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Government responsiveness and public acceptance of big-data technology in urban governance: Evidence from China during the COVID-19 pandemic

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ABSTRACT

The COVID-19 global pandemic has posed unprecedented challenges to nations and cities worldwide. Governments have adopted Information and Communication Technologies (ICTs) to rapidly control the spread of a novel coronavirus. As an innovative but controversial ICT-based tool, health QR code plays a vital role by assisting rapid contact tracing. Yet, whether and how citizens accept this policy tool remains an unknown theoretical and empirical question. In this paper, we study the sources that determine citizens' acceptance of health QR code in city governance. Based on a nation-wide online survey covering 28 major provincial-capital cities in China, we find that individual experiences and political identities affect citizens' acceptance of QR code. Even though public opinion regarding this issue is diverse, the government's responses to citizens' requests play a critical role in enhancing their acceptance of using QR code both in the current and future stages. Specifically, as the citizens perceive a higher level of city government responsiveness, they are less worried about privacy leaks and more likely to perceive the effectiveness of health QR code in improving public health, thus resulting in a higher acceptance. The results offer broad policy implications for smart cities and urban governance.

1. Introduction

The COVID-19 global pandemic has posed unprecedented challenges to nations and cities worldwide (Atkeson, 2020). National and city governments have had to take proactive and innovative policy measures to rapidly control the spread of a novel coronavirus while mitigating the social and economic consequences of the pandemic (Bonaccorsi et al., 2020; Mei, 2020). Information and Communication Technologies (ICTs) became one of the most innovative, powerful, yet controversial policy tools that governments have adopted to assist rapid contact tracing and contain virus transmission (Gan & Culver, 2020). Similar ICT-based apps have been launched in various nations such as Australia, Russia, Singapore, and South Korea (Ilyushina, 2020; Silverberg, 2021).

One example of these ICT-based tools is China’s health QR code system, a digital app system first adopted in Hangzhou City and has quickly diffused across the country since February 2020. The health QR code system enhanced the government’s capacity to collect and analyze individuals’ past geolocation data and contact history to categorize their risk of infection. It, therefore, enabled Chinese city governments to quickly identify and isolate potentially infected individuals. The health-QR-code system has been considered the “most important weapon” and a “significant achievement” underlying China's success in safely reopening its economy without experiencing massive rebounds of COVID-19 infection cases (Hua & Shaw, 2020; Smith, 2020).

Despite its much-touted potential in containing virus transmission, the health-QR-code system also raised broad concerns over its potential to infringe individual privacy and compromise data security and its use as a ‘surveillance technology’ (Dukakis, 2020; Huang, 2020; Ye, 2020). Citizens may have felt that they had to sacrifice privacy for mobility as city governments used the health-QR code system to determine not only the pace of economic reopening but also individuals’ ability to move around the city and beyond (Huang, 2020). The controversy around the health QR code reflects the dilemma of smart-city governance. The government has to strike a balance between adopting ICTs to enhance its governance capacity and addressing citizens’ privacy concerns to avoid significant public opposition. As scholars have noted, citizens'
acceptance is key to successful rollouts of new ICT tools in the pursuit of a smart city (Allam & Dhunny, 2019; Salvia & Morello, 2020).

An extensive literature has sought to understand the determinants of citizens’ acceptance of ICTs (e.g., Bromberg et al., 2020; Davis, 1989; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000). On the one hand, classical theories, such as the technology acceptance model (Davis, 1989), point to perceived usefulness and perceived ease of use as crucial determinants of users’ acceptance of new technology. On the other, amid the widespread application of ICTs in urban policy and governance, citizens’ concerns over privacy protection have become the center of scholarly and public debates over appropriate adoptions and regulation of ICTs (Braun et al., 2018; Li et al., 2015; Lim et al., 2019).

Governments have tried to address citizens’ privacy concerns by making regulatory policies and taking practical measures (Van Zoonen, 2016). For example, the European Union adopted the General Data Protection Regulation in 2016, and the United States also has several privacy laws that protect individual privacy (Van Zoonen, 2016). In the case of China’s health QR code, provincial and city governments set up special hotlines and online feedback channels to receive and respond to citizens’ concerns and inquiries, and also established a special tech support team to promptly solve the problems of the code system (Zhang, 2020). Besides, subnational governments have responded to COVID-19 in different ways, both in terms of mitigating the spread of infectious disease and meeting the critical needs of affected citizens and businesses (Benavides & Nukpezah, 2020; Liu et al., 2021; Mallinson, 2020). However, few have studied how government actions, particularly its responsiveness to citizens’ needs and concerns, shape individual perceptions and the eventual acceptance of an ICT-based policy tool, especially during extreme crisis situations.

To bridge this intellectual gap, we use China’s health QR code during COVID-19 responses as a case to investigate whether and how city governments’ responsiveness affects citizens’ acceptance of ICT-based policy tools in urban crisis governance. Drawn from the technology acceptance model (Davis, 1989) and theories of government responsiveness (Chen et al., 2016; Distelhorst & Hou, 2014), we theorize that local government responsiveness serves as a communication instrument that reduces citizens’ privacy concerns and increases the perceived usefulness. We utilize a unique dataset derived from a nation-wide online survey of 2800 citizens living in 28 major Chinese cities, conducted during May–June 2020. The statistical results show that city government responsiveness positively impacts citizens’ acceptance of the health QR code. Additionally, the mediating-effect analysis demonstrates that government responsiveness increases citizens’ acceptance through enhancing their perception of effectiveness while mitigating their privacy concerns. These findings contribute to the international literature on smart city governance (e.g., Lawrence et al., 2010; Wolff et al., 2020) with an analytic focus on citizens’ perspectives while establishing the links between improving broad government responsiveness and cultivating citizens’ engagement in the development of smart cities. This research also extends the literature on public acceptance and urban governance in China that has highlighted the roles of socioeconomic factors in citizens’ acceptance of urban planning and policymaking (Guo & Wei, 2019; Liu et al., 2018; Zhou & Dai, 2017). Furthermore, the findings also extend the literature on government responsiveness by investigating a social consequence of responsiveness instead of focusing on its origin.

The remainder of the paper proceeds as follows. We first introduce the background of health QR code in COVID-19 epidemic prevention and control. We then present a theoretical argument and propose hypotheses based on a comprehensive literature review, which is followed by the research design, data collection methods, and main empirical findings. Finally, we conclude the paper with broad policy implications beyond China’s case.

2. Background: the health QR code in China’s COVID-19 responses

The health-QR-code system, an ICT tool based on big data, was first developed and adopted in Zhejiang Province in February 2020, when the provincial government was considering ways to reopen its economy while maintaining the control of virus transmission. In collaboration with Alibaba, one of the biggest e-commerce companies, the Zhejiang provincial government released the health-QR-code mini-program embedded in smartphone apps. It tracked individual users’ geo-location data to assess their risk level of being exposed to COVID-19. Citizens would have to show a green bar on their health QR code app, reflecting a low risk of virus exposure, in order to travel across cities and provinces or enter public places such as office buildings, shopping malls, and hospitals.

A yellow or red bar indicated a higher risk of virus infection, leading to a restriction of movement or even quarantine. Before long, other provinces followed suit and developed similar versions of health-QR-code apps for the same purposes. Local governments have considered the code a useful policy tool for safely reopening the economy by expanding its contract tracing capacity to quickly identify and contain a new surge of coronavirus cases.

However, the rollout of the health-QR-code system was not without suspicion and controversy in the academic community and among the public. In the early days of its adoption, citizens often found travel across cities and regions more inconvenient because different provinces had adopted their own health-QR-code systems with little compatibility among different systems. The State Council of China had to step in to push for improved compatibility and coordination among localized health-QR-code systems and eventually roll out a national health-QR-code system as a substitute.

A more significant concern is that the health-QR-code system is, by nature, a type of surveillance technology that builds on individual-level GPS location tracking data. Big data analytic techniques allow governments and collaborating companies to quickly track an individual’s location and search the contact history to promptly identify potential close contacts. The adoption of such an invasive ICT tool raised widespread concern over the possible infringement of individual privacy and personal data security. To some extent, health-QR-code users had to trade privacy for health, freedom of movement, and reopening the economy. To address these concerns, the National Health Commission (2020) released a notice that required strengthening network information security and protecting personal privacy. The Cyberspace Administration of China (2020) released another statement requiring personal information protection.

In the usage of the health QR codes, citizens may face several technical difficulties. For example, some groups such as seniors, the less educated, or poorer individuals may face difficulties in accessing and using the health-QR-code app (Ramsey & Adams, 2020). It is known as the digital divide in the literature, generally referring to the phenomena that individuals with certain socioeconomic conditions are in disadvantage and benefit less from using digital apps (Lam & Ma, 2019). Local governments have made various effects to provided helpful guidance and deal with the concerns of the disadvantaged. Community workers have been mobilized to provide on-site guidance and instruction for residents. At the same time, hotlines and citizen feedback channels have allowed citizens to easily provide feedback and receive responses (Ye, 2022; Zhang, 2020). It would be interesting to examine the extent to which the rapid responses from city governments to address citizens’ needs can increase public acceptance of the health-QR-code system.

3. Literature review and hypotheses

3.1. Studies of smart cities and ICTs

Information and Communication Technologies (ICTs) have been
widely adopted for urban governance in the global smart-city movement. Although the policies and practices of smart cities vary by country and area, the technologies adopted usually involve digital traces of human activities to assist urban policy making and implementation (Lim et al., 2018; Meijer & Bolivar, 2016). For example, some city governments in the United States have improved public security by using big data analysis of crime records (Lee, 2013). Similarly, the Seoul government in South Korea collects and analyzes transportation and residence data to improve public transportation during the night (Lim et al., 2019). During the COVID-19 pandemic, various nations, such as China, Russia, Singapore, and South Korea (Byunghwa, 2020; Silverberg, 2021; Ye, 2020), have adopted ICT-based tools to assist rapid contact tracing. Through collecting, analyzing, and using big data about human activities, these smart-city technologies help city governments improve the quality and efficiency of public service delivery (Lim et al., 2018; Meijer & Bolivar, 2016; Wolff et al., 2020).

However, the idea of a smart city cannot be fully achieved without citizens’ engagement and acceptance in adopting ICT-based policy tools (Wolff et al., 2020). Although a city government may unilaterally decide to adopt a policy tool, the success of implementation depends on citizens’ acceptance and compliance (Wüstenhagen et al., 2007; Lawrence et al., 2010). Previous studies on other policy areas have shown that lack of public acceptance may lead to reduced effectiveness of the tool, increased costs to coerce compliance, or even heighten social sentiments that potentially challenge government legitimacy (Gu, 2016; Levi, 1988; Liu et al., 2018; Tsai, 2015; Zhou & Dai, 2017). During crisis responses, a government may use its emergency management power to enforce the adoption of a certain restrictive policy or an invasive technology, such as the health QR code in China (Zhang, 2020). Citizens’ acceptance, while shaped by their experiences of crisis responses assisted by the technology, may not only affect the effective implementation of a technological tool during the crisis but also influence its continued use when the crisis is over (Keeler, 1993; Mintrom & O’Connor, 2020; Ye, 2020). Thus, understanding the formation and determinants of citizens’ acceptance of an ICT-based policy tool during a crisis response offers valuable knowledge about the state-society dynamics during the development of smart cities.

3.2. Studies of technology acceptance

The classical “Technology Acceptance Model” (TAM), introduced by Davis (1989), offers a decision-theoretical framework for understanding the formation and determinants of an individual’s acceptance of a new technology. TAM assumes that users form their attitudes of technology acceptance based on rational evaluations of both usefulness and the ease of use of technology (Venkatesh & Bala, 2008). According to Davis (1989), a citizen is more likely to form a positive attitude toward and eventually accept a new technology if he or she perceives it to be useful or convenient to use. In the development of TAM, scholars find that individuals’ acceptance of technology is also subject to social influence (Venkatesh & Davis, 2000). For example, a person’s perception of the social norm may affect their acceptance of technology (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000). Specifically, one’s perceived social norm refers to the perceived behaviors of the other people in the society they consider important (Venkatesh & Davis, 2000).

In the case of ICT-based technologies, citizens’ concern over privacy protection and data security becomes a source of opposition to their adoption in urban governance (Braun et al., 2016; Li et al., 2015). Controversies and concerns over privacy leakage are particularly contentious with technologies that collect and use personal biological information and location tracking data (Allam & Dhunny, 2019; Salvia & Morello, 2020). However, some studies show that individuals make a tradeoff and are willing to sacrifice privacy for the benefits of technologies (Friedewald et al., 2017; Wilkowska & Ziefle, 2011). Although TAM provides a useful analytical framework for understanding citizens’ acceptance of ICT-based tools, it remains unclear how government actions during crisis shape citizens’ perceptions, thereby improving the overall level of public acceptance.

Although TAM provides a useful analytical framework for understanding citizens’ acceptance of ICT-based tools, it remains unclear how government actions during crisis shape citizens’ perceptions, thereby improving the overall level of public acceptance. In other controversial technologies, such as nuclear power, city government activities in terms of how governments communicate with citizens as well as how they respond to public concerns and sentiments, have consequential effects on shaping citizens’ attitudes (Guo & Wei, 2019; Wei et al., 2020). In other policy areas during normal decisions, previous studies also find that local government behaviors can influence citizens’ attitudes toward a policy measure (Liu et al., 2018; Zhou & Dai, 2017).

3.3. Studies of city government behavior and responsiveness

Local governments play critical roles in crisis management (Benavides & Nukpezah, 2020; Liu et al., 2021). In the case of the COVID-19 pandemic, governments have had to control the spread of the infectious disease while mitigating the pandemic’s adverse impacts on the economy and citizens’ livelihoods (Benavides & Nukpezah, 2020; Liu et al., 2021; Mallinson, 2020; Yan et al., 2020). During crisis policy making, governments also have to quickly respond to public sentiment in addition to issue specific requests from individual citizens (Dai et al., 2020). Political scientists coin the term of government responsiveness to denote the extent to which a government takes actions to respond to their citizens’ needs and concerns (Broockman, 2013; Distelhorst & Hou, 2014, 2017). While responsiveness is originally used to describe the behaviors of governments and politicians of western democracies, recent studies find that local governments in China, an authoritarian country, also exhibit a substantial level of responsiveness to local citizens’ requests and concerns (Chen et al., 2016; Distelhorst & Hou, 2014, 2017). The specific rates of responsiveness may vary across policy issues of different nature, localities of different local socioeconomic conditions and government capacities, and across types of requests made by different citizens and with different social stability implications (Chen et al., 2016; Distelhorst & Hou, 2014, 2017; Su & Meng, 2016).

Whereas existing studies have shed light on why and how city governments may be responsive to citizens’ needs, few have investigated the consequences of local government responsiveness, particularly with respect to citizens’ engagement and policy acceptance. Recent studies of pandemic control COVID-19 show that local governments’ different actions lead to different social outcomes (Liu et al., 2021; Mintrom & O’Connor, 2020). Nevertheless, few have examined how the city government responsiveness affects public attitudes and sentiments toward a sensitive technology tool adopted in a crisis. In this paper, we take a step forward by building a theoretical link between local government responsiveness and citizens’ acceptance of the technology.

3.4. Main hypotheses

We draw from both the classical theories of technology acceptance and the theories of government responsiveness to develop a theoretical framework for understanding citizens’ acceptance of a new and controversial ICT-based technology in urban crisis governance.

First of all, according to the Technology Acceptance Model, individuals, as rational people, form their level of acceptance of a new technology based on their evaluations of benefits, costs, and risk (Venkatesh & Davis, 2000). In the global crisis of COVID-19, citizens face extraordinary uncertainty about the potential benefit and cost of adopting a new ICT-based technology such as the health QR code system. On the one hand, the devastating impacts of the pandemic indicated great potential benefit of using the health QR code to contain the virus transmission (Ye, 2020). Previous studies have shown that crises promote the deployment and integration of ICTs in emergency management practices (Vogt et al., 2011) because it is relatively easier for
the government to get endorsements from citizens in a crisis than in normal circumstances (Keeler, 1993; Mintrom & O’Connor, 2020; Morley et al., 2020). On the other hand, citizens’ privacy concern can be a major obstacle for the adoption of the health-QR-code system as essentially a surveillance technology. Citizens may feel reluctance to endorse the use of ICT technologies if they have little confidence in the commitment and ability of government to prevent data leakage and privacy infringement (Morley et al., 2020).

City government behaviors and responsiveness during the pandemic prevention help citizens make a better inference about the benefits and potential costs of the technology (Kinder, 1998; Mintrom & O’Connor, 2020; Shanahan et al., 2011). Rapid response to the privacy concern with an ICT-based technology, including enactment of strong regulation over data and privacy protection, may serve as a communication instrument that informs citizens about the government’s commitment to utilize ICT’s advantage while minimizing the risk of privacy leakage (Druckman & Lupia, 2000; Mintrom & O’Connor, 2020; Ye, 2020). More broadly, government responsiveness to citizens’ needs and concerns in a time of crisis improves citizens’ confidence in the government’s commitment and ability to care for citizens’ well-beings, rights, and voices (Chen & Xu, 2020). In the case of China’s health QR code, such improved public confidence in government responsiveness may in turn enhance public perceptions of the ICT technology as a public health policy tool rather than a surveillance technology (Friedewald et al., 2017; Braun et al., 2018; Bromberg et al., 2020).

In other words, as citizens perceive a higher level of city government responsiveness, they are more likely to perceive the effectiveness of health QR code in improving public health and are less likely to be worried about privacy leaks. Our logical link between government responsiveness and citizens’ acceptance of a certain technology applies when the crisis conditions disappear (Keeler, 1993). Thus, we have the following two main hypotheses regarding the public acceptance that apply both during and after the pandemic.

**Hypothesis 1.** (Acceptance of health QR code and city government responsiveness)
City government responsiveness improves citizens’ acceptance of health QR code.

**Hypothesis 2.** (Mechanism)
City government responsiveness increases citizens’ perceived effectiveness of health QR code, and reduces citizens’ concern about privacy exposure.

### 4. Data source and measurement

Our data for empirical analysis came from a large-scale online questionnaire survey of citizens living in 28 major cities of China, including four provincial-level municipalities (Beijing, Shanghai, Tianjin, and Chongqing) and 24 provincial capital cities in mainland China (capitals of Tibet, Xinjiang, Qinghai were excluded due to difficulties to recruit enough respondents). Our targeted respondents were residents who have primarily lived in the same city since January 2020, so that the information accurately reflected their experiences and perceptions of government responses in the pandemic. We had to rely on online survey for data collection due to ongoing travel restrictions and followed a quota sampling method. In each city, we recruited 100 participants based on a quota structure reflecting the population structure by age, gender, and Hukou status in the city. We conducted detailed data cleaning and removed samples that were completed the survey in an extremely short time or provided inconsistent personal information or suspicious answers (e.g., choosing the same answer for a range of Likert-scale matrix questions), eventually obtaining 2598 valid samples.

Our dependent variable, level of acceptance toward the health QR code (code_accept), is captured by a Likert-scale question in the survey asking each respondent: “what is your attitude about the government’s implementation of health-QR-code policy?” Answers to this question range from the value of one indicating “totally oppose,” two indicating “relatively oppose,” three indicating “neutral,” four indicating “relatively support,” and five indicating “full support.” In addition to capturing citizens’ level of support with government adopting this invasive technology as a tool for pandemic control, we also capture citizens’ acceptance toward continuous adoption of the same technology in the future. This is measured by a second question asking each respondent whether they would “support the government to continue implementing the health-QR-code policy after the pandemic is over (such as when the government announces the end of public health emergency status),” with the value one indicating “support” and zero indicating “oppose.”

Our main explanatory variable is perceived city government responsiveness (city_responsiveness), which is captured in the survey with a 1–5 Likert scale question asking each respondent to rate the level of agreement with the statement “my city government responds to citizens’ needs and concerns in a timely fashion,” with the value of one indicating “completely disagree,” three indicating “neutral,” and five indicating “completely agree.”

Based on the Technology Acceptance Model (Davis, 1989), we include perceived usefulness and privacy concern as two additional predictors of public acceptance to the health QR code, which also are hypothesized as two possible mediating mechanisms from perceived government responsiveness to public acceptance. We mainly focus on two dimensions of concerns that shape the acceptance of QR code: benefit and potential cost of using the health QR code. Perceived
usefulness (perceived effectiveness) was measured by the average score of answers to three Likert-scale questions asking each respondent's perceptions of effectiveness of the health QR code in "protecting my health and safety," "reducing the infection of the coronavirus," and "helping facilitating reopening of the economy." Similarly, privacy concern was measured by the average score of answers to three questions regarding the respondent's degree of agreement with the statements regarding the potential of privacy exposure in the Health QR code. The three statements are: (1) "I feel uncomfortable that the health QR code system uses individual private information," (2) "the requirement of health QR code for individual private information is an invasion of privacy," and (3) "I feel that my privacy might be exposed by the health QR code."

We present the summary of statistics for all the variables used in the empirical analysis in Table 1. According to Table 1, the average of code_accept is 4.39, and on average, 89% of individuals support the use of QR code (i.e., code accept equals 4 or 5). This suggests that most of the individuals in our working sample supports the use of the health QR code. For the future use of health QR code, about 75% of individuals support it. The different attitudes toward the use of QR code now and in the future reflects the fact that citizens' support for QR code may not completely transit to future support. The average of privacy_concern is about 2.87, suggesting that a substantial proportion of individuals have some privacy concerns. The average of perceived_effectiveness is 4.20, suggesting that the majority of citizens realize the benefits of using the health QR code. The average of city_responsiveness is 4.24, suggesting that a large proportion of citizens perceive a relatively high responsiveness from their city governments.

Table 1 also presents other variables capturing individual characteristics. About 50% of participants in our working sample are male. The average of Ln(income) is about 9.31. The variable abroad_experience indicates whether one has experience of living outside of mainland China for more than a consecutive three months (1) or not (0). About 15% in the working sample have experience of living outside of mainland China. The variable education indicates one's educational level, ranging from 1 to 5 (junior high, high school, college for professional education, college, master and above). The variable party indicates whether one is a Chinese Communist Party member (1) or not (0). About 17% of individuals in our working sample are CCP members. The variable owner indicates whether one owns an apartment or not. On average, more than 80% of individuals own a house in our working sample. The variable local_urban_hukou indicates whether one has a local and urban residential registration. About 60% have local urban Hukou. The average age in the working sample is about 41. The variable senior_in_family indicates whether one has at least one senior person older than 65 in the household. About half of the individuals have a senior in household. The variable frontline_friend indicates whether one has a friend or relative who works either in the frontline of a hospital or community fighting against the coronavirus. The mean of this variable is a little less than one half. In addition, we also have a variable cellphone_use that indicates if one is skillful of using apps on a cellphone.

We compare the main socioeconomic variables in our survey data to those of a nationally representative data (Chinese Household Income Project 2018). To some extent, our dataset is fairly representative of Chinese population, with regard to gender, income, homeownership, Hukou status and age. However, our sample is biased toward higher education: about 59% of respondents in our sample has completed higher education. This bias may be caused by the fact that our survey is conducted online so that individuals with less education (such as those children and elderly residents) are less likely to complete the questionnaire survey with technical details. More educated citizens are more likely participate in public affairs (Liu et al., 2018; Zhou & Dai, 2017), and therefore, the study of these individuals is useful to understand public sentiment, which significantly shapes government behavior and public policy.5

Before running regressions, we first use some simple statistics to highlight the intuition about the relationship between the perceived government responsiveness and acceptance of health QR code. In our working sample, we calculate the percentage of individuals who accept the use of the health QR code (i.e., code_accept equals 4 or 5) in three different scenarios: when the perceived city government's responsiveness equals 1 or 2; when the perceived city government's responsiveness equals 3 or 4; and when the perceived city government's responsiveness equals 5. We plot the average acceptance rates under these scenarios in Fig. 1. Similarly, we also construct the average acceptance rates for future use of the health QR code in similar scenarios. We draw the picture in Fig. 2. As both figures show, the acceptance rate increases as the responsiveness becomes higher.

According to simple statistics, 89% of individuals in the working sample support the government use of the QR code during the epidemic while only 75% support the continuing use in the future. This difference can also be observed by comparing Figs. 1 and 2.

Table 1
Summary of statistics.

| Variable                | Observations | Mean | Standard error | Min | Max |
|-------------------------|--------------|------|----------------|-----|-----|
| Code_accept             | 2364         | 4.39 | 0.78           | 1   | 5   |
| Code_accept_future      | 2364         | 0.75 | 0.43           | 0   | 1   |
| City_responsiveness     | 2598         | 4.24 | 0.81           | 1   | 5   |
| Privacy_concern         | 2364         | 2.87 | 1.26           | 1   | 5   |
| Perceived_effectiveness | 2364         | 4.20 | 0.74           | 1   | 5   |
| Cellphone_use           | 2364         | 0.97 | 0.18           | 0   | 1   |
| Male                    | 2598         | 0.50 | 0.50           | 0   | 1   |
| Ln(income)              | 2598         | 9.13 | 0.70           | 7.31| 10.31|
| Abroad_experience       | 2598         | 0.15 | 0.36           | 0   | 1   |
| Education               | 2598         | 3.45 | 0.91           | 1   | 5   |
| Party                   | 2598         | 0.17 | 0.37           | 0   | 1   |
| Owner                   | 2598         | 0.86 | 0.34           | 0   | 1   |
| Local_urban_hukou       | 2598         | 0.60 | 0.49           | 0   | 1   |
| Age                     | 2598         | 40.56| 16.30          | 18  | 75  |
| Senior_in_family        | 2598         | 0.53 | 0.50           | 0   | 1   |
| Frontline_friend        | 2598         | 0.47 | 0.50           | 0   | 1   |

Fig. 1. Acceptance of health QR code and government responsiveness.
5. Empirical results

In this section, we conduct the empirical test of the main hypotheses. The results are either with OLS or ordered-probit model. Only when R squared is reported, the regression model is OLS; otherwise, the regression is in the form of ordered probit. City characteristics may affect citizens’ acceptance and may also be reflected in their perceived city government responsiveness. We control the city fixed effect in regressions so as to partially exclude a type of common source bias. 6

We first test Hypothesis 1 that city government responsiveness improves citizens’ acceptance of health QR code during and after the COVID-19 epidemic. The regression results are presented in Table 2. The first and the third column present the results from ordered-probit regressions, while the second and the fourth columns present the results from OLS regressions. The first-order implication from Table 2 is that perceived government responsiveness significantly predicts citizens’ acceptance of health QR code, both in the current stage and in the future. This verifies Hypothesis 1. In addition, the skill to use the cellphone is significantly correlated with the acceptance of health QR code. Furthermore, the regression results also show that whether one has living experience abroad and CCP party membership are also significantly correlated with their acceptance. Individuals with experience abroad are less likely to accept the QR code, and CCP members are more likely to accept it. These two correlations suggest that public opinion becomes diverse on this particular issue. Individuals with different personal experiences and political identities can have diverged preferences. Although polarization of public opinion presents a challenge for future implementation of health QR code policy, there is something that the government can do to reshape public opinion toward congruence. As citizens perceive a higher responsiveness from the city government, their acceptance is more likely to be enhanced.

Hypothesis 2 presents a mechanism, through which city government responsiveness plays an important role. Responsiveness affects citizens’ tradeoff between privacy concerns and perceived effectiveness. Specifically, the city government’s responsiveness not only helps inform citizens of the effectiveness of health QR code in improving public health, but also reduces citizens’ concern of privacy exposure. We formally test Hypothesis 2 and present the results in Table 3 for acceptance in the current stage. The first column suggests that as the citizens perceive a higher level of city government responsiveness, they are less worried about privacy leaks. The second column suggests that as the citizens perceive a higher level of city government responsiveness, they are more likely to perceive the effectiveness of health QR code in improving public health and protecting public security. The third column somehow demonstrates an indirect impact of responsiveness on acceptance. Specifically, as citizens become less concerned about the privacy leaks and more convinced about the benefit of using the QR code, they are more likely to accept it.

We present the OLS version of Table 3 in Table 4. The main findings remain unchanged qualitatively. Specifically, as the citizens perceive a higher level of city government responsiveness, they are less worried about privacy leaks and are more likely to perceive the effectiveness of health QR code. Notice that the third column of Table 4 shows that the marginal impact of responsiveness is 0.0817. It is smaller than the marginal impact estimated in column 2 of Table 2, which is 0.403. When considering the indirect channel through affecting the effectiveness concern and privacy concern, the direct impact of city government responsiveness becomes smaller. We use delta method to verify that, the indirect effect through privacy concern 0.0124 and the indirect effect through effectiveness concern 0.2136 are both significant under 95% confidence interval. The empirical result demonstrates the mediation effect through privacy concern and effectiveness concern.

In addition, Tables 3 and 4 also suggest that having experience abroad or a senior in the family significantly predicts a higher privacy concern. Party membership reduces privacy concern while increasing the perception of effectiveness. Furthermore, the impact of having a friend or relative working in the hospital frontlines is mixed. It increases both privacy concern and effectiveness perception.

Table 5 presents the extension of the analysis to citizens’ acceptance of future use of QR code when explicitly considering privacy concern and perceived effectiveness. The first column presents the results from an order-probit regression, whereas the second column specifies the results perceive a higher level of city government responsiveness, they are more likely to perceive the effectiveness of health QR code in improving public health and protecting public security. The third column somehow demonstrates an indirect impact of responsiveness on acceptance. Specifically, as citizens become less concerned about the privacy leaks and more convinced about the benefit of using the QR code, they are more likely to accept it.

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In addition, Tables 3 and 4 also suggest that having experience abroad or a senior in the family significantly predicts a higher privacy concern. Party membership reduces privacy concern while increasing the perception of effectiveness. Furthermore, the impact of having a friend or relative working in the hospital frontlines is mixed. It increases both privacy concern and effectiveness perception.

Table 5 presents the extension of the analysis to citizens’ acceptance of future use of QR code when explicitly considering privacy concern and perceived effectiveness. The first column presents the results from an order-probit regression, whereas the second column specifies the results
from an OLS regression. Similarly, as suggested by Tables 3 and 4, privacy_concern plays a negative role and perceived_effectiveness plays a positive role. When taking the two concerns into account, the direct impact of city_responsiveness becomes insignificant. Its marginal magnitude 0.0177 is also smaller than that in Table 2, 0.0657. It therefore suggests that city government responsiveness affects citizens’ acceptance of using QR code in the future mainly by affecting the tradeoff between privacy and effectiveness. We use delta method to verify that, the indirect effect of privacy_concern on perceived_effectiveness is 0.0239 and the indirect effect of perceived_effectiveness on code_accept is also significant under 95% confidence interval.

### 6. Conclusion and discussions

In this paper, we draw from the theories of technology acceptance and theories of government responsiveness to build a theoretical link between city government responsiveness and citizens’ acceptance of ICT-based tools in smart city governance. Using the health QR code of China as an empirical case, we conducted a nation-wide online survey to empirically test whether and how citizens’ level of acceptance is shaped by their perceptions of city government responsiveness during COVID-19 crisis responses. Our empirical analysis shows that government responsiveness affects citizens’ acceptance, the marginal impact of responsiveness does not significantly vary with individual trust. In other words, we do not find evidence that citizens’ intrinsic perceptions affected by cultural differences. However, that does not prevent the local government’s responsiveness from affecting public acceptance through its channel. Because we have few variables in the survey that directly measure the cultural dimension, we are unable to offer a comprehensive robustness check. However, we conduct a robustness check for the Chinese political culture; that is, the citizens exhibit a strong degree of trust toward the government, especially the central government (Chen, 2017; Li, 2008; Yang & Tang, 2010). Although individual trust of the central government directly affects acceptance, the marginal impact of responsiveness does not significantly vary with individual trust. In other words, we do not find evidence that denies applications of our result to content with a different level of political trust. The result suggests that the logical link between the local government’s responsiveness and citizens’ acceptance of the QR code can be naturally applied to other regimes with possibly different signal the benefit of the QR code and demonstrate the government’s commitment to protecting privacy, thus helping convince citizens to accept the use of QR code.

As we develop the theory based on a comprehensive literature review, the main logical link between local government responsiveness and citizens’ acceptance of technology can be widely applied to other regimes. As Yamawaki and Castro Filho (2020) point out, culture is an important dimension to understand citizens’ acceptance of technology. Our theory does not contradict this argument. When we apply the logic to a different regime, citizens’ intrinsic perception of risk about privacy leakage may be different from that of China because of cultural differences. How effectively a local government can convince citizens about the low risk and high usefulness is influenced by the magnitude of citizens’ intrinsic perceptions affected by cultural differences. However, the main logical link between local government responsiveness and citizens’ acceptance of technology remains the same. The main logical link between local government responsiveness and citizens’ acceptance of technology is the same.
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
Morley, J., Cowls, J., Taddeo, M., & Floridi, L. (2020). Ethical guidelines for COVID-19 government responses to Covid-19. The American Review of Public Administration, 50(6–7), 762–769. https://doi.org/10.1080/14494035.2020.1787627

Yamawaki, Y., & Castro Filho, F. (2020). Does cultural issues matter on the adoption of E-health technologies: Exploratory analysis for diverse user groups. In 2021 5th international conference on pervasive computing technologies for healthcare (PervasiveHealth) and workshops (pp. 593–600). IEEE. https://doi.org/10.1109/icct.2021.246627 (May).

Wolff, A., Barker, M., Hudson, L., & Seffah, A. (2020). Supporting smart citizens: Design templates for co-designing data-intensive technologies. Cities, 101, Article 102695. https://doi.org/10.1016/j.cities.2020.102695

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. Environment and Planning A, 39(8), 2251–2272. https://doi.org/10.1068/a39325

Yang, Q., & Tang, W. (2010). Exploring the sources of institutional trust in China: Culture, mobilization, or performance? Asian Politics & Policy, 2(1), 415–436. https://doi.org/10.1111/j.1943-0787.2010.01201.x

Ye, J. (2020). Governments worldwide navigate privacy versus urgency in fight against Covid-19. Retrieved from. POLITICO https://www.politico.com/news/2020/06/06/government-privacy-coronavirus-china-308105

Zhang, M. (2020). “Guizhou jiankangma” shangxian liutian fangwenliang chao sanqianwan renci [Six days after the “Guizhou health code” was launched, the page view reached thirty million]. Retrieved from. Guizhou Daily http://www.gz.xinhuanet.com/2020-02/28/c_1125636928.htm

Zhou, L., & Dai, Y. (2017). How smog awareness influences public acceptance of congestion charge policies. Sustainability, 9(9), 1579. https://doi.org/10.3390/su9091579