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Social Justice & Technical Efficiency: The Role of Digital Technology in Boston's 311 System

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SOCIAL JUSTICE & TECHNICAL EFFICIENCY: THE ROLE OF DIGITAL TECHNOLOGY IN BOSTON'S 311 SYSTEM

Research Paper

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Abstract

Does digital technology help or hinder the realization of social justice in government services? Applying theories of distributive justice, we analyzed 10-year data from Boston's 311 system (for residents to make requests for non-emergency services) paired with data from the American Community Survey. We found that, as residents used the system's digital channels (website and mobile app) more frequently, they submitted more requests. However, such technical efficiency from digital channel use, to our surprise, exacerbated the disparities between high-income and low-income communities in request volume. This unexpected finding may be explained by the uneven channel use trajectories and distributions of repeat users in different communities, as our additional analysis shows. These results not only have exposed previously hidden inequalities but also may help reconcile different theories of distributive justice. Practically speaking, technical efficiency and social justice should be balanced when employing digital technology in coproducing government services.

Keywords: Social Justice, Technical Efficiency, Distributive Justice, Inequality, Digital Divide, Digital Technology, E-government, Government Service, 311 System.

1 Introduction

As we submit this paper to this conference with the theme "New Horizons in Digitally United Societies," we are actually ambivalent about the relationship between technology and society. On one hand, as the COVID-19 pandemic hurtles toward the end of its second year, the impressive efficacy of the vaccines and medicines indicates a silver lining. Meanwhile, space tourism has become a reality. On the other hand, unfortunately, only 0.7% of the COVID-19 vaccine doses that have been administered worldwide have gone into arms in low-income countries (Holder 2021). As billionaires revel in space, nearly 17 million school children of low-income families in the U.S. still lack internet access at home, creating the so-called "Homework Gap" nationwide (Federal Communications Commission 2021). Apparently, despite marvelous technological advances, our society is still deeply divided, with stark socioeconomic inequalities in the allocation of often limited public resources. This dire reality prompts governments at all levels to act in order to narrow inequalities and maintain public trust. Otherwise, when a government is suspected of serving the privileged at the expense of the underprivileged, like in the Flint water crisis (Muhammad et al. 2018), the erosion of trust may destabilize and even undermine the entire society. To address inequalities, governments should go back to their *social justice* roots.

Indeed, "justice is the first virtue of social institutions" (Rawls 1999, p. 3). Accordingly, social justice is a primary objective for government services. Sadly, prejudice, discrimination, and other biases can cause a government to deviate from this goal, leading to injustice or inequalities. Among the remedies

that have been proposed, digital technology has often been viewed as a means to equalize access to opportunities (Aanestad et al. 2021). For example, numerous e-government programs have taken advantage of digital technology and vastly expanded access to and streamlined the delivery of government services (Rose et al. 2015). However, e-government faces a major barrier caused by the inequality in the access to and use of digital technology, dubbed "digital divide" (van Dijk 2020). To bridge the divide, extant research has thus far focused on expanding access to and increasing the use of digital technologies. Relatively little is known about whether improved technology access and use can bring about the intended social and economic outcomes, including narrowing inequalities and realizing social justice. This knowledge gap might have occurred as a result of assuming technology access and use will automatically produce the desired outcomes. However, time and again, this assumption has proven wrong (Greene 2021). To narrow the gap, we raise the study's Overall Research Question: *Does digital technology help or hinder the realization of social justice in the production of government services?*

To address this question, we study municipal 311 systems, through which residents make requests for non-emergency services from their local governments, because the issues of government services, digital technology, and social justice are intertwined in these systems. Originally introduced in the 1990s and operating from centralized call centers (Borins et al. 2007), most municipal 311 systems have added digital channels such as websites and mobile apps in recent years. However, the efficiency and effectiveness of these digital channels in reaching and serving the socioeconomically different communities, remain largely unknown. Hence, we ask the Specific Research Question: *Does the use of digital channels of a municipal 311 system increase or decrease the disparities between high-income and low-income communities in requesting government services?*

Accordingly, combining data from Boston's 311 system and the American Community Survey, we have found that as residents used the system's digital channels (website and mobile app) more often, they submitted more requests. However, such technical efficiency gained from digital channel use, surprisingly, exacerbated the disparities between high-income and low-income communities in request volume. Further analysis shows that the uneven channel use trajectories and distributions of repeat users in different communities may explain the unexpected effect of digital channel use. The results not only have exposed previously hidden inequalities but also, as our primary theoretical contribution, may help reveal and reconcile the differences in the theories of distributive justice. Practically speaking, when government information systems (IS) employ digital technology in coproducing government services, technical efficiency and social justice should be balanced.

2 Conceptual Background and Hypothesis Development

At the nexus of research on social justice, e-government, and digital divide, this study builds on and then synthesizes the insights that are relevant to government services from these research areas.

2.1 Social Justice and Theories of Distributive Justice

Broadly speaking, *social justice* refers to "justice in terms of the distribution of wealth, opportunities, and privileges within a society" (Lexico.com 2021). Social justice has been conceptualized as a set of principles for distributing rights and duties among cooperating members of a society (Harvey 2009; Rawls 1999). The principles help determine whether a distribution is just, as well as the process followed to make the distribution is also just. In short, social justice principles help a society make "a just distribution justly arrived at" (Harvey 2009, p. 98). Specifically, theories of distributive justice explain how social justice principles help make a just distribution of rights and duties in a society. Here we describe three schools of social justice theories relevant to government services.

First, the *utilitarian* theories of distributive justice prescribe actions that increase a society's overall welfare (Mill 1998). Accordingly, utilitarian theories posit that welfare-maximizing actions that benefit the well-being of the whole society would lead to a socially just distribution as an outcome. Although researchers debate on the specific measures of welfare, the utilitarian view is relevant here because all government services are utilitarian in essence. That is, any improvement of a government service, be it

snow removal or pothole repair, is likely to increase the welfare of the whole community. However, being a main perspective of distributive justice, ironically, the utilitarian theories do not detail how welfare is distributed among individual members of a community (Rawls 1999).

Second, the *egalitarian* theories of distributive justice are based on the premise that all human beings have equal worth or moral status, and thus they should be treated and treat each other as equals (Arneson 2013). In contrast to the utilitarian perspective, the egalitarian theories focus more on the process by which a distribution of resources, welfare, rights, or duties is made than on the specific distribution outcome (Sumner 1996). In the context of this study, the egalitarian theories propose that the production and provision of government services should ensure that all members in the community are treated equally, and there is no special treatment of or favoritism toward certain members or groups.

Third, the *contractarian* theories of distributive justice postulate that members of a society agree to, accept, and follow a set of principles of social justice as a type of social contract that guides and regulates the members' cooperation. A notable example of the contractarian view is Rawls' (1999) *justice-as-fairness* theory. Aiming to formulate the social contract for the basic structure of society, Rawls (1999) argued that social justice principles should be based on fair, original positions in which the members of society, equally situated, reach agreements on the principles.

Such fair original positions echo the equal worth and moral status prescribed by the egalitarian view. However, the contractarian view is more articulate. Like business contracts, social justice principles from the contractarian perspective specify the distribution of both rights and duties, and of both resources and responsibilities. Regarding government services, while the distribution of public resources should be fair and just, so is the distribution of public duties and responsibilities.

Summarizing, different theories of distributive justice offer valuable insights on what social justice means and how to achieve it in government services. The utilitarian view emphasizes the maximization of societal welfare. Toward that end, in making a socially just distribution of rights and duties, the egalitarian view endorses equality for all, whereas the contractarian view stresses fair distribution of both rights and duties. These theoretical views of social justice may be applied to guide government services, including e-government services enabled by digital technologies.

2.2 Technical Efficiency of Government Services with E-government

Pertinently, *e-government* is "the use of technology to enhance access to and delivery of government services to benefit citizens, business partners and employees" (Silcock 2001, p. 88). Due to the decreasing costs of digital technologies and the governments' significant information technology (IT) investment (Pang 2017), in the past two decades, e-government services have become increasingly available for service delivery, information delivery, civic participation, and coproduction of government services (Nam 2014).

E-government services can improve the efficiency of government services (Castro 2008). In particular, digital technology can help governments at different levels cut costs and produce more and better services. In respect to cost reduction, for example, compared to manual processes, the online purchasing and acquisition system saved the U.S. General Services Administration $90 to $240 in administrative costs *per transaction* (Office of Management and Budget 2005). Further, with regard to the quantity of services, for instance, the Online Crash Logs, the Kansas Highway Patrol's website for recording and distributing crash information, allows the media and public to search and retrieve at any time crash information, providing information services far more often, current, and accurate than the previous paper-and-phone-based system. However, such efficiency gains and other benefits from e-government may not be available to those who do not have access to computers or the internet (Nam 2014). This "digital divide" violates almost all of the social justice principles. Therefore, in order to achieve social justice in e-government services, the digital divide must be addressed and bridged.

2.3 Digital Divide

As a problem in e-government and other domains, *digital divide* refers to the "division between people who have access to and use of digital media and those who do not" (van Dijk 2020, p. 2). Digital divide

exists among persons (van Deursen and Helsper 2015), organizations (Forman 2005), communities (Kvasny 2006), and countries (Guillén and Suárez 2005). Regarding *access* to digital technology, affordability is a usual cause for this basic level of digital divide (Weiss et al. 2016).

When access is provided free of charge, for various reasons, people do not necessarily adopt and use digital technology (Hsieh et al. 2011). This is why most contemporary studies of digital divide focus on technology *use*, aiming to bridge the digital divide at this intermediate level. For example, individual traits, household characteristics, and social influence may explain variations in the internet adoption and use across geographic and ethnic lines (Agarwal et al. 2009). Moreover, digital literacy and technical skills have been found crucial to bridging the digital divide in technology use (Manžuch and Macevičiūtė 2020; Reynolds and Chiu 2016; van Deursen and van Dijk 2019).

Even if digital divide has been bridged fully at the basic and intermediate levels with universal access and routinized use, the social and economic *outcomes* may not reach a socially just distribution. For example, socioeconomically disadvantaged groups are more likely to use online crowdfunding platforms to pay their medical bills yet garner less in funding than their advantaged counterparts (Burtch and Chan 2019). Therefore, digital divide may exist at an advanced level, in the distribution of social and economic benefits from the use of digital technology. Although this level of digital divide has rarely been explored (Maceviciute and Wilson 2018), in government services, it is important to understand the connection between technology use and the service outcomes because, after all, digital technology is a means, not an end. To explore this connection, we synthesize the above insights from the three research areas in the context of municipal 311 systems for local government services.

2.4 Synthesis and Hypotheses in Municipal 311 Systems

Social justice theories shed light on the principles for producing and providing government services. *E-government* focuses on how digital technology can improve the efficiency of government services, but *digital divides* at multiple levels make the role of digital technology uncertain on social justice, especially about how digital technology affects a community in terms of service outcomes.

We choose to study municipal 311 systems because in them the issues about government services, digital technology, and social justice are intertwined. First introduced in Baltimore, Maryland, in 1996 to relieve the overload of that city's 911 system (Borins et al. 2007), a 311 system allows local residents to call the 311 hotline to report non-emergency problems that need government services. Over the years, 311 systems have opened digital channels (e.g., mobile app and website) in addition to its original hotlines and call centers, and have been deployed in hundreds of cities and counties in the U.S. and Canada (Newcombe 2014). Successful 311 systems help local governments not only identify service problems (Clark et al. 2020) but also measure government performances and allocate resources based on the patterns detected from the data in the systems (Newcombe 2014). Therefore, given the increasing potential benefits at stake, whether social justice is realized in government services through these digitalized municipal 311 systems has become an issue of both theoretical and practical significance.

For instance, 311 systems facilitate the *coproduction* of government services (Clark and Rokakis 2014) in that local residents serve as "human sensors" and report problems to the government (O'Brien 2018). If such crowd-based reporting activities supplement or replace the monitoring function played traditionally by the government, then government services can be regarded as being coproduced by the government and the residents jointly (Brandsen and Honingh 2016). Coproduction has complex implications regarding social justice. On one hand, social justice is relevant to not only the distribution of the services provided by the government, but also the distribution of the reporting responsibilities among the residents, since the residents assume the reporting responsibilities in these systems. On the other hand, if certain residents are unwilling or unable to report problems, then the distribution of responsibilities will be biased, leading to a biased distribution of services. Therefore, the pattern in the volume of service requests from a community over time can not only indicate the government services requested but also imply the services received there. Disparities in request volume between groups of different socioeconomic statuses have been documented. For example, an analysis of Boston's 311 system data from 2010 to 2011 found that low-income neighborhoods were less likely to use the 311

system to request services (Clark et al. 2013). However, it remains to be seen whether such disparities exist for a longer term and more recently, once the system has been assimilated and institutionalized.

Hypothesis 1: *The income level of a community is positively associated with the volume of service requests from the community in a municipal 311 system.*

Regarding the effects of digital technology, previous studies on IT's societal impacts indicate that IT encourages participation by employees, citizens, and socioeconomically disadvantaged groups through *empowerment*. For example, by letting the participant select the job activities that are personally meaningful and decide how to get the work done, crowdsourcing platforms, such as Amazon Mechanical Turk, enhance the participants' perceptions of their competence and impacts, and thus overall engagement (Deng et al. 2016). Similarly, empowerment has been found important to citizens' participation in e-government initiatives (Kang 2014; Naranjo-Zolotov et al. 2019). The introduction of digital channels to 311 systems provides additional ways for residents to participate in coproducing local government services. With mobile apps and 311 websites, residents can submit service requests at any time, no longer constrained by the regular business hours of the 311 call centers. Further, compared to the hotlines, apps and websites are relatively easy to use without any wait time. What's more, no verbal communication is required in digital channels, and thus people who cannot or do not like to communicate verbally can also participate. However, it is unclear whether the digital channels substitute or supplement the hotline. Substitution of the channels does not necessarily increase the overall volume of requests, but supplementation does. Therefore,

Hypothesis 2: *A community's use of the digital channels of a municipal 311 system is positively associated with the volume of service requests from the community in the 311 system.*

The digital divide literature suggests that the efficiency gains from digital channel use may not be distributed equally among different communities. Nevertheless, computers and mobile devices are becoming increasingly affordable (Vogels 2019). Governments at different levels have developed numerous programs to provide devices and internet *access* to low-income families for free or at low costs. Moreover, social institutions such as community centers and public libraries offer digital literacy programs that help increase the *use* of the internet and computers (Kvasny 2006; Manžuch and Macevičiūtė 2020). However, it remains to be seen whether the promise of these divide-bridging programs can be realized at an even higher level, to narrow the divide in the social and economic *outcomes*. If it can, then we would expect the convenience and affordability of digital technology and the increasing digital literacy to help reduce the income-based disparities in service request volume.

Hypothesis 3: *A community's use of the digital channels of a municipal 311 system negatively moderates the relationship between the community's income level and service request volume such that the more use of the digital channels is associated with the less disparity in service request volume between high-income and low-income communities.*

Figure 1 summarizes our research model.

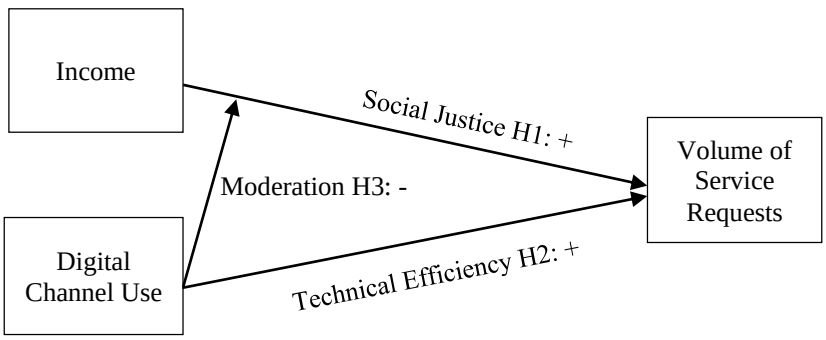


Figure 1. Effects of Income & Digital Channel Use on 311 Service Request Volume

3 Methods

3.1 Research Site: Boston's 311 System

We choose to study Boston's 311 system as an example of the municipal 311 systems for two reasons. First, Boston is one of the first U.S. cities that launched the 311 mobile app (Hartmann et al. 2017), providing ample time for the app to be assimilated into its user base and generate relatively stable use patterns. Second, Boston's 311 data can be traced back to 2010 and contains granular information about each request, detailed enough to address our research questions.

3.2 Data Collection

We obtained the 311 service request data in partnership with the Boston Area Research Initiative from the City of Boston (O'Brien et al. 2016). The dataset tracks users' requests in Boston's 311 system from 2010 to 2019 and provides detailed information about each service request, including the case's open and close date, content, department the case was assigned to, location of service needed, and channel through which the request was submitted. As of 2019, Boston's 311 system had 4 channels: the hotline, BOS:311 app, Boston.gov/311 website, and Twitter account @BOS311. The Twitter account was seldom used with only about 0.09% of the total requests, so we excluded from our analysis the requests submitted through Twitter. With the location data, each request can be connected to a census tract as defined by the U.S. Census Bureau. We then collected the demographic data about each census tract in Boston from the 5-year estimates in the 2010-2019 American Community Surveys (ACS).

3.3 Key Constructs and Measurement

Among the three key constructs in the research model, first, the dependent variable, the *volume of service requests*, is measured by the total number of requests submitted to the 311 system by all users from a census tract in a given year. Second, the *income* level of a community is measured by the mean household income of a census tract. Lastly, *digital channel use (DCU)* is measured by a census tract's percentage of service requests submitted through the 311 app or website. To account for potential alternative explanations, we include the following control variables at the census tract level: log-transformed total population, log-transformed mean travel time to work, and percentages of population that is foreign-born, in the labor force, male, over 65 years old, and black.

3.4 Analytical Model

We constructed the following fixed effects model to examine how income and digital channel use affect the total number of requests.

$$\ln(Total\ Number\ of\ Requests_{it}) = c_i + \beta_0 + \beta_1 \ln(Income_{it}) + \beta_2 DCU_{it} + \beta_3 \ln(Income_{it}) \times DCU_{it} + \gamma CONTROLS + Year_t + \varepsilon_{it} \quad (1)$$

where the dependent variable, $\ln(Total\ Number\ of\ Requests_{it})$, is the log-transformed total number of service requests made by 311 system users in census tract i in year t (log transformation necessary to meet the assumption of normal distribution in the regression analysis); c_i is the unobserved census tract fixed effects, such as the objective need for services; β_1 to β_3 are coefficients for the factors of interest; γ is the coefficient vector for the control variables; and $Year_t$ represents the year dummies to account for unobserved annual effects.

4 Results

4.1 Descriptive Results

Table 1 shows the descriptive statistics about the census tracts in Boston based on the 5-year estimates of the 2010-2019 ACS data. Figure 2 shows the distribution of the data from Boston's 311 system. Panels A-C show the distribution of service requests by year, reporting channel, and census tract. Service

requests increased consistently throughout the 10-year period. While the 311 hotline was the dominant reporting channel before 2015, the popularity of the 311 app increased dramatically over the years. The power-law distribution shown in Panel C entails the log transformation of the dependent variable.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Mean Household Income ($)	1,926	83,066	41,416	16,311	280,120
Total Population	2,040	1,663	1,101	0	9,324
Mean Travel Time to Work (min.)	1,933	29.642	5.499	7	58
% Population in Labor Force	1,974	68.789	11.836	0	100
% of Population Foreign-Born	1,974	26.935	13.214	0	100
% of Population Male	1,974	48.763	7.319	0	100
% of Population over 65-year-old	1,974	11.317	8.555	0	100
% of Population Black	1,974	21.839	25.646	0	100

Table 1. Descriptive Statistics of Demographic Information about Census Tracts in Boston

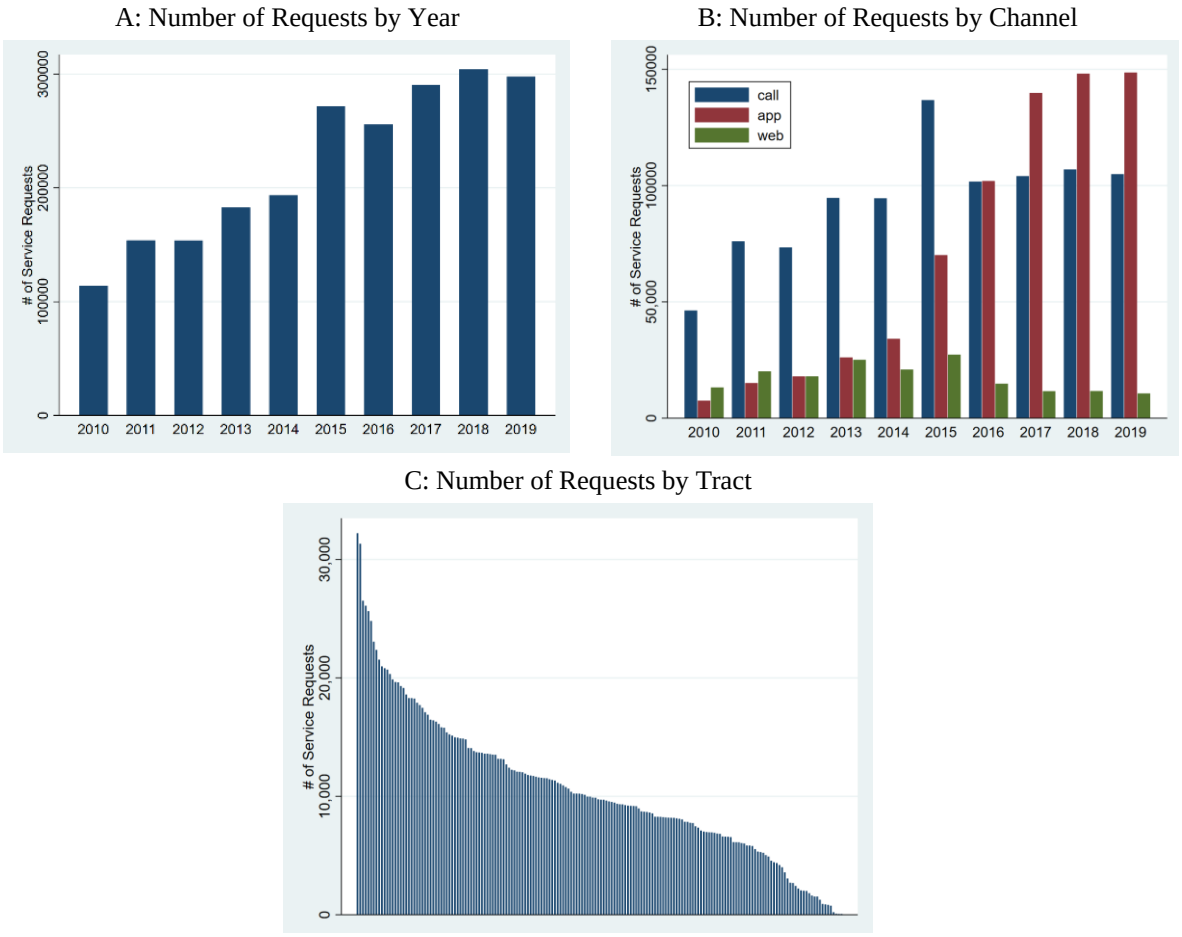


Figure 2. Distribution of Service Requests

4.2 Analytical Results

Table 2 presents the regression results of the fixed effects model for the total number of requests. Model 1 has only the control variables. To Model 2, we added income, which has a significant positive effect on the total number of requests ($\beta = 0.153$, $p<0.001$), indicating that the higher income a community

has, the more requests made there. This result supports Hypothesis 1 and indicates that a community's income level contributes to the disparity in request volume between communities. Model 3 shows that digital channel use has a positive effect on the total number of requests ($\beta = 1.181$, $p<0.001$), suggesting that more digital channel use in a community is associated with more requests made there. So Hypothesis 2 is supported about the efficiency gain of the 311 system from its digital channels.

	Model 1	**Model 2**	**Model 3**	**Model 4**
ln(Income)		0.153*** (0.037)	0.117*** (0.033)	0.030 (0.040)
Digital Channel Use (DCU)			1.181*** (0.101)	1.149*** (0.100)
ln(Income) X DCU				0.211*** (0.048)
Controls				
ln(Total Population)	-0.238*** (0.065)	-0.230*** (0.060)	-0.200*** (0.058)	-0.153** (0.054)
ln(Travel to Work Time)	0.037 (0.105)	-0.005 (0.104)	0.036 (0.084)	0.038 (0.082)
% of Population in Labor Force	0.004* (0.002)	0.001 (0.002)	0.001 (0.002)	0.002 (0.002)
% of Population Foreign-Born	-0.001 (0.001)	0.001 (0.002)	0.002 (0.001)	0.002 (0.001)
Gender (% of Population Male)	0.001 (0.002)	0.000 (0.002)	-0.000 (0.002)	0.000 (0.002)
Age (% of Population over 65)	-0.002 (0.004)	-0.001 (0.004)	0.001 (0.003)	-0.000 (0.003)
Race (% of Population Black)	-0.002 (0.002)	-0.002 (0.001)	-0.002 (0.001)	-0.002 (0.001)
Tract Fixed Effects	-Included-	-Included-	-Included-	-Included-
Year Dummies	-Included-	-Included-	-Included-	-Included-
Number of Observations	1,686	1,686	1,686	1,686
Within R^2	0.800	0.807	0.836	0.842

Robust standard error reported in parentheses. * p <0.05; ** p <0.01; *** p<0.001

Table 2. Effects of Income and Digital Channel Use on Total Number of Requests

Model 4 explores how digital channel use moderates the relationship between income and request volume by adding the interaction term of digital channel use and income. The result shows a significant positive effect of the interaction on the total number of requests ($\beta = 0.211$, $p<0.001$), indicating that the more digital channel use, the larger the disparity in request volume between high-income and low-income communities. As depicted in Figure 3, the slope of income on the total number of requests becomes steeper as digital channel use increases. This result means that, while digital channel use boosts service request volume in all communities, the request volume increases more in high-income communities than in low-income communities, enlarging, rather than reducing, the disparity in request volume. This unexpected result rejects Hypothesis 3, which predicts the opposite. To investigate why

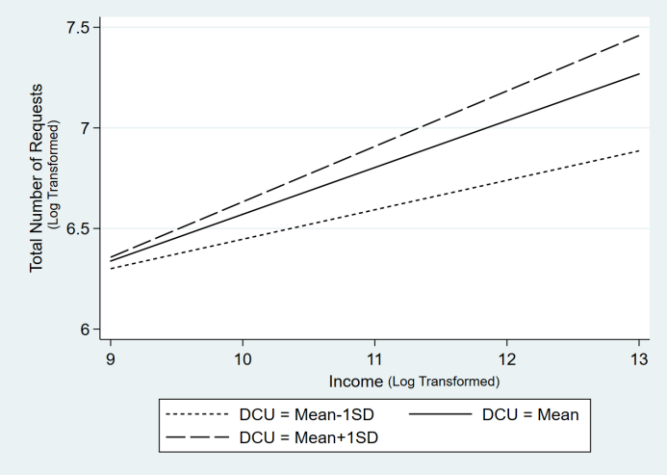


Figure 3. Moderation of Digital Channel Use (DCU)

digital channel use exacerbated the inequality in the volume of service requests, we conducted post-hoc in-depth analysis of digital channel use.

4.3 Post-Hoc Analysis of Digital Channel Use

4.3.1 Channel Use Patterns over Time

One possible explanation for the unexpected result regarding Hypothesis 3 is that different communities may use the available reporting channels in different ways and thus show different patterns of channel use over time. Accordingly, we employed growth curve modeling (GCM) to describe and explain how digital channel use changes over time in high-income and low-income communities. GCM refers to "statistical methods that allow for the estimation of inter-individual variability in intra-individual patterns of change over time" (Curran et al. 2010, p. 122). Compared to traditional longitudinal models, GCM is highly flexible in handling non-normally distributed or discretely scaled repeated measures, complex nonlinear or compound-shaped trajectories, time-varying covariates, and multivariate growth processes (Curran et al. 2010). To compare the growth curves of channel use in high- and low-income communities, we first dichotomized the census tracts based on their mean household incomes in 2010. We used Boston's average household income as the cutoff and coded the tracts with mean household incomes at or above the city's average as high-income (High-Income = 1) and the tracts below the city's average as low-income (High-Income = 0). We assessed two aspects of channel use: digital channel use (% of requests made with app and website), and the Herfindahl–Hirschman Index (HHI) of channel use (concentration of channels used in a census tract).

	DCUX100			**HHI (Channel Use)X100**		
	Model 5	**Model 6**	**Model 7**	**Model 8**	**Model 9**	**Model 10**
Year	2.256*** (0.219)	2.258*** (0.219)	1.987*** (0.296)	-1.768*** (0.228)	-1.737*** (0.227)	-1.418*** (0.306)
$Year^2$	0.170*** (0.020)	0.169*** (0.020)	0.185*** (0.026)	0.118*** (0.018)	0.115*** (0.018)	0.048* (0.024)
High-Income		4.614** (1.600)	5.047** (1.772)		-3.373*** (0.970)	-7.331** (2.353)
High-Income X Year			0.480 (0.396)			-0.600 (0.420)
High-Income X $Year^2$			-0.024 (0.032)			0.131*** (0.031)
Control Variables	-Included-	-Included-	-Included-	-Included-	-Included-	-Included-
Tracts Fixed Effects	-Included-	-Included-	-Included-	-Included-	-Included-	-Included-
Number of Observations	1,686	1,686	1,686	1,686	1,686	1,686
Wald χ^2	2048.21	2148.82	2077.50	78.71	91.01	122.52

Robust standard error reported in parentheses. * p <0.05; ** p <0.01; *** p<0.001

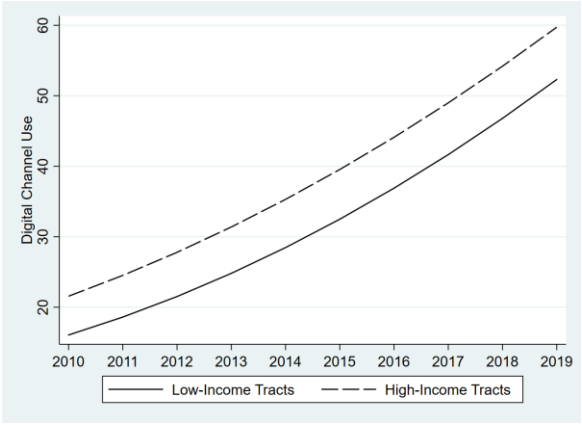
Table 3. Channel Use Patterns over Time

Based on the Bayesian Information Criterion and the Akaike Information Criterion, we used a quadratic model with random intercept and random slope as the baseline (Models 5 and 8 in Table 3), added the High-Income dummy to see whether there is a systematic difference in channel use between high-income and low-income communities (Models 6 and 9 in Table 3), and explored whether and how the systematic difference in channel use changes over time (Models 7 and 10 in Table 3).

As shown in Model 5 in Table 3, digital channel use followed an upward U-shape trajectory (β for Year = 2.256, p<0.001; and β for $Year^2$ = 0.170, p<0.001), suggesting digital channel use increased over the years. Model 6 indicates that high-income communities systematically had higher digital channel use than low-income communities (β = 4.614, p<0.01). Specifically, for any given year, high-income communities made 4.614% more requests through digital channels than low-income communities. The non-significant coefficients for the interaction terms in Model 7 indicate that the high- and low-income communities had parallel trajectories of digital channel use, as depicted in Panel A of Figure 4.

Model 8 in Table 3 suggests that the HHI of reporting channels followed a downward U-shape trajectory (β for Year = -1.768, p<0.001; and β for Year^2 = 0.118, p<0.001), indicating that, over time, Boston residents used more diversified channels for making 311 requests. Model 9 suggests that high-income communities were more diversified in using different reporting channels than low-income communities (β = -3.373, p<0.001). Model 10 shows that the high- and low-income communities followed different trajectories in using reporting channels, as depicted in Panel B of Figure 4.

A: Digital Channel Use



B: HHI of Reporting Channels

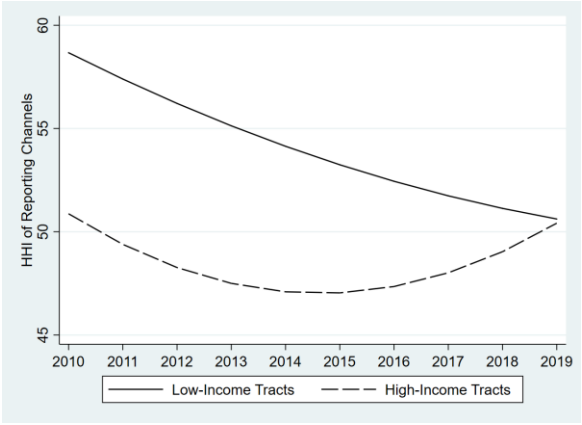


Figure 4. Channel Use over Time

Overall, the GCM analysis of digital change use indicates that the high-income communities led the low-income communities in using the digital channels. By using the digital channels earlier, high-income communities had an early-mover advantage. We suspect that they went through the learning curve earlier, accumulated more experiences of using the various functions of each digital channel, and thus enjoyed more convenience brought by the digital channels. In addition, the GCM analysis of the reporting channel HHI reveals a nearly linear downward trajectory for low-income communities, suggesting that residents there might have substituted the digital channels for the hotline. In contrast, high-income communities experienced a U-shaped trajectory, consisting of an initial escalated diversifying period followed by a converging period. The escalated diversification indicates the new channels supplemented traditional channels. Through such supplementation, existing users might have made more requests using the new channels, and new users might have been attracted to use the 311 system. In sum, the early-mover advantage and supplementation in the high-income communities might explain why digital channel use widened their lead in request volume over low-income communities.

4.3.2 Distribution of Repeat Users

Another possible explanation is that high-income communities have more repeat users well equipped with high digital skills and multiple digital devices than low-income communities do. Individuals with more education and higher household income are more likely to use the web and apps (Perrin 2015). Accordingly, we used a proprietary dataset containing the identification number of each unique user of Boston's 311 system (O'Brien et al. 2016). We first coded the users that made more than one request in a given year as repeat users (Repeat User = 1) and those who made only one request as one-time users (Repeat User = 0). After setting the location of each user at the centroid of all locations reported by the same user, we then aggregated the request-level data to calculate the number of repeat users in a census tract and the average requests per repeat user. The following fixed effects model examines the relationship between income and repeat users in each census tract.

$$\ln(DV_{it}) = c_i + \beta_0 + \beta_1 \ln(Income_{it}) + \gamma CONTROLS + Year_t + \varepsilon_{it} \qquad (2)$$

where DV_{it} represents either the number of repeat users or the average requests per repeat user.

Table 4 shows that there are positive relationships between the mean household income and the two dependent variables. These results suggest that high-income communities had more repeat users (Model 11, $\beta = 0.157$, $p<0.05$) than low-income communities did. Moreover, the repeat users in high-income communities made more requests (Model 12, $\beta = 0.267$, $p<0.05$) than their peers in low-income communities.

	ln(# of Repeat Users) Model 11	**ln(Average Requests per Repeat User) Model 12**
ln(Income)	0.157* (0.067)	0.267* (0.119)
Control Variables	-Included-	-Included-
Tract Fixed Effect	-Included-	-Included-
Year Dummies	-Included-	-Included-
Number of Observations	1,686	1,686
Within R^2	0.778	0.252

Robust standard error reported in parentheses. * p <0.05; ** p <0.01; *** p<0.001

Table 4. Distribution of Repeat Users across Census Tracts

We further compared repeat users and one-time users on their use of digital channels, which is calculated as the percentage of requests made through digital channels for each group of users in a given census tract. As Model 13 in Table 5 shows, on average, repeat users made 4.4% more requests through digital channels than one-time users did ($\beta = 0.044$, $p<0.001$), given the same income level. Model 14 further reveals that the repeat users in high-income communities had higher digital channel use (β for the interaction term = 0.019, $p<0.05$) than those in low-income communities. Jointly, the two models indicate that repeat users and their heavy use of digital channels might explain why the disparity in request volume between high- and low-income communities increased as a result of digital channel use.

	Model 13	**Model 14**
Repeat User (Dummy)	0.044*** (0.005)	-0.165 (0.105)
ln(Income)	0.043*** (0.008)	0.034*** (0.001)
Repeat User X ln(Income)		0.019* (0.008)
Control Variables	-Included-	-Included-
Tract Fixed Effect	-Included-	-Included-
Year Dummies	-Included-	-Included-
Number of Observations	1,686	1,686
R^2	0.511	0.517

Robust standard error reported in parentheses. * p <0.05; ** p <0.01; *** p<0.001

Table 5. Effect of Repeat Users vs. One-Time Users on Digital Channel Usage

5 Discussion

By analyzing the 10-year service request data collected from Boston's 311 system, we have obtained interesting findings about the role of digital technology in the coproduction of government services requested by the city's residents. Foremost, low-income communities, *ceteris paribus*, made fewer requests than high-income communities did, suggesting that inequality in the services requested (and thus received possibly) by the residents, even after the system had been put in use for many years, still existed. Further, the users of the system's digital channels helped increase request volume across all communities, indicating substantial technical efficiency gain. However, to our surprise, digital channel use *enlarged*, rather than reduced, the disparity between high- and low-income communities in request volume. This unexpected result may be explained by the different patterns of digital channel use over time and varied distribution of repeat users between high- and low communities, as our post-hoc analysis

has revealed. With these findings, our study contributes back to the research areas where we gleaned valuable insights to motivate and guide our research design and analysis in the first place.

5.1 Research Contributions

Specifically, we make contributions to research on digital divide, e-government, and social justice. First, our finding that the use of Boston's 311 system's digital channels divided further, rather than equalized, communities supports and extends a key insight from the digital divide literature: *Bridging the digital divide at a lower level cannot bridge it at a higher level automatically*. At the basic level, the digital divide exists in *access* to digital technologies. When the divide is bridged with free or universal access, for various reasons, the divide in the *use* of digital technologies still exists at a higher, intermediate level. Numerous ways have been proposed and implemented to bridge the digital divide in *use*, but as shown in this study, heavy use of digital technology does not necessarily bridge the divide at an even higher level, which is the disparity in the *outcomes* from accessing and using digital technologies. While much effort in digital divide research is focused on bridging the divide in technology access and use, we extend the core insight from this research area to the higher, advanced level, with direct measurement of disparities in a key outcome – resident engagement.

Second, due to the existence of digital divide at multiple levels, to realize the full potential of e-government, it is not enough to promote access to and use of digital technologies. E-government research should go beyond the studies of technical barriers to understand and enhance the connections between technology and government services as an outcome. Apparently, as this study shows, efficiency gains from e-government were not distributed equally among the communities at different income levels. This unsettling finding brings us back to the social justice principles that are supposed to guide government services.

Finally, this study contributes to social justice research in the digital age with thought-provoking findings about the relation between digital technology and social justice. *Does digital technology help or hinder the realization of social justice in government services?* We have to give the clichéd answer: *It depends*. Indeed, the answer depends on the specific school of social justice theories to which one subscribes. For those with the *utilitarian* view, our finding that digital channel use improved the request volume signals not only technical efficiency but also social justice, because under the primary objective of the utilitarian view – maximization of social welfare – efficiency and justice are consistent with each other. From the *contractarian* perspective, which emphasizes the socially just distribution of both rights and duties, our finding that residents from low-income communities made fewer requests implies that they fulfilled their reporting responsibilities to a lesser degree than residents in high-income communities. Consequently, residents from low-income communities may deserve fewer services than residents in high-income communities, and so justice is served according to the contractarian view. In contrast, those holding the *egalitarian* view must be concerned with our finding – the inequality in request volume in different communities. They should be even more concerned with the seeming divergence between technical efficiency and social justice, indicated by the even worse inequalities hidden previously but exposed by our examination of digital channel use. To the egalitarians, our findings suggest that digital technology enhances efficiency at the expense of justice.

These different theories of social justice could be reconciled. As our post-hoc analysis shows, the situation was not that residents from low-income communities deliberately shirked reporting responsibilities. They adopted the digital channels later and used the digital channels less than residents in high-income communities. Therefore, finding ways to narrow the inequalities in digital channel use can help not only realize social justice in the egalitarian view, but also bring about more meaningful social justice in both the contractarian and utilitarian views. When *all* communities adopt digital channels early and use them often, on one hand, the distribution of reporting responsibilities and service benefits is likely to occur equally across communities, thus realizing the contractarian social justice at a higher level than it was in the study. On the other hand, the higher level of contractarian social justice also means even greater social welfare, sought by the utilitarian thinkers. Taken together, reconciling the three perspectives of social justice implies that technical efficiency does not have to be gained at the

expense of low-income communities. In sum, as our primary theoretical contribution, understanding the role of digital technology in government information systems like the 311 system has helped both *reveal* and *reconcile* the differences in social justice theories.

5.2 Limitations and Future Research Directions

Conspicuously, this is a study of just one city's 311 system during a specific decade. The generalizability to other locations and other periods should be tested with data on the 311 systems elsewhere and at other times, because 311 systems are developed, operated, and used very differently depending on the priorities of the government, resident characteristics, and the developer's capabilities. Further, we have aggregated the original request-level data to the census tract level, where we have conducted the analysis. Making ecological inferences about user behaviors must be cautious and requires finer-grained analysis. Moreover, although we have explored possible explanations on why digital channel use moderated the effect of income on service request volume in unexpected ways, our exploration is by no means exhaustive. Future research may examine other data and factors to explain why digital channel use exacerbated inequalities.

6 Conclusion

"Technology is neither good nor bad; nor is it neutral" (Kranzberg 1986, p. 545). This very first Kranzberg's Law reminds us to study "how technology interacts in different ways with different values and institutions" (Kranzberg 1986). Despite social justice as a core value for government services, technology is often designed to maximize efficiency (Harvey 2009). Therefore, our study has practical implications for various stakeholders of municipal 311 systems.

As the existing or prospective users of such systems, the residents, especially those living in low-income communities, should use the systems to submit more requests for services. They should take advantage of the popular digital channels (e.g., mobile app and website), as well as the underutilized or traditional channels (e.g., social media and hotline). Sending more requests will not only increase their chances of receiving more government services, but also raise the awareness of their reporting responsibilities in coproducing the services, according to the contractarian view of social justice.

For the governments developing new or improving existing 311 systems, they should not abandon their traditional monitoring programs, especially in low-income communities where many service needs may not be requested by residents using the 311 system in a timely manner or at all. Meanwhile, governments may consider attracting new users by revamping underutilized channels such as the 311 social media account and transforming traditional channels such as the hotline with digital features (e.g., virtual agents) to both contain costs, expand coverage, and boost participation. In doing so, they should foreground social justice features such as multilingual support and unbiased algorithms to balance between technical efficiency and social justice, "to the greatest expected benefits of the least advantaged" (Rawls 1999, p. 72).

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