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Coproduction of Government Services and the New Information Technology: Investigating the Distributional Biases

This article investigates how communications advances affect citizens' ability to participate in coproduction of government services. The authors analyze service requests made to the City of Boston during a one-year period from 2010 to 2011 and, using geospatial analysis and negative binomial regression, investigate possible disparities by race, education, and income in making service requests. The findings reveal little concern that 311 systems (nonemergency call centers) may benefit one racial group over another; however, there is some indication that Hispanics may use these systems less as requests move from call centers to the Internet and smartphones. Consistent with prior research, the findings show that poorer neighborhoods are less likely to take advantage of 311 service, with the notable exception of smartphone utilization. The implications for citizen participation in coproduction and bridging the digital divide are discussed.

Recent years have witnessed local governments on the brink of employee layoffs, major cutbacks in services, and even bankruptcy. In the current economic climate, it has become more important for local governments to find ways to reduce their budgets yet still deliver the level and quality of services to which residents have become accustomed. One method increasingly employed is coproduction, whereby government engages citizens as partners in service delivery.

In the traditional conception of public service delivery, services are distributed through government to the citizenry (De Araújo 2001). This traditional model has government as the active player, while citizens take more passive roles. Increasingly, governments are examining how to best engage the public (Bryson et al. 2013) and, in particular, the use of online or electronic means to do so (Norris and Reddick 2013). The concept of coproduction as a new model of service delivery challenges the standard view by involving citizens directly in service provision. Traditional ideas of service planning and management need to be revised to incorporate coproduction (Bovaird 2007). Although coproduction was a prevalent topic for public managers and researchers in the 1970s and early 1980s, it fell out of favor as governments and scholars alike focused on efforts geared toward improving services and saving money through privatization and marketization (Alford 1998). With continuing budgetary challenges and growing appreciation of the limitations of privatization, though, the focus on coproduction has been renewed over the past decade.

Innovations in how government services are delivered in the 2010s, especially the use of new electronic communications technology, have brought coproduction back to the fore, both as a service delivery option and as the subject of academic inquiry. This article focuses on one such innovation, the 311 call center.[1] These centralized government call centers offer nonemergency information to citizens, comparable to 411 for general information or 911 for emergency services. Despite the rise of such systems, experts and practitioners worry that they do not attract people from diverse demographic backgrounds, a perennial issue in coproduction research.[2]

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This article examines whether the 311 system for requesting government services results in use throughout a jurisdiction or facilitates the "haves" gaining greater access and limiting opportunities for historically disadvantaged groups. To address this question, we use the citizen relations management (CRM) database of the City of Boston, which includes data gathered from the city's Mayor Hotline (Boston's version of 311), online portal, and smartphone application. The workhorse of any 311 system, CRMs are

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the "centralized local government public information centers that take non-emergency service requests from citizens … [enabling] 311 systems to route requests to the appropriate department and follow through on the fulfillment of service requests" (Ganapati 2011, 430). The CRM logs all citizen-generated requests for services (such as fixing a pothole, cleaning graffiti, etc.), as well as the work orders generated to fix the problems. From this rich data source, we create maps of all service requests in the City of Boston and combine that information with data about the neighborhoods where those problems were reported. These maps and more detailed statistical models allow us to develop an understanding of how a 311 system might affect citizens' ability to participate in the coproduction of public services.

The findings for Boston suggest that we have little cause for concern that 311 systems may benefit one group over another based on race: the racial composition of a neighborhood provides little predictive power in assessing the number of service requests. However, the results give some indication that Hispanics may be left behind as 311 systems expand beyond the basic call center to the Internet and smartphone applications. The results demonstrate significant negative relationships between the share of the Hispanic population in a neighborhood and the likelihood of using the city's service request web portal. With respect to income, the findings show that the poorer a neighborhood, the less likely it is to take advantage of the 311 system. A notable exception is smartphone utilization. The greater the percentage of the two poorest income groups in a neighborhood, the more service requests were made using Boston's smartphone application. This result suggests that smartphones may have potential to bridge the digital divide. We find additional evidence that Boston's smartphone application may help attract a large and rather transient population into the coproduction of government services: young college-age individuals.

This result suggests that smartphones may have potential to bridge the digital divide.

This article is organized into five sections. The first section presents the grounding of coproduction in the literature of citizen participation and the emerging importance of the new communications technology for the coproduction model. The next section further explores the relevance of coproduction for 311 call center systems. The third section describes the data and methodology of this inquiry and is followed by empirical evaluation of the hypotheses. The article concludes with a discussion of the findings and their implications for coproduction and the involvement of citizens in 311 systems.

Citizen Participation and Coproduction

In *The Age of Direct Citizen Participation*, Nancy Roberts defines direct citizen participation as "the process by which members of a society share power with public officials in making substantive decisions related to the community" (2008, 5). Elaine Sharp argues that citizen participation includes "any form of involvement in community affairs that has the potential to shape the allocation of public resources or the resolution of community issues" (2012, 102). In contrast to indirect citizen participation (i.e., representation), direct citizen participation embraces increased cooperation between public administrators and actively involved private citizens (Roberts 2008) and civic engagement (Sharp 2012, 102). According to Kaifeng Yang and Sanjay Pandey, effective citizen participation is achieved when "government decisions and government–citizen relationships can be substantively improved" (2011, 889).

The field of public administration has often encouraged citizen participation and has recognized a variety of different citizen roles through which it might take place, including voter, customer, and active citizen (Schachter and Yang 2012). Roberts (2008) outlines several models of direct citizen participation, including *coproduction*, in which citizens adopt the role of volunteer or "coproducer." In the coproduction model, administrators are responsible for facilitating the joint provision of service design and delivery with citizens (Roberts 2008, 21). Terry Cooper and Pradeep Chandra Kathi observe that "[c]oproduction is joint provision of a public service by the public agency as well as by the service consumers" (2005, 47), a view shared by Stephen Percy (1984) and by Sharp (2012), who identifies coproduction as "an alternate conception of citizen participation" (Sharp 1980, 109). In *Citizen, Customer, Partner: Engaging the Public in Public Management*, John Clayton Thomas (2012) explains that coproduction has increased as government's work has shifted from products to services.

Scholars have observed profound implications of the coproduction model. Charles Levine argues that coproduction can strengthen the "bridge" between citizens and government by revitalizing citizenship (2008, 89–90), and Elinor Ostrom employs a similar metaphor to describe coproduction's potential for "breaching the great divide" between government and its citizens (1996, 1073). Based on Ostrom's observations and conceptual framework, Taco Brandsen and Victor Pestoff describe coproduction as "one way through which synergy could occur between what a government does and what citizens do" (2006, 496). Tony Bovaird asserts that "the coproduction approach assumes that service users and their communities can—and often should—be part of service planning and delivery"—a "revolutionary concept in public service" (2007, 846).

In addition to changing the relationship between citizens and their governments, researchers find that coproduction can increase the effectiveness and efficiency of service delivery (Parks et al. 1981, 1001). One way in which improvements in service production can result is from citizens making requests for assistance or providing information to service agents, as noted by Gordon Whitaker (1980) and others (Bovaird 2007; Brudney and England 1983; Thomas 2012). Citizen service requests provide necessary information to local governments concerning service needs and shortfalls (Whitaker 1980, 243–44). Sharp observes that citizens exhibit "participatory behavior" whenever they contact public officials, either to request a service or to lodge a complaint (2012, 103–4). Ostrom notes that "if citizens do not report suspicious events rapidly to a police department, there is little that department can do to reduce crime in an area or solve the crimes that occur" (1996, 1079). Percy cites several examples of how citizens might participate in police services, such as "reporting crimes to police, providing information on criminal matters and suspects, and testifying in court" (1984, 432–33). By providing information to government officials, citizen coproduction facilitates better decision making and the ability to respond to citizen demands and concerns more effectively (Percy 1984, 437).

Crime is not the only service domain in which citizens might make requests for assistance or share information with public administrators and local governments. Indeed, Whitaker's model recognizes the possibility of active citizen participation across service domains (Brudney and England 1983, 60). Coproduction is observed in a wide variety of policy areas, such as education, the environment, health care, and sanitation (Alford 2009; Ben-Ari 1990; Kiser and Percy 1980; Ostrom 1996; Sharp 1980). Educational success requires the active engagement of student coproducers in learning and parent involvement in homework (Levine 2008, 83; Ostrom 1996, 1079). Environmental programs engage citizens in recycling and community cleanup campaigns (Kiser and Percy 1980, 1). Doctors must "rely on patients to behave in certain ways" to ensure successful treatment, such as taking prescribed medication and participating in physical therapy (Alford 2009, 1). Coproduction in local sanitation services encourages citizens to "literally go half way" in curbside trash pickup efforts (Sharp 1980, 111). Sharp argues that these "less spectacular forms of participation" are often forgotten in discussions of citizen participation but affect the capability of government to improve service conditions (1980, 112–13).

From the inception of the coproduction model in the early 1980s, scholars have recognized the influence that technology and "technical feasibility" would have in setting the limits and potential of citizen coproduction activity (Parks et al. 1981, 1002; cf. Kiser and Percy 1980, 4). Sharp observes the need for public administrators to remain open to new forms of citizen coproduction and appropriate government responses (1980, 113). More recently, Bovaird concludes, "Though we cannot predict the outcomes of these complex adaptive coproduction processes, they clearly extend the opportunity space of available solutions for social problems" (2007, 857).

The new information technology has extended the applicability of the coproduction model in government service delivery. John Alford (2002) contends that recent technological advances may lead to an increased ability to perform coproduction activities. In an essay on applying technology to enhance citizen engagement with local governments, William Barnes and Brian Williams (2012) urge public administrators to embrace the new information technology in response to a changing society and citizenry. Albert Meijer claims that the Internet can facilitate improvements in citizen contacts through social networking and online support groups in the "networked coproduction of public services" (2011, 598). His results suggest that new media and online networks can boost coproduction and information exchange between citizens and their government (606).

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Despite the growing interest of researchers and practitioners in the applications and consequences of the new information technology for the coproduction of government services, Meijer finds that "Scholarship on coproduction of public service repeatedly ignores the role of the new media" (2011, 598). Accordingly, the remainder of this article will investigate how new information technology, such as 311 call centers, the Internet, and smartphones, affects the ability of citizens to participate in the coproduction of public service delivery.

Coproduction and Its Application to 311 Call Centers

Centralized, nonemergency government 311 call centers originated in Baltimore in 1996 as a response to an overload of the 911 system with nonemergency calls (Borins et al. 2007). Baltimore saw immediate and substantial positive results through lower crime rates and cost savings totaling $100 million in the first three years (Borins et al. 2007). Given Baltimore's success, the Bill Clinton administration promoted 311 to improve government performance at the local level. Boston mayor Thomas M. Menino viewed 311 systems as a way to achieve the core value of local government—"helping people"—which could be accomplished by paying "attention to basic quality of life issues … such as filling potholes, removing graffiti, and ensuring that the city streets are clean, safe, and well-lit" (City of Boston Performance Management System 2011, 1). Since the Baltimore experience, a growing number of cities have expanded 311 systems to encompass the Internet through dedicated municipal portals, social media, and smartphone applications.

Research has not yet examined how 311 systems may have improved citizen interaction with government, however. Little is known regarding how 311 may have transformed citizens' access to government or affected the ability of different demographic groups to request and receive services. Prior research on 311 systems is extremely limited (Borins et al. 2007; Mazerolle et al. 2005; Schultz 2003). Very few studies have investigated the use of advanced smartphone technology in government services (Fioretti 2010; Floreddu and Cabiddu 2012; Ganapati 2011; Traunmüller 2011),[3] and none that we are aware of has investigated the distributional consequences of these technologies.

The questions that we seek to answer in this article pertain to the changing role of citizens in the delivery of government services in the twenty-first century as a result of the introduction of new information technology. To understand the consequences of 311 for public services, we turn to the concept of coproduction.

Coproduction arose from a fiscal environment similar to the present era, with the local government fiscal crisis of the 1970s "that affected provision of civic services" (Cooper and Kathi 2005, 47). Levine asserts that limited public resources encourage coproduction in the delivery of services, a theme echoed by Larry Kiser and Stephen Percy (1980, 1). But, as Nathan Glazer observes, coproduction is "more than a financial panacea for fiscally strapped governments" (quoted in Levine 2008, 83). To the contrary, Jeffrey Brudney and Robert England argue that coproduction's main contribution is the "appreciation of the role that citizens can and do play" in service delivery (1983, 62). Levine sees coproduction as a vehicle for "continuous day-to-day involvement of individuals and neighborhoods in government" (2008, 83). Richard Rich argues that for the average citizen, these "small increases in the quality of the various municipal services delivered in his or her area can combine to improve significantly the quality of community life" (1981, 63). Similarly, Pestoff views coproduction as "an important means of enhancing both the quality and quantity of public services" (2006, 507).

Bovaird (2007) suggests that this increase in quality and quantity of services occurs at very low cost to government. For example, the economic consequences for cities using phone-based versus Internet or smartphone-based systems are substantial. The cost of operator-based 311 systems range from $1.15 to $5.49 per call (Pew 2010), while the cost per reported case for the Internet/smartphone are estimated to be 80 percent to 90 percent less (Lagan 2011; 311: Charlotte and Mecklenburg County 2005). Because cost considerations will likely drive cities to invest even more in the Internet and smartphone-based technologies, it is important to examine their consequences for the coproduction of government services.

One possible implication concerns distribution: the potential advantages of coproduction for citizens and governments notwithstanding, scholars have found that participants in coproduction come primarily from wealthy communities. Thus, the apprehension arises that coproduction can perpetuate and worsen the disproportionate control over community resources possessed by the more affluent (Bovaird 2007). Additionally, many citizens do not have the ability to perform services that require specialized training, so that they cannot take advantage of coproduction (Pestoff 2006). The cost of services is not eliminated by coproduction, but instead, some of the costs are transferred to the citizen. The efficiency and effectiveness of coproduction depend on the ability of citizens to perform their roles in service delivery (Pestoff 2006).

Scholars have examined the participants in coproduction and disparities in involvement. According to one study, those engaging in coproduction activity tend to be older, female, and inactive in the labor market; with the exception of older people, these same groups are also more willing to engage in higher levels of coproduction (Löffler et al. 2008). Another study asserts that those with more education and with higher-paying jobs are more likely to be involved in coproduction activities, including the improvement of public services, the crafting of policy, and service in community or neighborhood councils (Norris and McLean 2011). Although studies may vary on specifics, most scholars agree that disadvantaged populations such as racial minorities, those with less formal education, and those in lower socioeconomic circumstances tend to participate less in coproduction activities, which will diminish the benefits they can derive from the model (Barker 2010; Holmes 2011). This research underlies our first hypothesis:

> **Hypothesis 1:** Historically disadvantaged groups are less likely to participate in coproduction through 311 systems.

Despite the benefits of integrating new information technology into coproduction, some citizens prefer more traditional ways of receiving services from and interacting with government (Gagnon et al. 2010). These citizens may not have the experience, training, or resources needed to use the new information technology. This "digital divide" describes the gap between the "technology haves and have-nots" caused by the lack of computer access, Internet access, and technological expertise (Horton 2004,17). Dyson (2011) finds evidence "that marginalized groups are the ones most adversely affected by the digital divide. Those who are already disadvantaged by income or education are more likely to be excluded from digital citizenship."

Mitlin (2008) shows that coproduction can be used to obtain political influence and access to resources by creating opportunities for citizen involvement in areas typically reserved for government. Scholars have noted the difficulty of engaging marginalized groups in coproduction and public services (Barker 2010; Holmes 2011). The incorporation of information technology into coproduction can further limit the groups that have the ability and access to participate. Older adults and those with low income, those who are unemployed, or those who have less formal education tend to suffer from digital exclusion (Nash 2011). One study shows that whites are more likely than blacks or Latinos to participate in e-government (Bryer 2010). Another scholar identifies level of education, age, income, race, ethnicity, and gender as potential factors in digital exclusion (Schradie 2011).

Research has shown that minorities tend to have less access to technological resources, limiting their ability to participate fully in digital coproduction activities (Nash 2011; Schradie 2011). Because these groups are often in greatest need of government services (Nash 2011), their exclusion from technologically advanced coproduction may be especially problematic. People from diverse backgrounds, then, may need supplementary support or facilitation to participate in coproduction (Needham 2009). Some communities are attempting to solve the problem of digital exclusion in coproduction by making computers and Internet access more widely available at public libraries and community centers (Nabatchi and Mergel 2010). Other cities provide handheld computers or digital cameras to citizens so that they can report on community conditions (Svara and Denhardt 2010). Some governments promote Internet access by funding programs to implement Internet connectivity in the home (Hodgkinson 2011).

Increasingly, governments are adopting new channels of information technology, such as telephone, smartphone, and the Internet, to broaden services and involve citizens (Gagnon et al. 2010). Technologies such as social networking and smartphones have recently been used to help victims of natural disasters and other emergencies, for instance, Google People Finder during the 2011 tsunami and earthquake in Japan (Weintraub 2011). Information and communication technology has enabled and initiated new partnerships and coproduction relationships between citizens and government (Alford 2002; Löffler 2011).

Despite the growth in the use of new information technology by government, little, if any, research has investigated the effects of the shift to new media on the provision of services. For example, many cities have iPhone and Android-based applications but no Blackberry applications for 311 reporting. A recent Nielsen survey found that African Americans are more likely than any other racial group to own a Blackberry (Kellogg 2011), so this preference for a particular technology could skew the usage and penetration of phone-based technology in government coproduction of services. Research has not determined whether neighborhoods with larger minority populations are taking advantage of 311 systems. A pattern of domination of 311 by certain groups will advantage them but disadvantage others.

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Scholars have long debated the relationship between the development of information and communications technologies (ICTs) and citizen participation. Using the Internet as a key technology of ICTs, a large body of work addresses two perspectives on the effects of ICTs on citizen participation: optimism and pessimism (Bimber 2001; DiMaggio et al. 2001; Katz and Rice 2002; Krueger 2002; Norris 2010). The key argument of the optimistic position is based on the mobilization hypothesis, which postulates that the development of ICTs will not only reduce the costs of information and communication for citizen participation but also get citizens—particularly those who are inactive in the current system—more involved and engaged in public life (Chen and Dimitrova 2006; Delli Carpini 2000; Krueger 2002; Norris 2001; Ward, Gibson, and Lusoli 2003; Weber, Loumakis, and Bergman 2003). By contrast, the reinforcement hypothesis underpins the pessimistic perspective, which argues that technological innovations merely reinforce participation of those who are already informed and motivated through traditional channels and thus exacerbate existing social inequities between the information haves and have-nots (Best and Krueger 2005; Delli Carpini 2000; Kavanaugh 2002; Norris 2001). Even though one recent study finds both mobilizing and reinforcing effects of the Internet on political participation (Nam 2012), the majority of empirical studies seem skeptical about the mobilizing effects of the Internet on citizen participation, particularly on civic engagement and political participation, and find either a weak effect on political participation or little evidence to support a significant relationship between the Internet and civic engagement (Bimber 2001; Chen and Lee 2008; Delli Carpini 2000; Krueger 2002, 2006; Park and Perry 2008).

Although the new information technology may be facilitative for some, it may pose another barrier to communicating with government for others. In this research, we examine the consequences of expanded technological channels for coproduction for disadvantaged groups. Our second hypothesis proposes:

> **Hypothesis 2:** As coproduction extends its application to the Internet and smartphones, the historical disparities will exacerbate the problems of unequal participation in coproduction.

Methodology

This section presents the data and methods used in the study to test the hypotheses concerning coproduction of services. We model citizen service requests as a function of sociodemographic variables, including race, income, and education; land use (zoning); and a geospatial dependence variable. We begin with the data sources.

Data Sources

Our study relies on data drawn from the City of Boston's CRM database. The CRM tracks work orders generated by government employees (e.g., by city inspectors) and citizens. The database includes all information logged through the 311 system: information and service calls made to the Mayor's Hotline, service requests made through the city's Internet portal, and requests made through the smartphone application. The city limited the data available to one year, from March 1, 2010, to February 28, 2011. All citizen-generated requests that could not be mapped to their geographic origin were removed (these items are almost exclusively general information requests not tied to a specific location).

In order to make inferences about the neighborhoods generating citizen service requests, we had to collapse the request data by their location into census block groups, which allowed us to associate with them demographic data derived from the U.S. Census Bureau's 2005–2009 American Community Survey. Because demographic information is not available for each service request, the association with the census data is the only way to incorporate this information and examine the spatial or group implications for service delivery. Collapsing the data changes the unit of analysis from the individual service request to the census block group. Consequently, we have observations from 537 block groups for statistical analysis—though the actual number of individual service requests generated during the one-year period in those census block groups was far greater, 101,895. Of those requests, city departments made 44,500 requests, and citizens made 57,395. Citizen requests consisted of 39,092 made through the Mayor's Hotline; 13,523 made on the Internet; and 4,780 made through the Citizens Connect smartphone application. This methodology allows us to gain the demographic information, but we lose the specificity and richness of the individual request data.

Figure 1 presents the geospatial distribution of the service requests made during the study period. Figure 1, panel F shows that requests made using smartphones are highly concentrated in the northern Boston areas, including Downtown, Beacon Hill, and South End. Figure 1, panel D demonstrates higher concentrations of hotline requests in areas such as Downtown, Beacon Hill, South End, Charlestown, Maverick Square, South Boston, and Central City. Internet requests (figure 1, panel E) add more distinctive concentrated nodes in areas such as Oak Square, Allston-Brighton, and Jamaica Central, in addition to the concentrated areas seen in hotline requests. Although the geographic dispersion of all requests made by citizens (i.e., Mayor's Hotline, Internet, and smartphone requests) is concentrated in the northern and central areas of the city (figure 1, panel C), requests made through city departments show higher concentrations in the southeastern area of the city (figure 1, panel B). This geospatial distribution may imply that citizens can play complementary roles in detecting needs for government service provision in combination with the normal operations of local government. This result may intimate that governments with limited resources could focus service agents' or inspectors' time determining need in the areas where citizens' requests are relatively sparse and use citizens' requests to provide information on areas of need elsewhere.

Models and Measurement

The dependent variables in our analysis consist of the number (count) of service requests of each type for the $N = 537$ census block groups in Boston for the study period (we use the 2000 census block group boundaries). Requests with geolocation coding encompass more than 80 different categories, including street potholes, snow not plowed from a roadway or sidewalk, a dead animal in the street, problems with streetlights, and so on.[4]

We estimate six models, each incorporating the same set of independent variables and differing only in the dependent variable, the type of service requests counted. The first model, *total requests,* is the sum of all service requests, including those submitted by city department employees and by citizens. The second model, *departmental requests,* counts only those service requests filed by city department

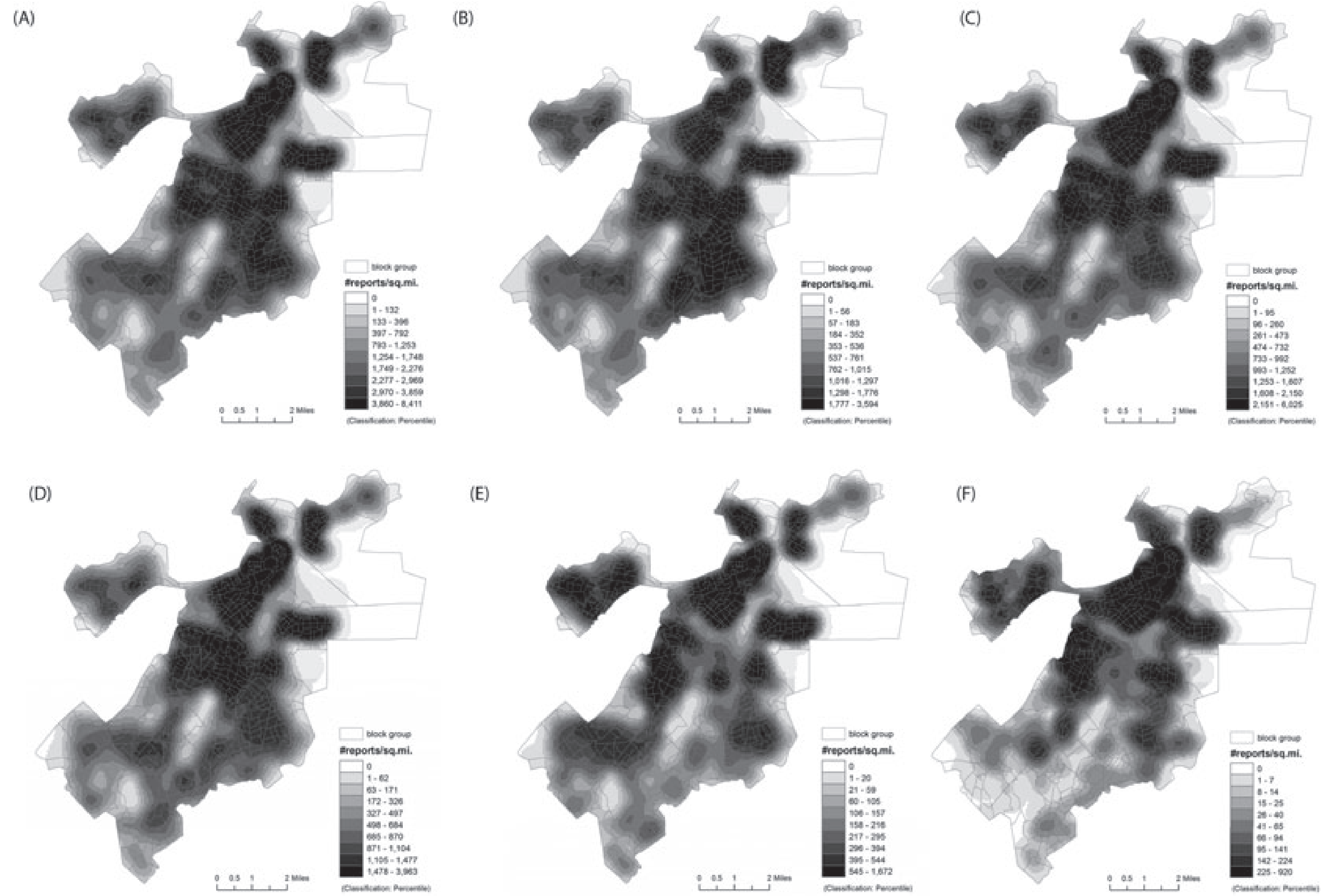

Figure 1 Kernel Density Maps of Boston 311 Reports with a Half-Mile Bandwidth: (A) All Reports, (B) Departmental Report, (C) All Citizens' Report, (D) Mayor's Hotline, (E) Internet, and (F) Smartphone Report.

employees. Because citizens have the option of calling a department directly, after which employees of that department are expected to log the request as a departmental request, it is possible that citizens made some of these requests. However, employees of the City of Boston indicated that very few, if any, service calls are made directly to the departments (i.e., citizens use the 311 system).

The third model, *citizen requests,* examines all requests made by citizens to the 311 system regardless of the mode of communication they used (telephone, Internet, or smartphone). In the fourth model, *hotline,* the dependent variable is the number of requests made to the Mayor's Hotline; requests for general information, such as hours of operation for an office or agency rather than for services, were excluded. The fifth model, *Internet,* counts only those service requests made using the City of Boston's service request Web site. The dependent variable in the sixth model, *smartphone,* consists of the number of citizen requests made using the city's smartphone application, Citizens Connect, which is available for both iPhone and Android phones.[5]

To explain citizen coproduction activity, all six models of citizen service requests use the same set of independent variables consisting of demographic variables and zoning variables. The former comprise race/ethnicity,[6] income, education, home ownership, and population of the census block group. The source of these data is the U.S. Census Bureau's 2005–2009 American Community Survey. To understand the characteristics of the census block groups more fully, we obtained data on land-use zoning from the Massachusetts Office of Geographic Information (MassGIS 2007). The zoning variables measure the percentage of land area within a block group devoted to various uses. Although we recognize the potential for intercorrelation among these variables, the findings show the independent effects of the variables.[7] Table 1 presents the descriptive statistics by census block group of all variables used in the analysis.

Given our spatial analysis, we tested for global spatial clustering (i.e., autocorrelation) in the patterns of each type of service request (Anselin, Sridharan, and Gholston 2006). If spatial autocorrelation is present, suggesting that the individual service requests are not randomly distributed spatially, a spatial lag variable is one method that can take into account the effects of spatial dependence in the model. Based on this examination, we found that for five of the six models, a spatial lag variable is required and, thus is included in the model. The appendix explains the derivation and use of the spatial lag variable in our analysis.

Statistical Estimation

We use negative binomial regression analysis to estimate the six statistical models for the different types of citizen service requests. Because our dependent variables are counts of events, the number of service requests received from within a census block group in Boston during the study period (one year), negative binomial and Poisson models are appropriate. In all six models, specification tests indicate

Table 1 Descriptive Statistics and Source: Dependent, Independent, and Spatial Lag Variables (*N* = 537 block groups)

	Mean	SD	Min.	Max.	Data Source
Dependent Variable					
Total requests	188.94	97.35	8	729	City of Boston CRM
Departmental requests	82.63	42.39	2	270	City of Boston CRM
Citizen requests	106.32	65.84	5	589	City of Boston CRM
Hotline (telephone) requests	72.42	42.67	4	320	City of Boston CRM
Internet requests	25.07	22.46	0	338	City of Boston CRM
Smartphone requests	8.82	12.15	0	94	City of Boston CRM
Race and Ethnicity (Omitted category: White)					
% Population: Black	25.97	30.60	0	100	U.S. Census Bureau, 2005–9 American Community Survey
% Population: Asian	7.44	11.80	0	90.48	U.S. Census Bureau, 2005–9 American Community Survey
% Population: Other race	14.12	15.48	0	84.62	U.S. Census Bureau, 2005–9 American Community Survey
% Population: Hispanic	0.15	0.17	0	0.79	U.S. Census Bureau, 2005–9 American Community Survey
Income (Omitted category: Median income: $50,000–$75,000)					
Median income: Under $25,000	21.42	20.69	0	88.41	U.S. Census Bureau, 2005–9 American Community Survey
Median income: $25,000–$50,000	20.13	15.64	0	70.97	U.S. Census Bureau, 2005–9 American Community Survey
Median income: $75,000–$100,000	12.98	13.91	0	80.95	U.S. Census Bureau, 2005–9 American Community Survey
Median income: Over $100,000	29.49	25.02	0	100	U.S. Census Bureau, 2005–9 American Community Survey
Education (Omitted category: % Population without high school diploma or GED)					
% Population: With high school diploma	24.19	13.91	0	76.22	U.S. Census Bureau, 2005–9 American Community Survey
% Population: Some college	13.85	8.78	0	47.69	U.S. Census Bureau, 2005–9 American Community Survey
% Population: Associate's degree	5.13	4.66	0	25.32	U.S. Census Bureau, 2005–9 American Community Survey
% Population: Bachelor's degree or higher	40.43	26.61	0	100	U.S. Census Bureau, 2005–9 American Community Survey
Control Variables					
% Population renting	61.08	23.97	0	100	U.S. Census Bureau, 2005–9 American Community Survey
Population (logged)	6.93	0.40	5.83	8.30	U.S. Census Bureau, 2005–9 American Community Survey
% Population: 18–24 years	11.84	12.34	0	84.76	U.S. Census Bureau, 2005–9 American Community Survey
% Zoned conservation	7.82	15.95	0	88	U.S. Census Bureau, 2005–9 American Community Survey
% Zoned "other"	8.34	19.89	0	100	U.S. Census Bureau, 2005–9 American Community Survey
% Zoned "zero value" property	0.92	4.32	0	50	U.S. Census Bureau, 2005–9 American Community Survey
% Zoned commercial	8.25	13.10	0	84	U.S. Census Bureau, 2005–9 American Community Survey
% Zoned industrial	4.54	13.60	0	90	U.S. Census Bureau, 2005–9 American Community Survey
Spatial Lag Variables					
All service requests lag	187.06	55.46	45.75	405	Data generated through the spatial analysis
Departmental requests lag	82.80	28.18	17.5	199.25	Data generated through the spatial analysis
Citizen requests lag	104.26	37.79	27.75	306	Data generated through the spatial analysis
Hotline (telephone) requests lag	71.28	25.47	16.25	195.25	Data generated through the spatial analysis
Smartphone requests lag	8.33	7.39	0.25	43.75	Data generated through the spatial analysis

that the data are "overdispersed," and thus the appropriate statistical procedure is the negative binomial rather than the Poisson (Long 1997).

The results of the estimation of the six models provide insight into the demographics of the neighborhoods (block groups) where the service requests originated (rather than the individuals making the requests). Because the service requests do not include the demographic data essential to our analysis of coproduction, we have no other way of inferring the characteristics of those making the requests, so we must make inferences from the demographics of the neighborhood to the individual users of the Boston 311 system. Although the necessity for inference presents a limitation, given the underdeveloped state of the literature regarding this very new approach to coproduction and the rich information concerning service requests otherwise available to us, our study can still provide valuable insight into the basic characteristics of different types of request generation and their implications for various demographic groups in the City of Boston.

Findings

Figure 2 presents the distribution of service requests for the Boston area for each of the request channels examined in this article. The figure identifies the "high-high"[8] block groups for all six request channels. All service requests (figure 2, panel A), departmental requests (figure 2, panel B), all citizens' requests (figure 2, panel C), and hotline requests (figure 2, panel D) show very similar locations of clusters for low rates of requests, which appear to be the southern areas of Allston and Brighton, Fenway, and the northeast end of Charlestown. However, the locations of local clusters of high rates of requests (i.e., hot spots) are varied over different request channels. The hot spots for departmental requests are Dorchester, Mattapan, and West Roxbury. Figure 2, panel F and figure 2, panel G show where people use the Internet and smartphones to make service requests. The South End, Mission Hill, Fenway, Hyde Square, and Jamaica Plain areas are statistically significant clusters of higher rates of service requests using smartphones. The statistical analysis attempts to explain these distributions of service requests.

We use negative binomial regression analysis corrected for spatial autocorrelation when necessary to explain these patterns for all six types of service requests. Hypothesis 1 proposed that historically disadvantaged groups are less likely to participate in coproduction through 311 systems. To measure historical disadvantage, we use three broad categories: race, income, and education. For hypothesis 1, we examine the results for total service requests, departmental

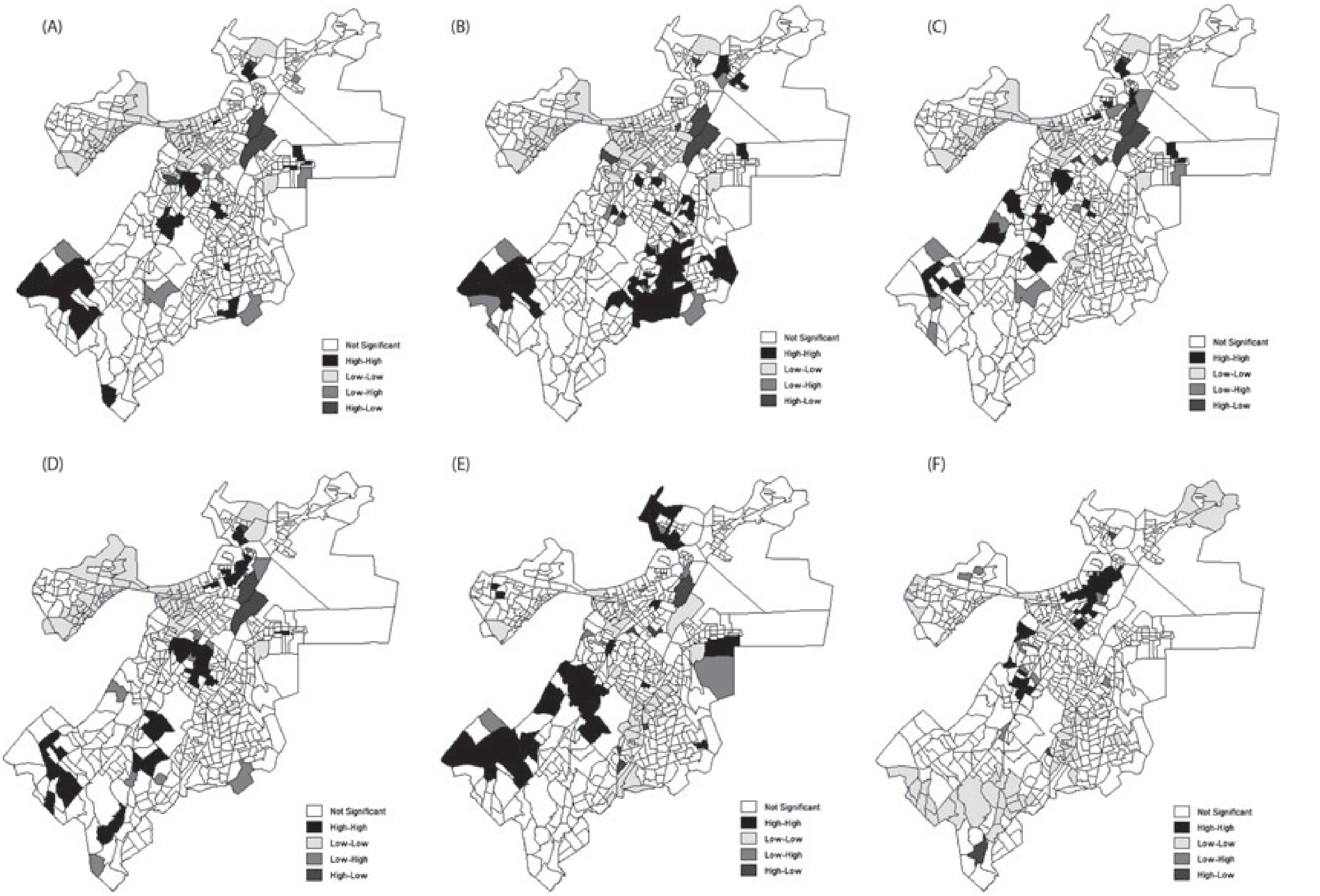

Figure 2 Local Cluster Maps of Boston 311 Reports (significance filter of $p < .05$): (A) All Reports, (B) Departmental Report, (C) All Citizens' Report, (D) Mayor's Hotline, (E) Internet, and (F) Smartphone Report.

requests, and citizen requests (models 1–3) because they correspond to the broadest conception of coproduction (models 4–6 examine particular channels of service requests). Table 2 presents the results.

The findings in table 2 show that across the first three models, blacks/African Americans and whites (the omitted category) do not differ with respect to service requests. The Asian population variable is negative and statistically significant in models 1–3, indicating that census block groups with larger Asian populations request and likely receive fewer services than whites from government departments. Yet the practical difference between the groups is negligible: a 1 percent increase in Asian population in a block group results in a 0.0057 decrease in the expected number of service requests—that is, it would take nearly a 200 percent increase in the Asian population to decrease service requests by just one request. The "other" racial category is not significant in any of the three models, likewise suggesting no difference. The Hispanic population variable is negative and statistically significant at $p < .10$ in model 1 (total service requests) and model 3 (citizen requests), indicating that for each 1 percent increase in Hispanic population, we expect a decrease of about 0.3 in the number of service requests (compared to whites) in both models. This variable has the second-largest effect on the predicted number of service requests in the models (behind only block group population).

Turning to the income distribution in the city's block groups, we examine whether wealthier neighborhoods—which presumably have better access to government leaders and resources—likewise have greater opportunity to attain better service levels, as suggested by service requests. Four ordered categories are used to measure the income composition of each block group, with an additional omitted group (median income between $50,001 and $75,000). As the coproduction research would suggest, in model 1 (total service requests) and model 2 (departmental requests), the percentage of the population making less than $25,000 annually bears a negative relationship to service requests, indicating that compared to the omitted category, as the percentage of low-income people increases, block groups are less likely to request services and departments are less likely to make service requests in these areas. In model 3, the percentage of residents with incomes less than $25,000 in a block group is again negatively related to citizen service requests, although the relationship is not statistically significant.

The effect of education on service requests is statistically significant in only one instance: the percentage of the population with a bachelor's degree or higher education in a census block group is associated with departmental requests (model 2). The omitted category is the percentage of the population in a block group that does not have a high school diploma or GED. The results of model 2 suggest, paradoxically with reference to the coproduction literature, that as the percentage of the population in a block group with a bachelor's degree or higher education increases, the number of service requests will decrease (relative to the lower education group). This result

Table 2 Negative Binomial Regression Models of Service Requests

	Hypothesis 1			Hypothesis 2		
	(1)	(2)	(3)	(4)	(5)	(6)
	Total Requests	Departmental Requests	Citizen Requests	Hotline	Internet	Smartphone
Race and Ethnicity (Omitted category: White)						
% Population: Black	0.0009	0.0010	0.0005	0.0023**	–0.0079***	–0.0043**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]
% Population: Asian	–0.0057**	–0.0054***	–0.0054**	–0.0045*	–0.0093***	–0.0055
	[0.002]	[0.002]	[0.003]	[0.003]	[0.003]	[0.005]
% Population: Other race	–0.0002	–0.0005	–0.0001	0.0001	–0.0014	0.0010
	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.005]
% Population: Hispanic	–0.3026*	–0.2504	–0.3382*	–0.2023	–0.6411**	–0.7144
	[0.158]	[0.161]	[0.176]	[0.170]	[0.286]	[0.469]
Income (Omitted category: Median income: $50,000–$75,000)						
Median Income: Under $25,000	–0.0031**	–0.0035***	–0.0027	–0.0033*	–0.0013	0.0045
	[0.001]	[0.001]	[0.002]	[0.002]	[0.002]	[0.004]
Median income: $25,000–$50,000	0.0016	0.0006	0.0022	0.0014	0.0030	0.0070*
	[0.001]	[0.001]	[0.002]	[0.002]	[0.002]	[0.004]
Median income: $75,000–$100,000	0.0013	–0.0015	0.0032	0.0023	0.0061*	0.0075*
	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.004]
Median income: Over $100,000	0.0005	–0.0010	0.0013	0.0018	–0.0021	0.0058*
	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]	[0.003]
Education (Omitted category: % Population without high school diploma or GED)						
% Population: With high school diploma	–0.0013	–0.0029	0.0001	0.0006	0.0040	–0.0162***
	[0.002]	[0.002]	[0.003]	[0.003]	[0.004]	[0.006]
% Population: Some college	0.0002	–0.0018	0.0023	0.0018	0.0077*	–0.0045
	[0.003]	[0.003]	[0.003]	[0.003]	[0.004]	[0.006]
% Population: Associate's degree	–0.0044	–0.0060	–0.0020	–0.0025	0.0046	–0.0203*
	[0.004]	[0.004]	[0.005]	[0.005]	[0.007]	[0.012]
% Population: Bachelor's degree or higher	–0.0015	–0.0049**	0.0016	0.0001	0.0094***	–0.0026
	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.005]
Control Variables						
% Population renting	–0.0061***	–0.0071***	–0.0054***	–0.0052***	–0.0083***	0.0003
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.003]
Population (logged)	0.7368***	0.7175***	0.7423***	0.7300***	0.8164***	0.5460***
	[0.052]	[0.055]	[0.055]	[0.055]	[0.081]	[0.110]
% Population: 18–24 years	–0.0078***	–0.0068***	–0.0076***	–0.0088***	–0.0079**	–0.0061*
	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.004]
% Zoned conservation	0.0021**	0.0013	0.0026**	0.0020	0.0022	0.0085***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.003]
% Zoned "other"	0.0014	–0.0006	0.0026**	0.0027**	0.0006	0.0051**
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]
% Zoned "zero value" property	–0.0089*	–0.0078	–0.0106*	–0.0099	–0.0150**	–0.0144
	[0.005]	[0.006]	[0.006]	[0.006]	[0.006]	[0.013]
% Zoned commercial	0.0059***	0.0043***	0.0064***	0.0064***	0.0030	0.0104***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]
% Zoned industrial	0.0043***	0.0051***	0.0042***	0.0042***	0.0032	0.0083***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]
Spatial lag	0.0021***	0.0058***	0.0037***	0.0065***		0.0464***
	[0.000]	[0.001]	[0.001]	[0.001]		[0.007]
Constant	0.2356	–0.1661	–0.7094	–1.0685**	–2.3058***	–2.0198**
	[0.462]	[0.496]	[0.481]	[0.484]	[0.659]	[0.943]
ln alpha	–1.9387***	–2.0153***	–1.7402***	–1.7582***	–1.2373***	–0.2872***
	[0.095]	[0.102]	[0.089]	[0.086]	[0.114]	[0.080]
Observations	537	537	537	537	537	537
Pseudo R^2	0.0557	0.0714	0.0604	0.0613	0.0769	0.0739

Robust standard errors in brackets ***$p < .01$; **$p < .05$; *$p < .1$.

may be attributable to the large, transient college-age population in Boston, which has less incentive or reason to request services than permanent residents.

Based on this analysis of the three broad categories of historical disadvantage, in the Boston data relatively small differences in service requests in models 1–3 seem to be attributable to race/ethnicity, income, and education levels of citizens in a neighborhood (block group). Some evidence of these effects does appear with respect to income and the percentage Hispanic population. It may be that (Spanish) language barriers inhibit communication with government or, perhaps, this group may have less interest or motivation in interacting with the city.

Other variables included in the models help explain the variation in service requests. Without question, the primary driver in these models is population. In all three models, a 1 percent increase in the population of a block group yields approximately a 0.7 increase in the number of requests, statistically significant at $p < .01$. In addition, Boston has numerous colleges and universities, whose residents may be less connected to a neighborhood or the city and less likely or committed to interact with the local government. We have tried to control for this population through two variables: the percentage of the population between the ages of 18 and 24 in a block group and the percentage of the population who are renters. Although neither variable is a perfect proxy for university students, both capture some aspect of this demographic.[9] The findings for models 1–3 show that as the percentages of 18- to 24-year-olds and of renters in a block group increase, the number of service requests decreases. These effects are statistically significant at $p < .01$, thus supporting our conjecture.

Because neighborhoods differ in their residential/commercial/industrial composition, all models control for zoning or land use as well. The results in table 2 show that compared to the omitted group (percentage of the block group area zoned residential), the larger the percentage of commercially and industrially zoned land in a block group, the more likely the neighborhood will generate service requests from citizens and from government departments. This pattern might suggest that people request services in the areas where they work and play rather than in places where they live. It may also suggest that residents are more likely to take personal responsibility for problems in their neighborhoods but feel that it is the responsibility of government to maintain nonresidential areas, where ownership is more "public" and less clear. Given the aggregate block group data available, we can only speculate in the absence of individual survey data.

Comparison of the results of models 2 and 3 reveals very little divergence in how citizens and government departments request services. The signs of the statistically significant coefficients are all in the same direction, and their magnitudes are very similar across the models. Thus, these findings suggest little difference in the mechanisms of service request generation across the geospatial area of our study. The results should be, in many ways, comforting to those who fear that increased citizen participation might skew how resources are distributed—giving those who already have power and resources better levels of services. We also recognize that the magnitude of most of the significant results show that demographic characteristics beyond population size have very little influence on the coproduction of service requests among the census block groups examined in this article.

The results should be, in many ways, comforting to those who fear that increased citizen participation might skew how resources are distributed—giving those who already have power and resources better levels of services.

Hypothesis 2 proposed that as coproduction extends its application to Internet and smartphones, historical disparities will exacerbate the problems of unequal participation in coproduction. To measure the effects of these new channels for requesting services through 311 systems, we rely on the same measures of historically disadvantaged groups used in models 1–3: race, income, and education. To evaluate hypothesis 2, we examine the results of models 4–6, which focus on particular service request channels for citizen coproduction.

The results of estimation of model 4 (Mayor's Hotline requests, a traditional 311 telephone call center), model 5 (Internet service requests), and model 6 (smartphone requests) show that blacks/African Americans are less likely than whites to use the Internet and smartphone channels to make service requests, but they are more likely to use the Mayor's Hotline. Although this variable is statistically significant in all three models, as in models 1–3, the coefficient sizes are small, so the practical differences between whites and blacks are minor: a 1 percent increase in black population in a census block group would be expected to yield a change of between only 0.0023 and 0.0079 in expected service requests. In all three models, the Asian population variable is again negative, and statistically significant in models 4 and 5, indicating that block groups with higher percentages of this group are less likely to make service requests. Like the black population variable, though, the Asian population variable, while statistically significant, has little practical significance because the size of the coefficient is so small. The coefficients for the other racial groups are not statistically significant in any of the three models.

The impact of the Hispanic population, which cuts across a variety of racial identities, shows a significant negative relationship for service requests made over the Internet ($p < .05$). A 1 percent increase in the Hispanic population of a census block group is associated with a 0.64 decrease in the number of service requests. The impact of Hispanic population is substantially larger than those of the racial groups; in fact, it is larger than that of any other variable in any of the six models, with the exception of population. As discussed in regard to models 1–3, a variety of factors may be responsible, such as (Spanish) language barriers, or perhaps reticence on the part of the members of this group, or their being newer to the area and thus less likely to tap into the local government for the services offered through Boston's Internet portal.

Next, we examine the effect of the income composition in a block group on the different service request channels. The under $25,000 income category produces one significant result across models 4–6: a negative relationship in model 4 (Mayor's Hotline). This category is again negatively signed in model 5 (Internet) but positively signed in model 6 (smartphone)—although these results are not statistically significant in either model. The positive results in model 6 intimate that smartphones may offer a limited bridge across the digital divide and allow residents to become more connected, which presumably would foster greater citizen participation and coproduction in government. This result may be seen with respect to the significant positive effect for the $25,000–$50,000 income category: as the size of this population increases in a census block group, so does the predicted number of service requests.

The effects of education on how these new technologies may help or hinder citizen coproduction do not yield a clear pattern. Model 4 generates no significant results. Model 5 demonstrates that compared to the omitted category (percentage without a high school diploma), higher percentages of a census block group with some college or a bachelor's degree or higher education will increase the predicted number of service requests received over the Internet. These results are not unexpected and provide some support for hypothesis 2. In model 6, all education categories are signed negatively, although only the high school diploma and associate's degree categories are significant. This last result is not consistent with the proposed hypothesis and may suggest that smartphones provide some help in bridging the digital divide.

As was the case in models 1–3, in models 4–6 population is the most consistent and substantial influence on service requests from the census block groups. The controls for the university population in Boston (proxied by the percentage of the population 18 to 24 years old and the percentage of renters) tell an interesting story. In model 4 (hotline) and model 5 (Internet), both variables are negatively signed and statistically significant. These results coincide with our initial claims that university students would be less connected with the local government and the coproduction of services. With respect to the smartphone application (model 6), however, these variables demonstrate either no significant difference from the omitted category or only a marginal difference, with the size of the 18- to 24-year-old population achieving statistical significance at $p < .10$. This finding may suggest that smartphones can help break down barriers to coproduction among students/youth through use of a technology especially popular with this group. Likewise, early research on coproduction (e.g., Kiser and Percy 1980; Parks et al. 1981) noted the importance of appropriate technology to effective coproduction. As was the case in models 1–3, the results show that the variables that control for the zoning mix in a census block group, the percentages of land zoned industrial and commercial, again increase the expected number of service requests.

Boston's methods of facilitating citizen coproduction may bring groups into coproduction that might have otherwise been excluded.

Our interest in the relationship between the request generation process of the departmental requests and the citizen requests led us to run additional tests. Using a seemingly unrelated regression (SUR) model with departmental requests and citizen requests both as dependent variables allows us to examine this question. Earlier studies (Clark and Whitford 2011) have used these SUR modeling techniques to provide evidence of a "flypaper effect" (departmental and citizen requests moving together) or a "crowding out" effect (departmental or citizen requests suppressing the other). The results of the statistical tests suggest the presence of a flypaper effect, but they do not indicate which of these processes (departmental requests or citizen requests) drives the relationship: more citizen requests in a neighborhood could drive more departmental requests, or more departmental requests could drive more citizen requests.[10] Untangling this relationship is not possible with the present data but calls for further research.

Conclusion

As established in the literature of the coproduction model, this study demonstrates that citizens can and do play a complementary role in identifying and reporting needs for services in combination with the local government. In this way, they reduce the monetary and human capital costs required to determine where services are needed in the coproduction of government services. As demonstrated by the Boston example, more is asked of citizens than Borins sees as "the minimum level of social cooperation," that is, that "they refrain from violence" (2008, 56). Coproduction in Boston, and in many other cities using 311 systems, has transformed citizens into "sensors," "detectors," or "reporters" of the problems facing the city.

Our study has unique value in that we can address some of the major concerns of inequality that can arise from these newer technologies for citizen coproduction of services that have hitherto gone uninvestigated. Local government officials face gulfs in their knowledge of what the citizenry needs, and these "gulfs are often exacerbated by social inequalities and group discrimination" (Borins 2008, 57). Our study reveals that 311 systems have the potential to offer "innovations that bridge the worlds of public agencies and insular communities" (Borins 2008, 57): Boston's methods of facilitating citizen coproduction may bring groups into coproduction that might have otherwise been excluded.

The findings of our analysis of the Boston 311 system suggest relatively little cause for concern that such systems may benefit one racial or ethic group over another, with one exception, Hispanics. The results of the statistical models indicate a significant negative relationship between the size of the Hispanic population in a neighborhood (i.e., census block group) and the number of service requests received by government. Income may play some role in the generation of service requests from the city through the 311 system. Yet the analysis reveals a significant positive relationship between larger percentages of the two poorest income categories in a block group and the number of service requests sent by smartphones, thus suggesting that smartphones may help bridge the digital divide. The results also suggest that the smartphone application may attract Boston's large, transient college-age population to coproduction, a group that is less likely to participate through other channels such as the Mayor's Hotline or the Internet.

Of course, our study has limitations that should be taken into account in placing the results in proper context. First, the data available do not allow us to tie specific demographic information to each service request; instead, we rely on the demographic information for the census block group to allow generalization regarding the service requests made within that geographic area. This limitation confronts all studies using this type of data because citizen service requests are generally anonymous or stripped of the sociodemographic characteristics of the users; citizen survey data would be necessary to overcome the limitation. Second, this study relies on the events and experiences of one city, Boston, over the period of one year. Future studies should obtain data from multiple jurisdictions across longer periods of time to verify these results. And third, we lack detailed information concerning how the city manages and prioritizes the data generated through the 311 system, which is crucial to the coproduction process.

The volume of citizens' requests to government through the various channels of 311 communications in Boston, including Mayor's Hotline, Internet, and smartphone, demonstrates a vigorous level of participation. Citizens submitted more requests for services—56 percent of our sample—than city employees—44 percent—and the number of requests totaled more than 100,000 over the one-year study period. On average, the City of Boston receives more than 150 requests for specific, geolocatable services each day. Although we cannot conclude that Boston is becoming any more responsive or that the community any "stronger" as a result of the 311 system, it is clear that the city takes these requests for services seriously. The city reports performance monthly with respect to meeting self-imposed standards for 26 different measures (City of Boston 2011; City of Boston Performance Management System 2011). Each of these measures of performance arises from the citizen coproduction achieved through the Mayor's Hotline, the city's Web site, or its smartphone application.[11]

This study has helped provide a better understanding of the limits and potential of coproduction processes. The open, transparent, and real-time information sharing that can take place between government and citizens through advanced information technology may help foster a more engaged citizenry. A legitimate concern over the last several decades, however, has been the digital divide, that is, the apprehension that as society becomes increasingly "wired" or linked electronically, some groups may be left out, just as they were in past nondigital eras. These results provide some very limited evidence that smartphone technology may alleviate some of the disparity of the digital divide. Further research should consider how coproduction—particularly the new technological forms examined here—will affect government and how it can improve the practices of public management and citizen engagement alike.

Appendix: Spatial Analysis

The first step in this process is our exploratory spatial data analysis. Each of the requests in the CRM database is coded by the city with locational information (i.e., X and Y coordinates); the geographic locations of the requests are identified and represented using a geographic information system (GIS). In order to discern geographic concentrations or dispersions of service requests, kernel density maps (seen in figure 1) are created for each different type of service request channels using ESRI ArcGIS 10 software. The kernel density of service requests is estimated with respect to the number of requests per square mile using a half-mile bandwidth around each point of the requests.

As shown in the kernel density maps (figure 1), the geographic distribution of the locations of service requests reveals that some areas have higher concentrations of requests than others. To assess whether the spatial pattern is attributable to chance (spatial randomness) or a significant spatial autocorrelation (i.e., spatial clustering), we calculate the Moran's *I* statistic test. This test is used as a measure of the global spatial clustering and assesses whether block groups with higher and lower levels of each service request tend to cluster geographically rather than in a random pattern (Anselin 1995; Anselin, Sridharan, and Gholston 2006).

For this spatial analysis, the likelihood of citizens' service requests is estimated by the ratio of the number of service requests in each census block group for a given time period to the population 18 years and over in the block group who might make such requests, rescaled by multiplying by 1,000 persons. The raw counts of service requests by different request channels per each census block group are also used to test global spatial autocorrelation. Open GeoDa software (Anselin, Syabri, and Kho 2006) is used for this exploratory spatial data analysis. To construct a spatial weight matrix for Moran's *I*, we define neighbors using the *k*-nearest neighbors ($n = 4$)

Table A1 Spatial Autocorrelation of Boston Service Requests (March 2010–February 2011)

	Channel Type	Moran's *I*	*p*-value*
Raw count of service requests (block group level)	Total requests	0.1584	< .001
	Departmental requests	0.2809	< .001
	Citizen requests	0.1887	< .001
	Hotline	0.1966	< .001
	Internet	0.1597	< .001
	Smartphone	0.2901	< .001
Raw count of requests/adult population (block group level)	Total requests	0.3702	< .001
	Departmental requests	0.5266	< .001
	Citizen requests	0.3081	< .001
	Hotline	0.351	< .001
	Internet	0.2834	< .001
	Smart phone	0.2754	< .001

Pseudo *p*-values generated from 999 random permutations in Open GeoDa.

method rather than contiguity relationships to avoid a "hollow effect" attributable to the unique geographic arrangement of block group boundaries in the City of Boston, particularly the area around the northwestern suburbs such as Brookline (Anselin, Syabri, and Kho 2006).

Significant Moran's *I* statistics in table A1 show that the location of service requests per census block group is spatially autocorrelated. The block groups that have high rates of service requests tend to be located near other census block groups with high rates. The converse is also true, that those block groups with low rates are usually adjacent to other block groups with low rates. This result suggests significant and positive spatial autocorrelation for all request types, that is, significant clustering rather than a random spatial distribution. Thus, spatial dependence should be taken into account in model specification; otherwise, the estimation of the dependent variables (counts of service requests by different channels) will be biased.

Given this evidence of spatial autocorrelation, we develop a variable to remove the bias. The development of the spatial lag variable is based on the location of the spatial nonrandomness (spatial clusters), using the local indicator of spatial association (LISA) method (Anselin 1995; Anselin, Sridharan, and Gholston 2006). We produce LISA cluster maps using Open GeoDa software (see figure 2).

LISA measures whether the rates of service requests are closer to the values of each neighbor for each block group. The highlighted census blocks in figure 2 are statistically significant clusters or outliers at $p < .05$, based on significance testing with a Monte Carlo permutation approach (Anselin 1995). Four types of spatial autocorrelation are identified: "high-high" indicates clustering of high values of service request rates (high values surrounded by high values); "low-low" indicates clustering of low values of service request rates (low values surrounded by low values); and "low-high" or "high-low" indicate that low values are surrounded by high values and vise versa, which are spatial outliers.

Because the observed service requests are aggregated based on geographic units—census block groups—the spatial effects need to be taken into account in a regression analysis, as suggested in geography and spatial econometrics literature (Anselin et al. 1996; Anselin and Rey 1991; Cliff and Ord 1972). As previously, the dependent variables (raw count of service requests by different report channels) exhibit spatial dependency, which means that an observation in a block group is likely to be correlated with the observations of its neighbor block groups. This spatial relationship of the dependent variable would affect coefficient estimations and inferences of a regression model. A simple spatial autocorrelation test of the regression residuals indicates a significant positive spatial autocorrelation in five of our model specifications, although not in the model for the Internet channel, and the Moran's *I* statistics of regression residuals of the five models are positive and statistically significant: 0.1655 (total report), 0.2287 (departmental report), 0.1541(citizens' report), 0.1961 (hotline report), and 0.1214 (smart phones). Pseudo *p*-values from 999 random permutations for all statistics are less than .001. These results suggest that some information in the dependent variables is repeated in the model specifications, which could lead to biased and/or misleading coefficient estimations and inferences.

To address this issue, in this study, the spatial effects evidenced by spatial autocorrelation of regression residuals are handled by incorporating a spatially lagged dependent variable (Wy) as one of the explanatory variables in the model specifications:

$$y = \rho Wy + X\beta + \varepsilon.$$

In this spatial regression model, block-group-level service requests by different report channels are modeled as a function of various block-group-level explanatory variables and service requests by the same report channel in neighboring block groups. The dependent variable (y) is a vector of observations of service requests by different report channels at the census block-group level. X is a vector of explanatory variables, β is a vector of regression coefficients, ε is a random error term on the dependent variable, W is a spatial weights matrix that represents neighbor structure of geographic units (i.e., census block group), and ρ is a spatial autoregressive coefficient. This study constructs the spatial weight matrix (W) based on the k-nearest neighbors ($n = 4$) method and the spatial lag variable (Wy) with Open GeoDa (Anselin, Syabri, and Kho 2006).

Notes

1. Some local governments have a centralized call center yet do not use the 311 telephone number. However, the premise and operation of these systems are no different from those using 311.
2. Personal interviews with Alissa Black, director of the New America Foundation California Civic Innovation Project, and Brett Goldstein, the City of Chicago's chief information officer, both in 2011.
3. We use Norris's definition of e-government: "the provision of government information and services electronically 24 hours per day, 7 days per week" (2010, 180). Although this article is not ostensibly on e-government, it has applications to that field. A number of studies address the implications of e-government for citizens and/or governments (Meijer and Thaens 2009; Moon and Norris 2005; Norris 2004, 2009, 2010; OECD 2008; Welch, Hinnant, and Moon 2005), but most look primarily at the dissemination of information (Fioretti 2010; Kuzma 2010; OECD 2008) rather than the two-way communication flows that we examine here (although a few have; see Chang and Kannan 2008; Mergel, Schweik, and Fountain 2009; Morgeson, VanAmburg, and Mithas 2011).
4. A complete listing of these services is available upon request from the authors.
5. Although other organizations, for example, SeeClickFix.com, have recently created compatibility with their Web sites and smartphone application, the Boston CRM data used in this study predate that integration.
6. For the variable indicating the percentage of the population within a census block group that is Hispanic, Hispanics can be of any race—thus, this variable overlaps the racial variables.
7. Perfect multicollinearity was not present in any of the models, and the correlations among the variables were largely not statistically significant. Those that were significant were rather weak. As a result, none of the variables had to be eliminated from the models.
8. Four types of spatial autocorrelation are identified: "high-high" indicates clustering of high values of service request rates (high values surrounded by high values); "low-low" indicates clustering of low values of service request rates (low values surrounded by low values); and "low-high" or "high-low" indicate that low values are surrounded by high values and vise versa, which are spatial outliers.
9. More detailed student-focused data are available at the census tract level, but no such data exist at our level of analysis, the census block group.
10. The postestimation Breusch-Pagan test of independence suggests that we reject the null hypothesis of independence ($\chi^2 = 185.642$). The residuals of the two models are positively correlated (at about 0.6).
11. For example, for the Public Works Department, these performance measures include the number of requests for snow plowing/salting, scheduling a bulk item pickup, pothole repair, miscellaneous snow complaints, street light outages, parking "space saver" removal, highway maintenance, recycling stickers, and dead animal pickup.

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