2b), they are likely to get faster power restoration than before, which may mitigate the existing service delivery gap. In contrast, if hypothesis 2a is true, it may even enlarge the existing service delivery gap between the minority group and the nonminority group.

At the community level, communities that have a higher level of service requests are more likely to get the local government's response first. Studies on local service delivery have argued that most service delivery rules are born of efficiency considerations (Jones et al. 1978; Lyons, Lowery, and DeHoog 1992; Mladenka 1989; Schachter 2007). Citizen service requests via 311, with accurate location information in real time, can save government human resources from searching and locating service needs (Bovaird 2007; Brudney and England 1982; Parks et al. 1981; Thomas and Streib 2003). Thus, local governments are likely to provide services as a consequence of citizen requests as they reflect citizen needs for services. Early empirical evidence from environmental enforcement and solid waste management has suggested that these departments assign routes based on citizen requests and the use of the service (Jones et al. 1978). With new features of the open 311, all service requests are reflected on a map, and the entire process can be tracked by the public (Tang et al. 2019). Given the transparency and public pressure, governments may be even more likely to prioritize service delivery to communities with higher service demand. Hence, if minority communities are more likely to submit service requests via 311 (hypothesis 2b), they are more likely to get faster service delivery than nonminority communities, which can help narrow the existing equity gap in service delivery. In contrast, if hypothesis 2a is true, coproduction via 311 is likely to exacerbate the disparities.

Hypothesis 3a: Technology-enabled coproduction is likely to exacerbate the disparities in service delivery.

Hypothesis 3b: Technology-enabled coproduction is likely to mitigate the disparities in service delivery.

Methods

Sample and Data

We test our hypotheses in the context of Tallahassee's power restoration after Hurricane Michael in 2018. The Tallahassee government launched its two-way 311 system "DigiTally" in 2013. DigiTally can be accessed online and through mobile apps. Service requests made through phone calls are also entered into the DigiTally system by the Customer Operation Center. The city has been actively encouraging citizens to submit nonemergency service requests, such as power outages, potholes, and broken infrastructure, and to monitor the service delivery process. Tallahassee can be viewed as an extreme case for e-governance among midsize U.S. cities because of the city government's progressiveness in ICT innovation and community engagement (Tang et al. 2019). In addition, the city has a relatively young and well-educated population that is more likely to embrace new ICTs. However, the percentage of the population that is historically disadvantaged is 44.6 percent, which is higher than the national level in 2018 (U.S. Census Bureau 2018). Having an ideal environment for e-governance, Tallahassee may represent a best-case scenario for us to explore how technology-enabled coproduction affects service distributional equity in midsize cities.

We focus on power service restoration after a hurricane to control for service issue prevalence. Minority communities and affluent nonminority communities within the city may have different levels of issue prevalence for a given service. For example, there could be more potholes in minority neighborhoods because of the lack of maintenance. However, affluent communities may have more service issues related to parks and recreation. Thus, the level of issue prevalence is a vital confounder in explaining the variation in e-governance participation across communities, though it has not received enough attention in previous empirical research. In October 2018, Hurricane Michael hit Tallahassee as a Category 3 hurricane, which resulted in a citywide power outage. Ninety-seven percent of customers served by the Tallahassee Utility experienced a power outage after this hurricane. Therefore, this service issue as prevalent in every community in Tallahassee.

To test how citizen coproduction via 311 affects equity in power service delivery across ethnic groups, we compile a household-level data set. This novel fine-grained data set combines power service request data from DigiTally, power outage status collected by the utility's smart meters, demographic data from the U.S. Census Bureau and Leon County, which enables us to compare service restoration times of those who submitted service requests through DigiTally and those who did not. To avoid the simultaneity bias between service restoration time and 311 request submission, we only select the power restoration requests submitted during the first two days after the hurricane (appendix B provides a detailed discussion on sampling strategies). Within this time frame, 688 requests were submitted by citizens through DigiTally web portal or app. After removing duplicated service requests, 665 households that participated in coproduction via DigiTally are included in our sample. To compare with those who did not participate in 311 coproduction, we draw a random sample of 3,000 households from the remaining 79,000 residential households that experienced a power outage but did not report outage issues through DigiTally.

To further understand how Tallahassee government incorporates 311 request data into its service delivery routines, we rely on an analysis of in-depth interview data to supplement our quantitative analyses. Two rounds of face-to-face semistructured interviews were conducted with 15 city government officials from different departments, with each lasting 45 to 90 minutes. Table 1 reports the departments of the interviewees. In the summer of 2017, we interviewed 11 officials who were directly involved in the development and management of the DigiTally system to understand how DigiTally was adopted and utilized in each department and how they promoted it to citizens. The second round of interviews were conducted with officials from the utility and information technology department in the spring of 2019, with a focus on how DigiTally request data and smart meter data were

Table 1 Interview Sample Descriptive Information

	Departments	Number of Respondents
Round 1		
Summer2017	Office of Communication; Parks, Recreation, Neighborhood Affairs Department; Office of Technology and Innovation; Customer Operation Center; Office of the City Manager; Policy Department; Office of Public Transportation (StarMetro); City Utilities	11
Round 2		
Spring 2019	Office of Technology and Innovation; City Utilities	4

managed and utilized in power restoration decision-making after Hurricane Michael (Table C1 summarizes our interview analysis).

Models and Measurement

We estimate five models to test our hypotheses. Table 2 provides a detailed description of all variables, and Table 3 reports the summary statistics. Table 4 reports our empirical models and results.

Empirical Model for Coproduction Participation. Model 1 tests whether historically disadvantaged groups are less likely to participate in technology-enabled coproduction (hypothesis 2). The dependent variable is citizen participation in technology-enabled coproduction. As defined in the theoretical framework, we study one type of coproduction: citizen service requests (Whitaker 1980). In the digital era, e-governance technologies such as 311 enable citizens to submit service requests online or via mobile apps and monitor the entire service delivery process. Following previous 311 studies (Clark, Brudney, and Jang 2013; Clark and Brudney 2018; Minkoff 2016), we measure 311-based citizen coproduction for power service using a binary variable that captures whether a household submitted a power restoration request to DigiTally after Hurricane Michael. We use logistic regression to estimate model 1.

The explanatory variable is the minority status of a household, measured as the percentage of minority household members among all household members. As discussed, our classification of minority groups follows the Code of Federal Regulations. Except for non-Hispanic whites, all other racial groups are categorized as minority groups. Existing studies on distributional biases in coproduction use the percentage of minority residents in a census block group or census tract to measure minority status (Clark, Brudney, and Jang 2013; Minkoff 2016). With a fine-grained data set, we are able to measure minority status at the household level. As shown in figure 2, only a few households have mixed racial composition. Most households in our sample can be classified as 100 percent minority households or nonminority households. Figure 3 presents the spatial distribution of service requests and the racial composition of households in the city.

We also include control variables that may affect technology-enabled coproduction. Following existing 311 research (Clark, Brudney, and Jang 2013; Pak, Chua, and Moere 2017), we control for a vector of SES variables, including the median income in the block group, age of the house, percentage of age groups in a household, education level, and percentage of renters in the block group. Among age groups, we control for the percentage of the elderly in the household because the digital divide literature suggests that the elderly population is less likely to use the internet and mobile apps and therefore to participate less in technology-enabled coproduction (Van Deursen and Van Dijk 2011). In addition to the

Table 2 Measurements and Data Sources

Variable	Measurements	Data Source
Dependent variables		
Coproduction participation	If a household reported power outage through DigiTally. (Binary: yes = 1, no = 0)	City of Tallahassee Utility, DigiTally system, 2018
Service restoration	Number of hours it took to restore electricity service for a household after power outage (Count: 0–288)	City of Tallahassee Advanced Metering Infrastructure Database, 2018
Explanatory variables		
Minority household	Percentage of minority residents in the household	Leon Country voter registration records, 2017
Community participation	Number of total requests submitted in each census block group	City of Tallahassee Utility, DigiTally system, 2018; U.S. Census Bureau, 2018 American Community Survey
Control variables		
Population density (logged)	The number of people per square mile in a census block group	U.S. Census Bureau, 2018 American Community Survey
Median income (in thousands)	Household median income by block group	U.S. Census Bureau, 2018 American Community Survey
Age of house	Age of house (household level)	Leon County Property Appraiser, 2018
Education	Percentage of people who have a bachelor's degree or higher in the block group	U.S. Census Bureau, 2018 American Community Survey
Elderly: 60 years or older	Percentage of residents in a household who are 60 or older	Leon County Property Appraiser, 2018
College students: 18–24 years	Percentage of residents in a household who are between 18 to 24 years old	Leon County Property Appraiser, 2018
Renter percentage	Percentage of people who are renting in the block group	U.S. Census Bureau, 2018 American Community Survey

Table 3 Summary Statistics

Variable	Obs.	Mean	SD	Min.	Max.
Dependent variables					
Coproduction participation	3,515	0.146	0.354	0	1
Service restoration	3,515	75.134	35.187	0	288
Explanatory variables					
Minority household	3,515	0.21	0.387	0	1
Community participation	3,515	5.455	10.039	0	54
Control variables					
Population density (logged)	3,515	7.76	0.495	4.089	9.674
Median income (in thousands)	3,515	89.043	27.139	10.307	134.25
Age of house	3,515	36.767	12.05	3	121
Education	3,515	0.576	0.129	0	0.876
Elderly: 60 years or older	3,515	0.359	0.48	0	1
College students: 18–24 years	3,515	0.008	0.09	0	1
Renter percentage	3,515	0.066	0.108	0	0.715

Table 4 Empirical Results

Dependent Variable	Coproduction Participation	Service Restoration			
	1	2	3	4	5
Minority household	0.842*** (0.192)	0.044** (0.020)	0.103*** (0.023)	0.062*** (0.020)	0.060*** (0.023)
Coproduction participation		−0.134*** (0.029)	−0.069** (0.033)		
Minority household * Household participation			−0.259*** (0.049)		
Community participation				−0.012*** (0.001)	−0.012*** (0.001)
Minority household * Community participation					0.0003 (0.002)
Control variables					
Age of house	0.019*** (0.006)	0.011*** (0.001)	0.011*** (0.001)	0.011*** (0.001)	0.011*** (0.001)
Median income (in thousands)	−0.063*** (0.005)	0.005*** (0.0004)	0.005*** (0.0004)	0.005*** (0.0003)	0.005*** (0.0003)
Population density (logged)	−1.962* (0.199)	−0.039** (0.017)	−0.023 (0.017)	0.018 (0.017)	0.017 (0.017)
Education	−2.522*** (0.869)				
Elderly: 60 years or older	−0.947*** (0.191)				
College students: 18–24 years	0.580 (0.733)				
Renter percentage	9.813*** (0.945)				
Constant	17.878*** (1.673)	3.766*** (0.147)	3.676*** (0.148)	3.379*** (0.142)	3.383*** (0.143)
Observations	3,515	3,515	3,515	3,515	3,515
Log likelihood	−598.8	−17,038	−17,024	−16,974	−16,974
Pseudo R^2	0.688	0.164	0.171	0.194	0.194

Notes: Model 1 reports odds ratios from the logit model. Models 2–5 report incidence rate ratios from negative binomial regression.
$^*p<.1$; $^{**}p<.05$; $^{***}p<.01$.

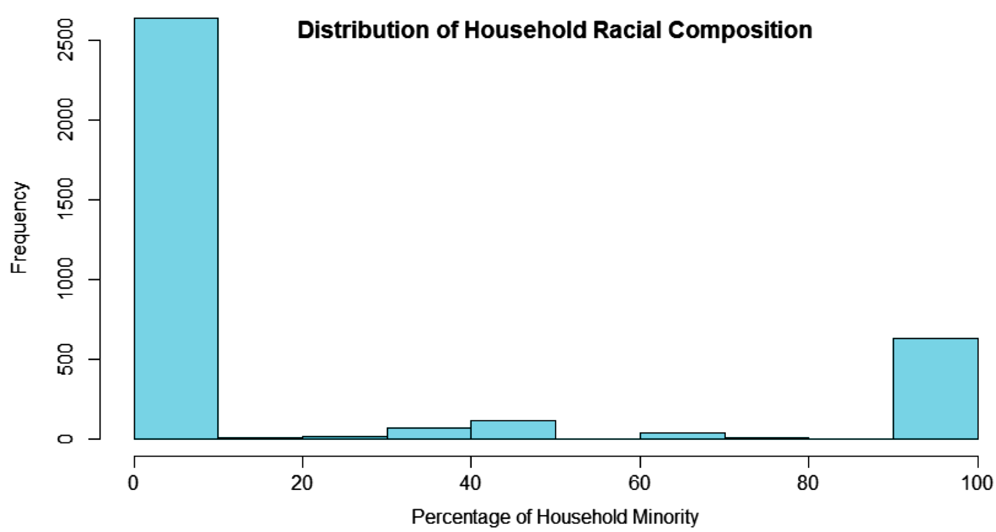

Figure 2 Distribution of Household Racial Composition

SES variables, we also control for population density to capture the neighborhood effects on coproduction participation.

Empirical Models for Equity in Service Delivery. Next, we estimate the impacts of technology-enabled coproduction on distributional equity in service delivery (hypothesis 1 and hypothesis 3). Distributional equity concerns “the level of municipal services distributed to different groups” (Jones et al. 1978; Sharp 1980, 1982, 1984; Clark et al. 2020). We estimate distributional impacts by interacting minority households and coproduction participation to examine the level of services distributed to different racial groups and whether technology-enabled coproduction makes a difference.

In models 2–5, the dependent variable is power service restoration time. Service delivery is defined as getting service to citizen-consumers (Jones et al. 1978; Sharp 1980; Whitaker 1980). In our case, service delivery is restoring electricity service to customers after the hurricane. Given that electricity service is generic, the best way to capture and compare the level of service distributed to different groups is to use the power service restoration time, which is measured as the number of hours the power outage lasted at the household level after the hurricane hit Tallahassee. Our measurement is consistent with the performance measure used in previous 311 studies (Clark et al. 2020; Sjoberg, Mellon, and Peixoto 2017), which use response time to assess how quickly local governments respond to 311 requests. However, the response time for 311 requests does not capture service delivery for citizens who do not make service requests on 311 platforms. In addition, it may suffer from data input errors. To investigate how 311-enabled coproduction affects citywide service distribution and to reduce measurement errors, service restoration time is calculated using objective data from the Tallahassee Utility’s smart meter system, which automatically records the electricity consumption of each household every 30 minutes. Since service restoration time is a count variable that is overdispersed, we use negative binomial regression to estimate models 2–5 (Hilbe 2011).

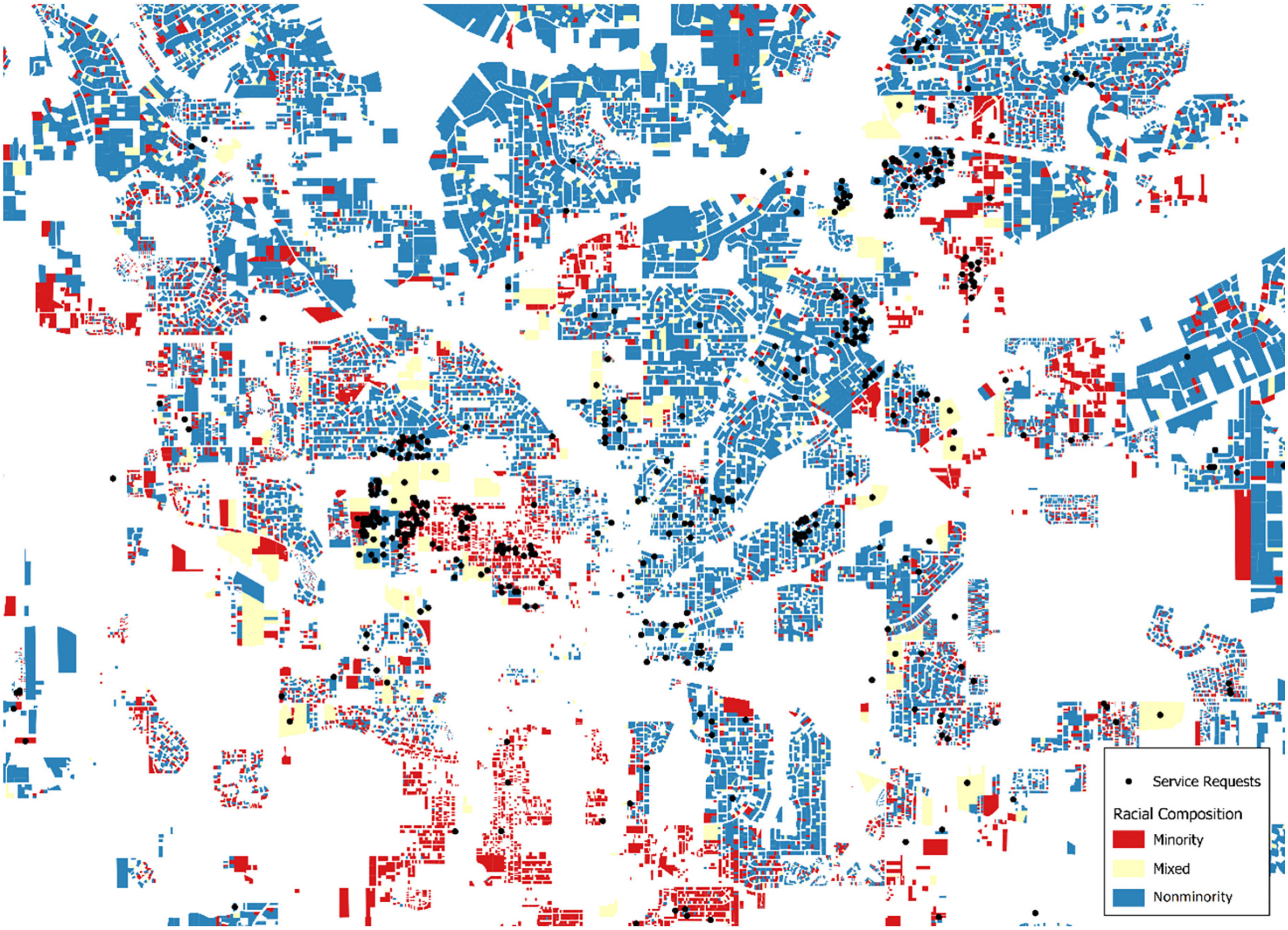

Figure 3 Spatial Distribution of Service Requests and Racial Composition of Households

The explanatory variables for models 2–5 are minority household and coproduction participation. To investigate how distributional equity is affected by individual-level coproduction and community-level coproduction participation, we measure coproduction participation at the household level and the census block group level, respectively. Models 2 and 3 test the impacts of household-level coproduction, while models 4 and 5 use community-level coproduction participation to test whether the local government prioritizes communities with higher 311 requests. In models 3 and 5, we add the interaction terms between minority and coproduction participation at different levels to test how coproduction participation affects service restoration time across different racial groups. While we identify distributional inequity in service delivery between the historically disadvantaged groups and nonminority groups, we do not claim a causal relationship between race and service restoration.

We include population density, median income, and age of the house as control variables. The median income and age of the house are proxies to measure the quality of infrastructure in a neighborhood. We assume that it takes longer to restore electricity service for communities with poor infrastructure. We also control population density as a neighborhood with higher population density are more likely to submit more 311 requests. In addition, service restoration decision-making may also be affected if the service department follows the "efficiency" principle to prioritize service delivery (Jones et al. 1978; Lyons, Lowery, and DeHoog 1992; Mladenka 1989; Schachter 2007).

Results

Participation in Technology-Enabled Coproduction

Table 4 presents the regression results for the five models. From model 1, we observe that historically disadvantaged groups are more likely to participate in coproduction through the interactive 311 platforms after the hurricane. The coefficient on minority households (0.842) indicates that the odds that a minority household requests service restoration through DigiTally is 1.32 (*exp* [0.842] – 1) times higher than the odds for a nonminority household. Regarding the debate on the disparities in technology-enabled coproduction, this result confirms hypothesis 2b, that historically disadvantaged groups are more likely to participate.

Our SES control variables reveal a similar pattern. Residents in older houses or living in neighborhoods with lower income and education are more likely to request power restoration via DigiTally. Given that disadvantaged populations disproportionately reside in the older and poor neighborhoods, their pattern of coproduction conforms with our explanation to hypothesis 2b. Historically disadvantaged groups are more likely to submit service requests to DigiTally as they have greater needs for essential services, such as electricity and water, after the hurricane, while advantaged groups have more alternatives to adapt to disasters.

Consistent with the "digital divide" argument, we also observe that elderly residents are less likely to use smart technologies to report service issues. The negative coefficient on the population density in a block group suggests that people are less likely to submit service requests if they live in a populous neighborhood. It could be the "bystander effect" that people rely on others in the community to report power outages.

Distributional Equity in Service Delivery

Models 2 and 3 examine distributional equity in service restoration and how coproduction participation through the 311 system influences distributional equity. Model 2 shows that power restoration time for minority households is significantly longer than restoration time for nonminority households and that households that submit service requests to DigiTally experience faster restoration.

In model 3, we add an interaction term between minority household and coproduction participation to further examine how e-governance participation moderates the disparity in service restoration. Among residents who did not submit power service requests through DigiTally, the coefficient on the minority household (0.103) suggests that power restoration time for minority households is 10.85 percent (*exp* [0.103] – 1) longer than the restoration time for nonminority households. This result confirms hypothesis 1, that historically disadvantaged groups are more likely to experience slower service delivery among people who do not participate in coproduction. Our interviews with the city utility confirm that minority neighborhoods may experience longer restoration time as they have poor infrastructure, such as poorly maintained trees, grid systems, and roads (appendix C presents related interview quotes). Through participation in DigiTally, minority households obtained significantly faster power restoration than the nonminorities. On average, power restoration time for minority households that submitted service requests is 14.44 percent (*exp* [0.103 – 0.259] – 1) shorter than the restoration time of nonminority households that participated on DigiTally and 20.14 percent (*exp* [0.103 – 0.069 – 0.259] – 1) shorter than nonminority households that did not report power outages on DigiTally. Therefore, these results suggest that historically disadvantaged groups may greatly benefit from 311-based coproduction and that technology-enabled coproduction can help narrow or even close the equity gap in service delivery. This finding confirms hypothesis 3b.

We estimate models 4 and 5 to further investigate if the number of 311 service requests in a community affects service restoration time for individual households. As discussed earlier, community-level service demand reflected by 311 requests may influence the local government's priority in service delivery. The results in models 4 and 5 show that residents who live in a census block group with a higher level of 311 service requests are more likely to get service restoration faster. The coefficient on community participation suggests that one additional service request from a block group will reduce the average power restoration time by 1.19 percent for households in that block group. The utility representative mentioned in the interview that the utility used the power outage map to check outstanding power outages in service restoration and tried to "get many on as quickly as we can." The utility respondent also confirmed that many "decisions are made by efficiency" and that the utility prioritized neighborhoods with larger service demands when restoring residential electricity service. This qualitative evidence, together with our regression results, suggests that the city utility followed the efficiency rule in service delivery. By assessing the power outage map, it was likely to restore power services for communities with higher service requests first.

In model 5, we add an interaction term between minority household and community participation to test whether the service delivery prioritization based on community requests creates any distributional disparities between racial groups. The insignificant coefficient on the interaction term indicates that this service delivery rule does not affect minority households and nonminority households differently. This finding is consistent with our interview with the utility representative. The respondent emphasized that the restoration process did not favor or bias against any demographic group. The primary criterion for deciding priority is efficiency, which is to restore power services for many households as quickly as they can.

The results for other control variables are mostly consistent with our expectations. Positive coefficients on the age of house indicate that it takes longer to restore services for older neighborhoods. Community density is only negatively significant in model 2, suggesting that the government may prioritize service restoration in areas with higher needs. However, it is not significant in other models. Interestingly, neighborhoods with higher median income are likely to experience longer restoration time. Our interview data suggests that wealthier neighborhoods in Tallahassee tend to have more trees, which could create more difficulties for powerline restoration.

Discussion

Implications for Coproduction Theory and Practice

In this digital era, e-governance technologies have become increasingly used in the public sector and could have significant impacts on the coproduction of public services. Recent research has called for better integration of digital government and public management perspectives to understand the role of ICTs in the public sector (Gil-Garcia, Dawes, and Pardo 2018). Specific to coproduction research, how digital technologies impact different social groups in coproduction needs further investigation (Lember, Brandsen, and Tõnurist 2019; Verschuere et al. 2018). Our article joins these efforts by unveiling how 311 platforms, as a type of e-governance technology, affect the coproduction of local services, and how this, in turn, reshapes the distributional equity in service delivery.

Our empirical evidence on 311-facilitated coproduction in Tallahassee supports the optimistic position in the long-lasting scholarly debate on how ICTs affect sociodemographic inequity in coproduction participation. We demonstrate that historically disadvantaged groups are more likely to submit 311 service requests for critical service restoration after disasters. While traditional coproduction was dominated by groups who were easily able to navigate this process, 311 platforms powered by Web 2.0 and mobile technologies may lessen the need for participation skills that were traditionally required (Lember, Brandsen, and Tõnurist 2019), which reduces the coproduction barriers for minority groups. In addition to these "mobilizing effects" (Nam 2012), our findings suggest that minority groups may be more likely to participate in technology-enabled coproduction when they have greater needs for a specific type of public service. Disadvantaged groups have few economic resources or political capital to get prioritized in service restoration leading to higher needs for the essential services after disasters, such as electricity, water, and shelters. Therefore, they may have a stronger motivation to utilize 311 platforms to acquire attention from the government to regain essential services. With reduced costs and greater accessibility, e-governance technologies provide "digital capital" to the historically disadvantaged groups.

Extending the technology-enabled coproduction literature (Clark, Brudney, and Jang 2013; Clark et al. 2020), our findings shed light on how local governments incorporate 311 requests data in service delivery decision-making and its distributional impact. Our interviews with the city government officials support the classic argument that local service delivery routines are largely born of efficiency considerations (Jones et al. 1978; Lyons, Lowery, and DeHoog 1992; Mladenka 1989; Schachter 2007). For the Tallahassee Utility, they followed this efficiency rule and prioritized to repair the electric facilities that can restore the power service for a large group of people. Data from 311 assisted in their decision-making. By accessing the power outage map that visualizes 311 requests, they prioritized communities with a higher number of outstanding requests. Our regression results also confirm this service delivery rule. Since our results show that minority households are more likely to submit power outages to the 311 than the nonminority residents after disasters, minority groups have a higher chance to get prioritized in power restoration, which helps narrow and even close the equity gap in service delivery.

The Tallahassee case also suggests that increasing minority communities' awareness and acceptance of e-governance technologies is an important initial step in the utilization of this "digital capital." While access to smartphones and the internet has become less of an issue today, citizens may not utilize 311 if they are not aware of these new platforms. The City of Tallahassee government has actively marketed the DigiTally app on different communication channels (including 311 phone calls, text messages, radio, social media, and the government website) during every extreme weather event. These marketing efforts in previous extreme weather events have increased citizen awareness of the DigiTally app and facilitated citizens to learn how to use the app to participate in coproduction (Tang et al. 2019). On a day-to-day basis, the municipal utility and the neighborhood affair department also reached out to the low-income and minority communities through the Neighborhood REACH Program to demonstrate the utility's energy saving programs, conduct energy audits, and introduce digital platforms. Our interview data indicate that these targeted community engagement activities have helped improve the acceptance of DigiTally in low-income minority communities.

Limitations and Future Research

This study presents an extreme case to examine the coproduction of utility service in a midsize city during disaster recovery, which may limit its generalizability to some other service types or cities. In addition, our research focuses on residential service recovery. Because of the data limitations, we are unable to control spillovers from the restoration of nonresidential facilities, tree cover, and traffic interruption that may also affect power restoration process. Thus, our regression results report correlations rather than causal relationships. However, as one of the initial attempts to explore how e-governance technologies affect service delivery equity, this study could have some implications for future research.

First, our findings align with the results of a recent study on 311 responses in 15 U.S. cities, which indicates that race is not a factor that significantly influences local governments' responses to 311 requests related to utility services and public works (Clark et al. 2020). Our findings further extend this study and suggest that utility service restoration decisions are actually made based on the efficiency criteria to satisfy higher demands with fewer resources. Using 311 data to visualize service demands, local governments are likely to prioritize service delivery to communities with higher requests. Most 311 requests on utility services and public works are about infrastructure maintenance, which are relatively generic. Given the task similarity, we expect our findings on how local governments incorporate 311 data in service delivery may be generalizable to utilities and public works in cities that have 311 systems. For more individualized services, such as social and personal services (Osborne, Radnor, and Nasi 2013), it requires future research to examine how inputs from coproduction are utilized in service delivery decision-making.

Second, our case study suggests the importance of considering service issue prevalence and citizen service needs as two separate factors that can predict coproduction via 311 across demographic groups. Minority communities and nonminority communities may have different levels of issue prevalence for the same service due to the unequal investments in urban infrastructures. In our case, given a similar level of issue prevalence after the hurricane, historically disadvantaged groups are more likely to report power outages. One explanation is that they have greater needs for this essential service as they have limited financial capacity to evacuate or weatherize. Also, we cannot rule out the possibility that minorities benefit from the city government's outreach programs and have a higher awareness of the DigiTally app. Future research on the variation of service needs and technology awareness across racial groups will help us better understand the demographic pattern of coproduction participation.

Conclusion

This study takes an important step to fill the gap in understanding how citizen participation in technology-enabled coproduction makes a difference in service distributional equity. Using the case of the City of Tallahassee's power restoration after a hurricane, we test the long-lasting scholarly debate on possible disparities in e-governance participation between racial groups. In addition, we go one step further to examine the ultimate impacts of technology-enabled coproduction on distributional equity in service delivery. Our analysis indicates that racial minorities are more likely to make service requests through 311 systems for essential service restoration in disaster recovery. With active participation in technology-enabled coproduction, minority groups get a higher chance to be prioritized in power service restoration. While service delivery disparities between racial groups still exist among citizens who do not participate on the e-governance platform, the equity gap in service delivery has been narrowed for minorities who utilize e-governance technologies.

Our study highlights that e-governance platforms supported by Web 2.0 and mobile technologies have provided an alternative coproduction channel to historically disadvantaged groups that lack the economic or political capital to participate in traditional coproduction. Since these e-governance technologies are prevalent today, they can become "digital capital" for minority groups to change the distributional disparities in public service delivery. To facilitate the utilization of this digital capital, local governments may need to conduct marketing campaigns and community outreach to increase citizen awareness and acceptance of these e-governance technologies.

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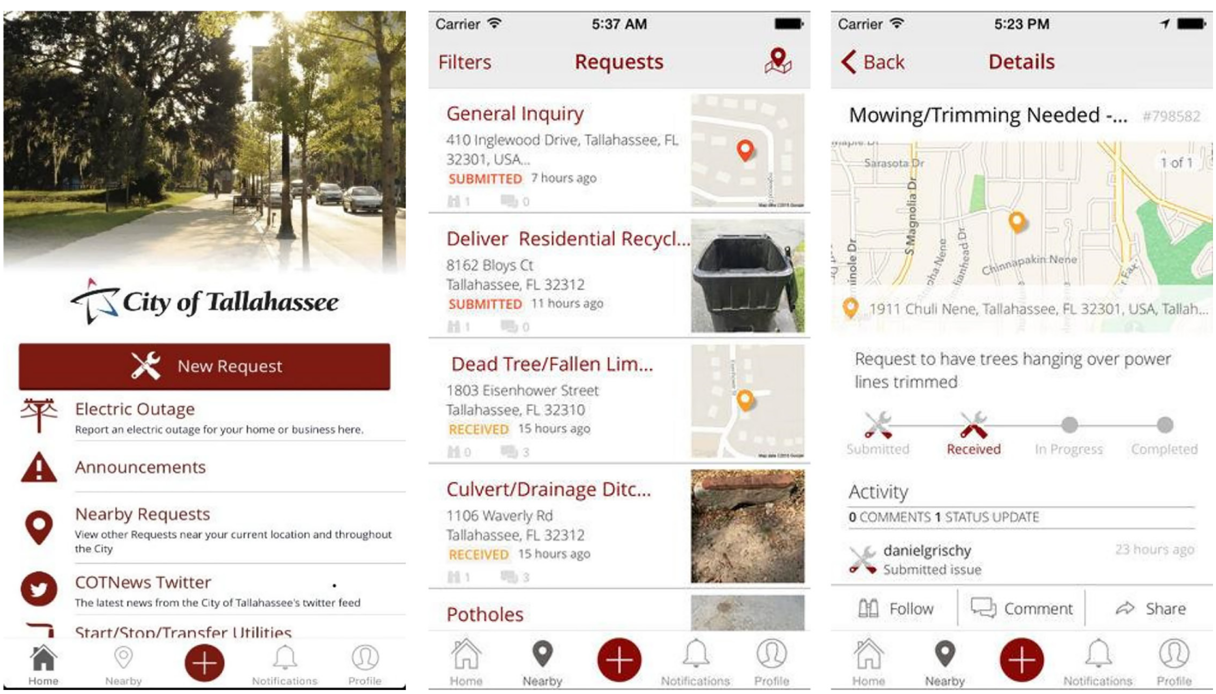
Appendix A



Source: Apple App Store.

Figure A1 Interfaces of DigiTally App

Appendix B: Sample Selection

We only keep the requests from the first two days after Hurricane Michael to avoid the endogeneity between service requests and time of power restoration. For the purpose of this study, we want to observe if requesting power outage service through 311 platform affects power restoration time at the household level. During the first two days after the hurricane, we can assume that citizens submit power restoration service requests because they experienced power outage caused by the hurricane (i.e., exogenous shock). At the end of day 2 (October 11), only 5.2 percent residents have power restored. However, at the end of day 3 (October 12), about 38.5 percent residents had their power restored. Residents who submitted power restoration service requests after day 2 are very likely to be those whose power had not been restored. The longer it takes, the more likely requests will be made. Thus, there is a reverse causality between power restoration time and service request submission for those who submitted service requests in later days. To address this endogeneity issue, we limit our analysis on service requests submitted during the early stage of service recovery.

To compare with households that reported power outages on DigiTally, we draw a 3,000 random sample from the rest 79,000 residential households who did not report to DigiTally. We conduct random sampling because using the population data to calculate power restoration exceeds our computational capacity. To calculate the service restoration time accurately, this study processes big data from the municipal utility's smart meter system. The smart meter system records electricity consumption every 30 minutes. For each household, 1,008 (48 * 21) data points for electricity consumption are included in our analysis. Including all households in the city exceeds the capacity of our statistic software. To balance analytical efficiency and representativeness, we choose a sample size of 3,000, which introduces more than 40 million data points into data processing. To test the robustness of our findings, we also use random samples ranging between 600 to 5,000 households that did not participate in the DigiTally platform. Our main findings hold across all models. To test the representativeness of our random samples, we also conduct two-sample t-tests between the random samples and the population that did not participate in DigiTally. The *t*-tests suggest that there are no significant differences between the random sample and the population on all independent variables.

Appendix C: Interview Data Analysis and Quotes

All interviews were recorded, transcribed, and imported into NVivo 10, creating 11 documents for analysis. To address our research questions, we only used interview data on DigiTally marketing and the utilization of DigiTally in service delivery in our analysis. The rest of the transcripts were used as background information to understand the adoption and management of DigiTally. The qualitative data was coded after our quantitative analysis to buttress and add nuance to the regression results. The interview respondents usually expressed a complete point in several sentences. Hence, our coding focused on "units of meaning" rather than keywords and phrases to avoid any misinterpretation of the data (Campbell et al. 2013; MacPhail et al. 2016). Below are some interview quotes that support our arguments in the results and discussion sections.

Table C1 Summary of Interviews

Theme	Example References
The map function of DigiTally can assist decision-making	"Our departments are using it internally to map service requests. Our maintenance staff go out and take pictures. It creates GIS coordinates so that they know where to send their crews to fix things immediately." " … my role after a storm is working with our system operators to manage all that, the inputs that in and out (for the 311 platform) … crews are calling in: 'All right, we are putting this group back on' … that way that it's like, well, let us be efficient … there is an advantage or there is a value to recording your outage …" " … if you take a picture, for the crew responding to it, they know exactly what you are talking about because it drops a pin on the map. So, there's no more guessing on what street the light is out."
The efficiency rule in service delivery	" … (When restoring residential electricity), we look at large neighborhoods. So if you have a neighborhood of 3,000, and neighborhood of 300, and you have an available truck will head to the neighborhood of 3,000." " … (the primary rule for residential electricity recovery is) get as many on as quickly as we can …"
Slower restoration in minority neighborhoods due to poor infrastructure	" … Older neighborhoods which may tend to be our color neighbors … the structures (are) older, the trees are older, which might tend to fall …" "At day six or seven … at the very southern end of our service territory (one minority neighborhood) … they still had poles leaning and wires along the streets and stuff … it wasn't really missed … this neighborhood has 50 homes and they are spread out … but we have not gotten down to that density yet. They were next on the list …"
DigiTally marketing related to storms	"We continue to market DigiTally using social media. We include the hyperlink to where to go to download it." "I guess the language we have been using for it recently is download it now, cause that's part of the way of being prepared. Do not wait for a storm to come and then try to use your electricity to get it, download it and use it now so you have it ready and on standby." " … we do a lot of the prep (by sending out messages and tips before hurricane hits Tallahassee), we offer up globally. We do not target but maybe these disadvantaged communities, embrace it more …" "I think in that we created some trusts and goodwill (through Neighborhood REACH program with disadvantaged neighborhoods) … And I think that then, when we come out with programs like hurricane prep, these communities may be more open and willing (to embrace it)."