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Research Article

Service Design and Citizen Satisfaction with E-Government Services: A Multidimensional Perspective

Abstract: *This research examines the relationship between service design and citizen satisfaction with e-government services. Based on a multidimensional conceptualization of service, we define three key service perceptions, each comprising different design characteristics, that jointly influence perceived service quality and citizen satisfaction with e-government services. The service perceptions and their corresponding design characteristics are: (1) perceptions of a core service—accuracy, completeness, self-service capability, and convenience; (2) perceptions of facilitating services—accessibility, privacy protection, security protection, and user support; and (3) perceptions of supporting services—personalization capability and transparency. We tested our research model using data from a two-stage survey of 3,065 users of three e-government services. The results showed that all design characteristics contributed to their respective service perceptions that influenced perceived service quality that in turn influenced citizen satisfaction. The finding of a three-way interaction among the service perceptions supported their complementary role in influencing perceived service quality.*

Evidence for Practice

- Service design characteristics of e-government services are central to citizens' evaluation of service experiences and lead to important outcomes, including perceived service quality and citizen satisfaction with e-government services.
- The design characteristics correspond to different elements of a service offering that include the core service, facilitating services, and supporting services. This mapping helps distinguish between design characteristics that are essential for service use and those that are optional and serve only to improve the service experience.
- Citizens' perceptions of the service elements (i.e., core service, facilitating services, and supporting services) play a complementary role in influencing perceived service quality of e-government services. All three service elements must be present to provide the best service experience to citizens.

The Internet and digital technologies have enabled governments to transform public service provision and deliver electronic government (e-government) services to citizens. The Internet has become an essential channel for citizen-government interaction and public service delivery. A majority of governments around the world are offering e-government services, complementing and sometimes replacing traditional offline services. For example, all 193 United Nations member states have launched national portals for disseminating government information, with 47 percent of these countries providing online transactional services, such as filing income tax returns and paying for utilities (United Nations 2018).

Despite the continued efforts in transforming public service delivery, significant challenges remain in designing effective e-government services that address citizens' needs and requirements (Goldkuhl 2016; Tummers and Rocco 2015). Service design determines the key elements of a service offering and consequently influences users' service experience and forms the basis for delivering valuable service outcomes, such as perceived service quality and user satisfaction (Beltagui, Candi, and Riedel 2016; Li and Shang 2020; Wirtz and Kurtz 2016). Service design is especially important in the public sector, as governments are obliged to provide accessible e-government services for the entire eligible population. Citizens' service experience determines the success of governments in accomplishing broader social and political goals, such as trust in government, social inclusion, community well-being, and sustainability (e.g., Porumbescu 2016; Twizeyimana and Andersson 2019).

Early approaches to designing e-government services often mirror those of the private sector, focusing on

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automating existing processes and moving existing government services online (Roberts 2011). However, many e-government services are designed according to common practice without considering quality as defined by citizens (Goldkuhl 2016). It is believed that a fundamental redesign of what government provides and how it interacts and engages with its citizens is required for true service innovation (Roberts 2011). The need for effective service design is evidenced by the fact that a significant proportion of citizens are not satisfied with their online interactions with public organizations in terms of functionality and interactivity (e.g., Linders, Liao, and Wang 2018; Sharma et al. 2018; Zheng and Schachter 2017).

The influence of service design on citizens' experience with e-government services can be examined through the psychological lens of behavioral public administration (Grimmelikhuijsen et al. 2017; Hassan and Wright 2020). Given the technological nature of e-government services, prior research has applied behavioral models of information systems (IS) adoption and continuance—such as the technology acceptance model (TAM: Davis 1989), the unified theory of acceptance and use of technology (UTAUT: Venkatesh et al. 2003), and the IS continuance model (Bhattacherjee and Premkumar 2004)—to examine citizens' perceptions of the benefits and difficulties encountered in the service process that influence service use and associated outcomes, such as perceived service quality and user satisfaction (e.g., Chan et al. 2010; Chen and Aklikokou 2020; Dwivedi et al. 2017; Mensah 2020; Mensah and Adams 2020; Moynihan and Lavertu 2012; Venkatesh et al. 2011; Wirtz, Mory, and Ullrich 2012).

Despite the predominant use of IS adoption and continuance models in previous studies on e-government, these models are unable to provide specific guidance to direct service design due to the generic nature of their core constructs. For example, TAM suggests that perceived usefulness and perceived ease of use influence individual adoption of a technology, but it does not specify which design characteristics contribute to usefulness or ease of use—this limitation of TAM and other technology adoption models has been identified in much previous technology adoption research for some time now (e.g., Venkatesh, Davis, and Morris 2007; Venkatesh, Thong, and Xu 2016). Also, these models contain a very small set of constructs and relationships, thus limiting the possibility of examining a broad, diverse set of design characteristics and their potential complementarity (Hong et al. 2014). Taken together, although previous studies provide an understanding of the general drivers of e-government service adoption, further research is needed to understand what specific design characteristics citizens value and to develop usable knowledge for practitioners to guide service design (Grimmelikhuijsen et al. 2017; Hassan and Wright 2020). There is a need for a systematic approach for the identification and validation of service design characteristics.

The objective of this research is to identify key design characteristics of e-government services and examine how citizen perceptions of these characteristics influence service experience outcomes. We leverage prior research on services and IS to guide our model development. First, we draw on Grönroos's (2000) multidimensional service conceptualization to define three key elements of e-government services—i.e., core service, facilitating services, and supporting services—and identify 10 design characteristics pertaining to these service elements—i.e., accuracy, completeness, self-service capability, convenience, accessibility, privacy protection, security protection, user support, personalization capability, and transparency. Second, we specify the three service perceptions as second-order formative constructs comprising various corresponding first-order design characteristics. These service perceptions capture user evaluations of the key aspects related to service use. Third, we identify perceived service quality and citizen satisfaction as service experience outcomes, which are two key measures for evaluating government performance (Brown 2007; Olsen 2015; Petrovsky, Mok, and León-Cázares 2017; Shingler et al. 2008). Overall, we posit that the three service perceptions, formed by various service design characteristics perceptions, will jointly influence the service experience outcomes.

The proposed research model was tested using data from a two-stage survey of 3,065 users of three e-government services in Hong Kong. Hong Kong is one of the most connected cities in the world (i.e., 100 percent population covered by mobile network and public Internet access) and ranked 18th globally in e-government development (Obi 2018), providing a suitable research context for this study. The findings will provide insights into how to effectively design e-government services to improve citizen satisfaction. The lessons learned from Hong Kong will provide guidance for similar countries with advanced e-government services to manage citizens' service experience, and also help less developed countries to anticipate and prepare for the challenges in e-government development.

Theoretical Foundation

A Multidimensional View of Service

Designing a new service requires the consideration of all elements of the delivered service. Most services are multidimensional bundles consisting of three major elements: core service, facilitating services, and supporting services (Grönroos 2000). Core service is a primary service or basic value offered by service

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providers, facilitating services are services or goods that are essential for the consumption of the core service, and supporting services are optional services or goods that enhance the perceived quality and value of the service package (Grönroos 2000). For example, an airline service includes core service (transportation), facilitating services (e.g., check-in procedures), and supporting services (e.g., in-flight meals) (Bolton and Drew 1991). Although this three-pronged service concept was originally developed for service design in the physical marketplace, it can be adapted to the online context (e.g., Grönroos et al. 2000).

Following prior research (Grönroos 2000; Grönroos et al. 2000), we conceptualize an e-government service as a multidimensional bundle consisting of a core service, facilitating services, and supporting services. A core service is the provision of a public service to citizens online. The facilitating services consist of essential services that make it possible for citizens to consume a particular core service. The supporting services consist of optional services that make the online service package more attractive to citizens. For example, an e-tax filing service consists of these three service elements. The core service is the online tax filing service that allows users to prepare, file, and pay their taxes. The facilitating and supporting services can be provided in various forms. One example of facilitating services is the provision of user support that allows users to use the online tax filing service. One example of supporting services is the provision of online personalization features that enable users to save their information for future use and customize the information they receive.

Edvardsson and Olsson (1996) suggested that a correspondence between a user's needs and a service offering is crucial. The core service and facilitating services determine the ability of a service to satisfy a user's primary needs, whereas the supporting services determine the ability of the service to satisfy secondary needs that arise after the user decides to use the service (Edvardsson and Olsson 1996). Continuing with the above example, after a person has chosen to use an e-tax filing service to satisfy the primary need of preparing and filing taxes, secondary needs will arise—e.g., how the person can personalize the service to improve the efficiency of service use. Supporting services that address such secondary needs will thus make a service more attractive to users. Overall, the multidimensional view of service facilitates the identification of e-government service design characteristics.

Perceived Service Quality

Service design has a significant influence on users' service experience (Beltagui, Candi, and Riedel 2016). A key focus of prior research on users' service experience is the conceptualization and measurement of perceived service quality. Perceived service quality is an assessment of how well the service level delivered matches the user's expectations on a consistent basis and represents a long-term overall evaluation of a service. It is defined as "a global judgment, or attitude, relating to the superiority of the service" (Parasuraman, Zeithaml, and Berry 1988, 16).

Perceived service quality is often considered to be a multidimensional construct. One of the most widely adopted conceptualizations of perceived service quality is SERVQUAL (Parasuraman, Zeithaml, and Berry 1988; Pitt, Watson, and Kavan 1995) that consists of five dimensions—tangibles, reliability, responsiveness, assurance, and empathy. Tangibles relates to the physical facilities, equipment, and appearance of personnel; reliability relates to the ability to perform the promised service dependably and accurately; responsiveness relates to the willingness to help customers and provide prompt service; assurance relates to the knowledge and courtesy of employees and their ability to inspire trust and confidence; and empathy relates to the provision of caring and individualized attention to customers (Parasuraman, Zeithaml, and Berry 1988). SERVQUAL and its adaptations have been used to examine perceived service quality of online services (e.g., Hu et al. 2009). Perceived service quality has been found to influence important outcomes, such as customer satisfaction, customer retention, and customer loyalty (e.g., Blut et al. 2015; Lionello, Slongo, and de Matos 2020). Thus, perceived service quality is a relevant and important construct in our theorizing about citizens' service experience in using e-government services.

Research Model Development

Service Perceptions and Service Design Characteristics

Based on Grönroos's (2000) service concept, we define key service perceptions with respect to the three service elements—i.e., core service, facilitating services, and supporting services. We define the three service perceptions as second-order formative constructs because they are formed as a combination of the specific service design characteristics perceptions (see figure 1). We identify key service design characteristics[1] and discuss their relevance to the corresponding e-government service perceptions.

Perceptions of Core Service. Perceptions of a core service are defined as the extent to which a person perceives an e-government service has the capability to deliver its primary (core) service. We identify design characteristics that determine this capability with respect to two inherent characteristics of e-government services. First, an e-government service can be viewed as an information service because the primary value exchanged between citizens and governments is information. An e-government service makes it more efficient and effective for citizens to transact online for required information than using traditional channels to acquire such information. Given the information-centric nature of e-government services, the quality of information provided by the services is particularly relevant to citizens' evaluation of such services. Prior research has found that information quality contributes to perceived service quality and user satisfaction (e.g., Li and Shang 2020). Thus, we identify accuracy and completeness, two dimensions of information quality that are often considered central to other information quality dimensions (e.g., Wixom and Todd 2005),[2] as design characteristics inherent in a core service.

Second, an e-government service can be viewed as self-service. The notion of self-service allows citizens the freedom to obtain services and perform service transactions without interacting with a human service agent (Meuter et al. 2000). Also, self-service allows citizens the convenience to receive services through the Internet at home or in other places at any time. This convenience, which helps to save citizens' time and effort required to receive services, is central to service evaluation (Berry, Seiders, and Grewal 2002). Thus, we identify self-service capability and convenience as two other design characteristics pertaining to a core service.

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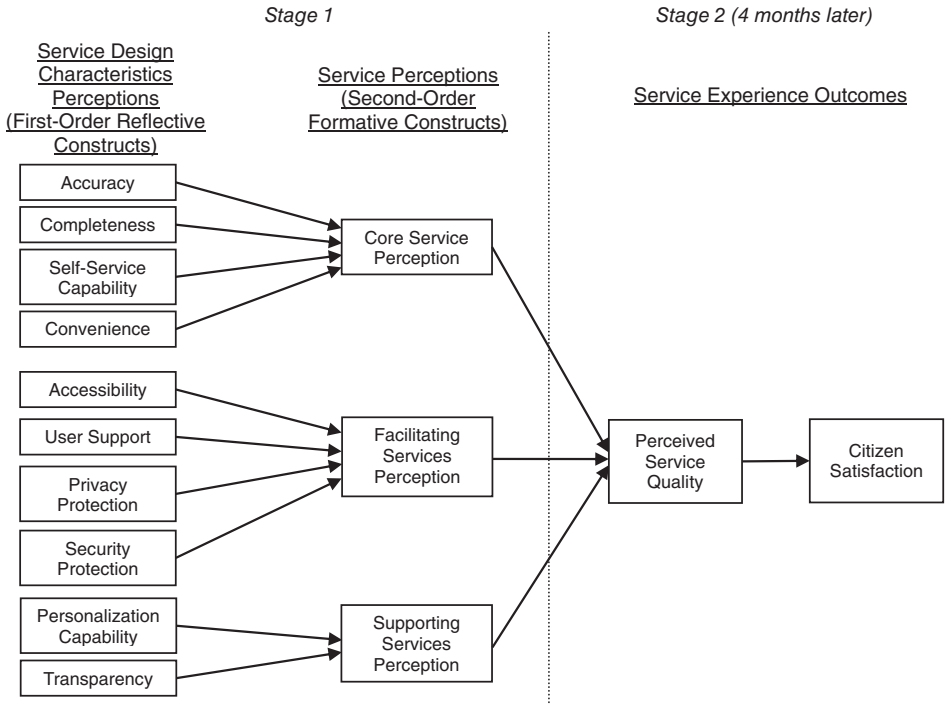

Figure 1 Research Model

Accuracy. Accuracy refers to the degree to which a person perceives the provided information or content is correct when using an e-government service (Wixom and Todd 2005). Accuracy is about the correctness of the information provided to citizens and pertains to the efficiency aspect of the information produced by a service (Li and Shang 2020). If the output is precise and has no ambiguity, citizens can easily and efficiently perceive the value of a focal service without spending additional time and effort for clarification, verification, or validation. From the aspect of service fulfillment, favorable service evaluation requires accurate information delivered during the service process. Accurate information presentations enable a citizen to progress through the service process and receive the core service he or she requests. The accuracy of the information available on websites can thus be expected to influence citizens' assessment of the service's utility and value (Rowley 2006). In sum, citizens will consider an e-government service to be capable of delivering its core service when it delivers accurate information.

Completeness. Completeness refers to the degree to which a person perceives an e-government service provides all the necessary information to fulfill a specific need (Wixom and Todd 2005). Completeness encompasses the notion of comprehensiveness by providing the information necessary to meet a citizen's needs. It is an essential aspect of information quality and can influence a citizen's use of a new service (Li and Shang 2020; Wixom and Todd 2005). Service providers need to provide information to facilitate citizens' understanding about their services. Without complete information, citizens can become confused or misguided, and may even become frustrated. Similar to the case of accuracy, the completeness of the information available on websites can thus be expected to influence citizens' service assessment (Rowley 2006). In sum, citizens will consider an e-government service to be capable of delivering its core service when it provides complete information.

Self-service Capability. Self-service capability refers to the extent to which a person perceives an e-government service allows him or her to access services without having to interact with any human service agents. In general, self-service has the potential to provide citizens with a sense of increased personal control (Meuter et al. 2000). The use of self-service allows citizens to use technology-based processes to help themselves, resulting in higher service efficiency than when using human processes. Such self-service opportunities can substantially alleviate the tedious and often inefficient face-to-face interactions between individual citizens and relevant service representatives. Also, self-service essentially transfers the control to the citizens. This increased perceived control influences perceived service quality and citizen satisfaction (Rowley 2006). As there is no direct human interaction, e-government services must be able to perform the functions of human service agents in order to deliver services to citizens. Thus, an e-government service with good self-service capability, which is technically advanced enough and functionally easy for citizens to operate, will be considered capable of delivering its core service.

Convenience. Convenience refers to a person's perceptions of the time and effort required to use an e-government service (Berry, Seiders, and Grewal 2002). Convenience relates to the flexibility and ubiquitous access that could be provided by the online channel. It removes the time or geographical barriers and meanwhile retains users' anonymity, and it is often cited by online users as a major reason for conducting business online (Udo, Bagchi, and Kirs 2010). For example, citizens can use online services to pay for utilities after normal working hours when they are at home, in the office, or on-the-go. Prior research has suggested that convenience is a key consideration in users' decisions to obtain services through online, rather than conventional, channels and has a significant influence on perceived service quality and user satisfaction (e.g., Duarte, Silva, and Ferreira 2018; Khan and Khan 2018). In sum, convenience influences

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citizens' perceptions about the capability of an e-government service to deliver its core service.

Taken together, we suggest that accuracy, completeness, self-service capability, and convenience are four key design characteristics that determine citizens' perceptions of a core service. Given that the core service determines the ability of an e-government service to satisfy citizens' primary needs (Edvardsson and Olsson 1996), perceptions of that core service are expected to have a positive influence on citizens' perceived service quality of that e-government service. Thus, we hypothesize:

H1: Perceptions of a core service will positively influence citizens' perceived service quality.

Perceptions of Facilitating Services. Perceptions of facilitating services are defined as the extent to which a person perceives an e-government service has essential characteristics that facilitate service use. First, we identify essential design characteristics that reduce the barriers to service use associated with the three levels of digital divide. The first-level digital divide (i.e., digital access divide) refers to the inequality of access to IT, such as access to computers and software (Wei et al. 2011). As the use of e-government services requires access to computing equipment and the Internet, such access is critical to facilitating service use. The second-level digital divide (i.e., digital capability divide) refers to the inequality of the ability to use IT, and the third-level digital divide (i.e., digital outcome divide) refers to the inequality of outcomes of exploiting IT (Wei et al. 2011). As a significant percentage of people lack the knowledge and skills to perform online tasks effectively to achieve expected service outcomes, user assistance will be necessary, especially for first-time users. Thus, we identify accessibility and user support as design characteristics pertaining to the perceptions of facilitating services.

Second, although the Internet enables users to access the services more conveniently, it also raises users' concerns about privacy and security risks (Featherman and Hajli 2016; Hong and Thong 2013). Eliminating these risks is an essential requirement because they will influence the acceptance and use of e-government services (Rust and Kannan 2003). Citizens will avoid using an e-government service if such risks are not effectively minimized through appropriate service design. Thus, we identify privacy protection and security protection as two other design characteristics pertaining to the perceptions of facilitating services.

Accessibility. Accessibility refers to a person's perception of the need to expend effort on acquiring the required computer resources to access an e-government service (Wixom and Todd 2005). Accessibility is crucial to users' decisions about whether to use online services or traditional offline services (Meuter et al. 2000). People's access to technology varies by demographic factors, such as ethnicity, income, age, gender, and education, resulting in an access divide that hinders certain groups of the general population from using e-government services (Ebbers, Jansen, and van Deursen 2016). The provision of multiple channels helps to bridge this access divide and increase service accessibility. For example, in some countries where people have limited access to the wired Internet but where mobile services have a high penetration rate, governments attempt to remove the infrastructure constraint by providing mobile services (Mossey, Bromberg, and Manoharan 2019). Greater accessibility will enable citizens, especially the technically disadvantaged groups, to overcome the barriers to using e-government services. Thus, accessibility contributes favorably to citizens' perceptions of facilitating services.

User Support. User support refers to the extent to which a person perceives he or she can obtain help from service personnel or designated sources in a timely manner when he or she has questions, difficulties, or problems using an e-government service (Thatcher et al. 2007). User support can be delivered in various forms, such as text instructions, interactive demos, and inquiry hotlines. As is the case with many IT systems, users will likely value responsive, helpful, and willing assistance specific to their inquiries, questions, or problems (Thatcher et al. 2008). Given adequate support, some of the barriers to service use can be reduced and citizens can use a service more effectively and efficiently, resulting in favorable service evaluation and outcomes (Thatcher et al. 2007). User support is essential, and it becomes increasingly necessary and almost obligatory when a core service is more complex (Roos and Edvardsson 2008). In sum, user support can create a facilitating condition for service use and contribute favorably to citizens' perceptions of facilitating services.

Privacy Protection. Privacy protection may be defined as the extent to which a person perceives an e-government service protects his or her personal information, with regard to the aspects of collection, accuracy, secondary use, and unauthorized access (Hong and Thong 2013). These four aspects pertain to individuals' primary concerns about organizational information privacy practices. The amount and sensitivity of personal information collected largely depends on the complexity of e-government services. Although the basic informational services involve very little personal information, the more complex transactional services often collect sensitive personal information that has great potential of information privacy infringement (Wu 2014). When citizens consider using an e-government service, particularly one that collects sensitive personal information, their privacy concerns can constrain their use of the service. Without proper privacy protection, citizens may withhold personal information necessary for the service, preventing them from fully using the service to obtain desired service outcomes. In contrast, privacy protection helps reduce citizens' anxiety associated with concerns about potential invasion of their privacy (Hong, Chan, and Thong 2019). As a result, citizens are more likely to provide personal information and be able to fully use the service. Thus, privacy protection contributes favorably to citizens' perceptions of facilitating services.

Security Protection. Security protection is defined as the extent to which a person perceives an e-government service safeguards itself from intrusion and attack by unauthorized individuals (Li and Shang 2020). Security protection is a key aspect of online service operation and can be deployed in the form of security features (e.g., security policies and disclaimers) and protection mechanisms (e.g., encryption and authentication) (Kim, Ferrin, and Rao 2008). Citizens form a perception of security protection based on how clearly they understand the level of security measures implemented in an e-government service. Security is a critical factor influencing citizens' use of e-government services,

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especially when the services involve personal privacy and financial transactions (Li and Shang 2020). The need for serious attention to security is evidenced by the fact that numerous local governments are under constant or near-constant cyberattack but practice cybersecurity poorly (Norris et al. 2019). Citizens will appreciate a core service only if they feel secure and safe, whereas the lack of security protection will deter citizens from using the core service. Thus, security protection is a prerequisite for e-government service use and contributes favorably to citizens' perceptions of facilitating services.

Taken together, we suggest that accessibility, user support, privacy protection, and security protection are four key design characteristics that determine citizens' perceptions of facilitating services. Given that the facilitating services are prerequisites for obtaining the core service, perceptions of facilitating service are expected to have a positive influence on citizens' perceived service quality. Thus, we hypothesize:

H2: Perceptions of facilitating services will positively influence citizens' perceived service quality.

Perceptions of Supporting Services. Perceptions of supporting services are defined as the extent to which a person perceives an e-government service has optional characteristics that make the service more attractive. We identify the optional design characteristics that can further accentuate the two inherent characteristics of e-government services—i.e., as an information service and self-service. First, the online service delivery channel, i.e., a website, can enable citizens to personalize information they receive. The provision of relevant information reduces the cognitive effort and time users spend on processing the information (Tam and Ho 2006), improving the effectiveness of an information service. Second, users increasingly seek control in their timing and process of conducting transactions and interacting with organizations in their use of self-service options (Rust and Kannan 2003). A more transparent e-government service that allows citizens to track the service status will enable them to exert better control. Thus, we identify personalization capability and transparency as design characteristics pertaining to the perceptions of supporting services.

Personalization Capability. Personalization capability refers to the extent to which a person perceives he or she can customize information and services provided online to fit his or her specific needs or preferences (Hinnant and O'Looney 2003). Personalization can be seen as the adaptation of an e-government service to a single citizen. Personalized e-government services can leverage the unique identity of a citizen and provide him or her with relevant information and facilitate re-use of data provided on earlier occasions to improve service efficiency (Wirtz and Kurtz 2017). Further, personalization can allow citizens to specify the information they want and, potentially, their preferred layout and presentation. A customized layout allows citizens to easily identify the necessary information. These personalization capabilities prevent citizens from receiving irrelevant information or being overloaded with information during their service use (Tam and Ho 2006). In sum, personalization capability can further improve the capability of an e-government service to deliver information to citizens. Thus, personalization capability contributes favorably to citizens' perceptions of supporting services.

Transparency. Transparency refers to the extent to which a person perceives he or she can obtain a clear understanding of how an e-government service works (Welch, Hinnant, and Moon 2005). It captures the depth of information and the ability to follow a process (e.g., service request) through its entire life cycle. The notion of self-service reduces the direct interactions between citizens and e-government service providers that in turn heightens the importance of transparency and makes it a desirable service characteristic. Greater transparency is essential not only for better understanding, but also to ensure that citizens have greater comfort with services and service performance (e.g., tracking the status of service requests). With greater transparency, citizens are better able to follow the service processes, resulting in better control and confidence in using the service (Mensah 2020; Rust and Kannan 2003). In sum, transparency can further improve the self-service capability of an e-government service. Thus, transparency contributes favorably to citizens' perceptions of supporting services.

Taken together, we suggest that personalization capability and transparency are two key design characteristics that determine citizens' perceptions of supporting services. Given that the supporting services determine the ability of a service to satisfy secondary needs that arise after the citizens decide to use the service (Edvardsson and Olsson 1996), perceptions of supporting services are expected to have a positive influence on citizens' perceived service quality. Thus, we hypothesize:

H3: Perceptions of supporting services will positively influence citizens' perceived service quality.

Complementarity of Service Perceptions

The three service perceptions, discussed above, jointly form an overall evaluation of an e-government service. Although these perceptions are independent and not causally related (Edvardsson and Olsson 1996), there is potential complementarity of the service perceptions in influencing citizens' perceived service quality. The complementarity perspective (e.g., Xu, Thong, and Venkatesh 2014) suggests that complementarities among strategic factors (e.g., technology, marketing, and supply chain management) can generate synergistic effects on firm performance or consumers' evaluation. Applying this perspective to the e-government service context, we suggest that citizens cannot rely solely on a single service element to achieve service outcomes. For example, the facilitating services (e.g., user support) must be present before citizens can consume a core service (e.g., online tax filing service). Similarly, a core service must be able to deliver its primary value (e.g., tax filing) before citizens will consider the supporting services (e.g., personalization features) to be attractive. Thus, the three service perceptions are expected to interact and complement each other when citizens form their perceptions of service quality.

We posit that the influence of perceptions of a core service on perceived service quality is subject to the perceptions of facilitating and supporting services. Specifically, citizens will be the most satisfied with an e-government service when they have favorable perceptions about all of its service elements—i.e., core service, facilitating services, and supporting services. When citizens have favorable perceptions of facilitating and supporting services, they are more likely to appreciate a core service, thus enhancing the

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positive influence of perceptions of a core service on perceived service quality. In contrast, when citizens have unfavorable perceptions of either or both facilitating and supporting services, favorable perceptions of a core service alone will not be sufficient to make citizens satisfied with an e-government service. Thus, we hypothesize:

H4: Perceptions of a core service, perceptions of facilitating services, and perceptions of supporting services will interact to influence citizens' perceived service quality, such that perceptions of a core service will more positively influence citizens' perceived service quality when perceptions of facilitating services and perceptions of supporting services are high than when either or both are low.

Service Experience Outcomes

Perceived service quality has been found to be associated with various service experience outcomes, such as customer satisfaction, customer retention, and customer loyalty (e.g., Blut et al. 2015; Lionello, Slongo, and de Matos 2020). In the public administration literature, citizen satisfaction is a key outcome that has been of great concern to scholars and practitioners (e.g., Brown 2007; Olsen 2015; Petrovsky, Mok, and León-Cázares 2017; Shingler et al. 2008). Therefore, an examination of the relationship between perceived service quality and citizen satisfaction provides greater comprehensiveness and criterion validity to the research model.

Citizen satisfaction is defined as citizens' affect toward (feelings about) their use of an e-government service. It represents an individual's psychological or affective state related to and resulting from a cognitive appraisal of the experiences with the service (Bhattacherjee and Premkumar 2004; Thong and Yap 1996). Perceived service quality and user satisfaction are key metrics of e-government success (Blut et al. 2015; Chan et al. 2010; Lionello, Slongo, and de Matos 2020; Udo, Bagchi, and Kirs 2010). Perceived service quality captures a citizen's overall evaluation of a service delivered by a service provider online. A favorable perception of service quality represents a positive experience with service use and will lead to greater citizen satisfaction. Thus, we hypothesize:

H5: Perceived service quality will positively influence citizen satisfaction.

Method

Sample and Procedure

The study was conducted in Hong Kong, a digital city with high penetration of information technology (IT) in the business, household, and government sectors. According to the Census and Statistics Department of Hong Kong (2019), 100 percent of the population is covered by mobile network and public Internet access. Almost 90 percent of businesses use the Internet to deliver goods, services, or information. Over 90 percent of households have access to the Internet at home. Most people aged 10 or above (90.5 percent) have used the Internet during the past year. Among these people, they used either personal computers (88.4 percent) or smartphones (98.8 percent) to access the Internet.

The Hong Kong government is actively implementing e-government services to improve its efficiency and provide better service quality to its citizens, as evidenced by its global ranking of 18th in e-government (Obi 2018). One of the key initiatives is the one-stop web portal (www.gov.hk) that offers quick and convenient access to a comprehensive range of government information services to individuals and businesses. About 75 percent of people are aware of e-government services, and about 70 percent of people have used these services (Census and Statistics Department of Hong Kong 2019).

The maturity of IT and e-government in Hong Kong has made it a suitable context for an investigation of citizens' perceptions and satisfaction with e-government services. We leveraged this context to collect data pertaining to three services: "electronic tax filing" (ETAX), "online appointment booking service" (OABS), and "e-government portal" (EPORTAL). ETAX allows citizens to file their income tax returns online; OABS allows citizens to book appointments with various government agencies (e.g., to schedule a meeting to apply for travel documents from the immigration department); and EPORTAL provides key government news and serves as a gateway to government agencies' websites that provide detailed government information (e.g., vehicle registration procedures, job vacancies). These three e-government services are representative informational and transactional services that differ in complexity, which help to demonstrate the generalizability of findings.

The data were collected using a two-stage survey. During the first stage, the survey was advertised through a banner placed on the homepage of the government web portal over a period of one month. When citizens clicked on the banner advertisement, they were directed to a web-based questionnaire on one of the three services. After the respondents answered the initial screening question to confirm they had prior experience with the service, they reported their perceptions of the design characteristics—i.e., accuracy, completeness, self-service capability, convenience, accessibility, user support, privacy protection, security protection, personalization capability, and transparency. Four months after the respondents completed the first-stage survey, we emailed the respondents an invitation to participate in the second-stage survey. Those who agreed to do so provided their evaluations of perceived service quality and satisfaction with their use of the services.

There were 7,316 respondents to the first-stage survey and 3,065 to the second-stage survey who had prior experience with one of the three services. Data analysis was based on the 3,065 respondents who completed both stages of the survey: 408 for the ETAX survey; 1,254 for the OABS survey; 1,403 for the EPORTAL survey. Of these respondents, 1,594 (52 percent) were women. The average age of the respondents was 27.8 years, with a standard deviation of 4.1. The average Internet experience of the respondents was 7.6 years, with a standard deviation of 2.6. Their average weekly Internet use was 22.1 hours, with a standard deviation of 13.7. Overall, our sample was diverse in terms of respondents' demographics and Internet use[3].

Non-response bias was assessed by comparing the demographic characteristics of respondents and non-respondents to the second-stage survey, and no significant differences were found between the two groups. Similarly, no demographic differences were found between early and late respondents.

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Table 1 Descriptive Statistics and Correlations (ETAX Sample)

		Mean	SD	ICR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Gender	0.44	0.50	—	—																	
2	Age	29.75	3.09	—	.02	—																
3	Education	4.16	1.56	—	−.06	.04	—															
4	Internet experience	8.54	2.30	—	−.04	.02	.27***	—														
5	Weekly Internet use	24.26	13.68	—	−.25***	−.14**	.10*	.25***	—													
6	Service use	4.15	2.09	—	.04	.06	−.01	.04	.11*	—												
7	Accuracy	5.69	0.99	0.92	.05	.03	.02	.08	.03	.24***	(.89)											
8	Completeness	5.61	1.03	0.96	.03	.05	.04	.14**	.04	.17***	.79***	(.95)										
9	Self-service capability	5.46	1.08	0.94	.02	.03	.03	.11*	.06	.19***	.57***	.51***	(.91)									
10	Convenience	5.90	0.97	0.90	.06	.00	−.05	.09	.04	.16***	.63***	.59***	.59***	(.87)								
11	Accessibility	5.39	1.20	0.96	.09	.01	.03	.08	−.01	.18***	.62***	.59***	.46***	.57***	(.95)							
12	User support	5.05	1.01	0.92	−.02	−.01	−.04	−.02	−.03	.12*	.52***	.51***	.39***	.48***	.57***	(.88)						
13	Privacy protection	5.26	1.09	0.94	.05	.01	.02	.01	−.04	.14**	.67***	.63***	.38***	.50***	.55***	.54***	(.90)					
14	Security protection	5.36	1.09	0.97	.02	.02	.05	.10*	.00	.18***	.68***	.63***	.48***	.55***	.64***	.56***	.74***	(.96)				
15	Personalization Capability	5.10	1.05	0.96	.03	.03	−.09	−.01	.00	.16***	.55***	.52***	.46***	.53***	.57***	.66***	.54***	.56***	(.94)			
16	Transparency	5.19	1.11	0.95	.02	.00	−.05	−.04	−.01	.12*	.62***	.64***	.36***	.49***	.53***	.66***	.66***	.58***	.62***	(.92)		
17	Perceived service quality	4.94	0.55	—	.06	.07	−.07	−.01	−.01	.26***	.46***	.41***	.43***	.47***	.46***	.46***	.44***	.46***	.47***	.45***	—	
18	Citizen satisfaction	5.18	0.87	0.95	.09	.00	−.05	.02	.02	.30***	.37***	.32***	.35***	.34***	.35***	.31***	.28***	.39***	.38***	.30***	.60***	(.93)

Notes: $N = 408$. ICR: internal consistency reliability. Square roots of AVEs appear on the diagonal in parenthesis. ICR and AVEs are unavailable for single-item measures, categorical variables, and formative constructs.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

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Table 2 Descriptive Statistics and Correlations (OABS Sample)

		Mean	SD	ICR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Gender	0.53	0.50	—	—																	
2	Age	27.05	4.26	—	−.06*	—																
3	Education	3.74	1.53	—	−.10***	.06*	—															
4	Internet experience	7.36	2.66	—	−.09***	.03	.27***	—														
5	Weekly Internet use	22.01	13.97	—	−.14***	−.03	.07**	.23***	—													
6	Service use	2.96	1.55	—	−.08**	.08**	.07*	.06*	.04	—												
7	Accuracy	5.47	1.08	0.95	.00	.06*	.06*	.17***	.12***	.07**	(.93)											
8	Completeness	5.37	1.10	0.96	.00	.05	.05	.16***	.08**	.10***	.81***	(.94)										
9	Self-service capability	5.32	1.11	0.93	.00	.08**	.07*	.13***	.08**	.04	.64***	.63***	(.91)									
10	Convenience	5.75	1.07	0.94	.04	.07*	.04	.14***	.08**	.07*	.71***	.67***	.70***	(.91)								
11	Accessibility	5.44	1.13	0.96	.01	.03	.04	.19***	.08**	.13***	.72***	.68***	.57***	.65***	(.94)							
12	User support	5.03	1.06	0.91	−.01	.04	.04	.15***	.08**	.12***	.65***	.64***	.56***	.57***	.61***	(.88)						
13	Privacy protection	5.13	1.12	0.95	.01	−.02	.05	.11***	.07*	.10***	.69***	.66***	.51***	.54***	.60***	.63***	(.91)					
14	Security protection	5.19	1.11	0.97	.00	.04	.05	.14***	.08**	.10***	.70***	.67***	.54***	.58***	.69***	.65***	.79***	(.95)				
15	Personalization capability	5.12	1.12	0.96	−.01	.07*	.02	.13***	.07*	.12***	.65***	.65***	.53***	.55***	.63***	.70***	.61***	.64***	(.94)			
16	Transparency	5.14	1.11	0.95	−.01	.05	.02	.14***	.08**	.13***	.72***	.76***	.53***	.58***	.62***	.71***	.67***	.66***	.70***	(.93)		
17	Perceived service quality	4.95	0.79	—	.00	.01	−.03	.10***	.04	.15***	.50***	.45***	.38***	.44***	.45***	.47***	.46***	.47***	.45***	.47***	—	
18	Citizen satisfaction	5.25	0.92	0.95	.05	−.01	−.02	.07*	−.01	.10***	.40***	.37***	.32***	.39***	.39***	.39***	.36***	.37***	.34***	.36***	.69***	(.93)

Notes: $N = 1{,}254$. ICR: internal consistency reliability. Square roots of AVEs appear on the diagonal in parenthesis. ICR and AVEs are unavailable for single-item measures, categorical variables, and formative constructs.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

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Table 3 Descriptive Statistics and Correlations (EPORTAL Sample)

		Mean	SD	ICR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Gender	0.53	0.50	—	—																	
2	Age	27.85	4.07	—	.00	—																
3	Education	3.93	1.54	—	−.04	.08**	—															
4	Internet experience	7.63	2.60	—	−.08**	.05*	.28***	—														
5	Weekly Internet use	21.52	13.43	—	−.12***	−.09***	.11***	.26***	—													
6	Service use	3.93	1.58	—	−.05	.04	.02	.07**	.08**	—												
7	Accuracy	5.39	1.06	0.94	.03	.02	.04	.14***	.14***	.10***	(.91)											
8	Completeness	5.22	1.07	0.95	.02	.01	.03	.12***	.15***	.11***	.80***	(.93)										
9	Self-service capability	5.12	1.07	0.91	−.03	.06*	.03	.12***	.09***	.10***	.58***	.57***	(.88)									
10	Convenience	5.49	1.10	0.93	.02	.11***	.02	.16***	.11***	.11***	.64***	.62***	.70***	(.90)								
11	Accessibility	5.37	1.11	0.96	−.01	.08**	.08**	.18***	.13***	.17***	.64***	.65***	.58***	.68***	(.94)							
12	User support	4.78	1.03	0.91	.02	.01	−.01	.08**	.05	.18***	.56***	.61***	.50***	.53***	.57***	(.88)						
13	Privacy protection	5.03	1.15	0.94	−.01	−.01	−.02	.07**	.08**	.11***	.66***	.66***	.49***	.51***	.56***	.53***	(.89)					
14	Security protection	5.21	1.11	0.97	−.02	.00	.02	.13***	.12***	.13***	.68***	.66***	.56***	.61***	.70***	.54***	.74***	(.95)				
15	Personalization capability	4.77	1.09	0.96	−.02	.00	−.02	.05	.05	.14***	.49***	.57***	.47***	.47***	.52***	.67***	.48***	.51***	(.94)			
16	Transparency	4.90	1.06	0.92	.01	.01	−.01	.06*	.10***	.17***	.63***	.76***	.49***	.52***	.56***	.66***	.62***	.57***	.63***	(.89)		
17	Perceived service quality	4.61	0.78	—	−.01	−.04	−.06*	.06*	.07**	.27***	.43***	.44***	.36***	.39***	.40***	.43***	.43***	.42***	.40***	.44***	—	
18	Citizen satisfaction	4.72	0.90	0.95	.03	−.01	−.06*	.00	.03	.21***	.36***	.39***	.31***	.35***	.35***	.39***	.37***	.36***	.35***	.38***	.73***	(.93)

Notes: $N = 1{,}403$. ICR: internal consistency reliability. Square roots of AVEs appear on the diagonal in parenthesis. ICR and AVEs are unavailable for single-item measures, categorical variables, and formative constructs.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

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Measures

We used previously validated scales and adapted them to the context of the three e-government services, except that self-service capability and convenience were measured using three items each that were self-developed. Appendix A provides the scales for the ETAX survey and their original sources. Unless otherwise indicated, all items were measured using seven-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree).

We included various individual difference variables, namely gender, age, education, Internet experience, and weekly Internet use, as control variables given their potential influence on Internet-related perceptions and behaviors. We also tested for the moderating effects of these control variables on the relationships between the service perceptions and perceived service quality. The results showed that none of the moderating effects was significant. Gender was coded as a dummy variable, with men coded as 0 and women coded as 1. Age and Internet experience were measured in years. The response categories for education were 1 (primary school), 2 (secondary school), 3 (associate degree), 4 (undergraduate degree), and 5 (graduate degree). Weekly Internet use was measured in hours. We also included self-reported service use as a control variable. It was measured using a single item adapted from Wixom and Todd (2005), with anchors as 1 (low use) and 7 (high use).

Results

We used partial least squares (PLS), a component-based structural equation modeling (SEM) technique, to analyze our data. We chose PLS for two reasons. First, PLS is suitable for studies that aim to examine the predictive power of the exogenous variables on the endogenous variables (Hair, Ringle, and Sarstedt 2011). Given that the key objective of our research is to examine the relevance of the identified design characteristics to the three service perceptions and also the influences of the service perceptions on perceived service quality, PLS is an appropriate tool as it focuses on prediction. Second, PLS can handle complex models with fewer restrictions than covariance-based SEM (e.g., LISREL, AMOS). In particular, PLS works better for hierarchical models with higher-order formative constructs (Lowry and Gaskin 2014). Therefore, PLS is suitable for testing our research model with four second-order formative constructs (i.e., perceptions of: core service, facilitating services, supporting services, and service quality).

Measurement Model

We assessed the reliability and convergent validity of the reflective constructs (i.e., the design characteristics and citizen satisfaction) using composite reliability and average variance extracted (AVE) (see tables 1 to 3). The internal consistency reliabilities of all constructs exceeded 0.90, and the AVE for each construct was greater than the recommended 0.50 level. We assessed discriminant validity by comparing the inter-construct correlations with the AVE of the individual constructs. The inter-construct correlations were all below the square root of the AVE of either construct. In sum, the scales possessed adequate reliability and validity.

We modeled the three service perceptions—i.e., perceptions of: core service, facilitating services, and supporting services—using a reflective–formative hierarchical latent variable model (Becker, Klein, and Wetzels 2012). Specifically, the service perceptions were modeled as second-order formative constructs consisting of their corresponding first-order reflective constructs of design characteristics. The repeated indicators approach was used to estimate the parameters in the measurement model (Becker, Klein, and Wetzels 2012; Lowry and Gaskin 2014). The construct validity of service perceptions was assessed by examining the weights of their corresponding design characteristics (Cenfetelli and Bassellier 2009). In all three samples, the weights of all design characteristics perceptions were significant (see table 4), indicating that all perceptions of design characteristics

Table 4 Sub-construct Weights for Formative Constructs

	Percs. of core service	Percs. of facilitating services	Percs. of supporting services	Perceived service quality
Accuracy	.30***/.30***/.31***			
Completeness	.33***/.30***/.31***			
Self-service capability	.28***/.26***/.26***			
Convenience	.27***/.28***/.29***			
Accessibility		.29***/.27***/.28***		
User support		.24***/.24***/.23***		
Privacy protection		.36***/.35***/.36***		
Security protection		.31***/.30***/.31***		
Personalization capability			.57***/.55***/.58***	
Transparency			.54***/.54***/.53***	
Tangibles				.25***/.20***/.20***
Reliability				.20*/.13**/.15***
Responsiveness				.21*/.11*/.15***
Assurance				.67***/.56***/.52***
Empathy				.19*/.12**/.19***

Notes: Results based on three samples (ETAX/OABS/EPORTAL) are shown.
N =408(ETAX), 1,254(OABS), 1,403(EPORTAL).
* $p < .05$;
** $p < .01$;
*** $p < .001$.

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contributed to the formation of their posited service perceptions. The reliability of service perceptions was assessed by testing for possible multicollinearity among their corresponding design characteristics (Cenfetelli and Bassellier 2009). All VIF values were below 2, indicating a low threat of multicollinearity. In sum, all three formative constructs of service perceptions possessed adequate construct validity and reliability. In addition, we conducted an expert survey of 15 highly experienced scholars in the area of e-government and/or technology/service design to confirm the substantive validity (Anderson and Gerbing 1991) of the design characteristics—i.e., the extent to which they are theoretically linked to perceptions of: core service, facilitating services, and supporting services. The results indicated that most respondents assigned the design characteristics to their posited service perceptions, confirming the substantive validity of the design characteristics (see appendix B).

Similar to the case of service perceptions, perceived service quality was modeled as a second-order formative construct consisting of five first-order reflective sub-constructs—i.e., tangibles, reliability, responsiveness, assurance, and empathy. Because perceived service quality is an endogenous variable, the two-stage approach was used to estimate the parameters in the measurement model (Becker, Klein, and Wetzels 2012; Lowry and Gaskin 2014). The construct validity and reliability of perceived service quality were assessed using the same criteria described earlier in the case of service perceptions. In all three samples, the perceived service quality construct possessed adequate construct validity and reliability (see table 4 for the weights of its sub-constructs).

Finally, we reduced the concern of common method bias by using procedural remedies (Podsakoff et al. 2003), including guaranteeing response anonymity and measuring the key predictor and criterion variables in separate (first- and second-stage) surveys. The concern of common method bias was further alleviated by the findings of significant interaction effects in the analysis of the complementarity of service perceptions, given that interaction effects can be severely deflated through common method variance and thus are more difficult to detect (Siemsen, Roth, and Oliveira 2010).

Structural Model

Table 5 presents the results of the structural model testing. The results were consistent across the three samples. First, all three service perceptions (i.e., perceptions of: core service, facilitating services, and supporting services) had positive effects on perceived service quality. These results provided support for H1, H2, and H3. Second, perceived service quality had a positive effect on citizen satisfaction, thus supporting H5.

Complementarity of Service Perceptions

We examined the complementarity of the service perceptions by including all two- and three-way interaction terms among the three service perceptions (created by multiplying their mean-centered scores) in the model predicting perceived service quality. The results showed that there was a significant three-way interaction among the service perceptions in all three samples (see table 6).

To understand the nature of the interactions, we plotted them following Aiken and West (1991) and Dawson and Richter (2006). In figures 2, 3, and 4, the four separate unstandardized regression lines were plotted at high (i.e., one standard deviation above the mean) and low (i.e., one standard deviation below the mean) values for the three variables involved. Following Dawson and Richter (2006), we also performed slope difference tests to further examine the interactions.

Figure 2 shows the simple slopes of perceived service quality on perceptions of a core service at high and low values of perceptions of facilitating services and perceptions of supporting services.

Table 5 Predicting Perceived Service Quality and Citizen Satisfaction

	Perceived service quality	Citizen satisfaction
Gender	.02/–.00/–.00	.05/.05*/.04*
Age	.05/–.02/–.06*	–.05/–.02/.01
Education	–.06/–.07**/–.06*	–.01/.00/–.01
Internet experience	–.04/.02/.00	.03/.01/–.04
Weekly Internet use	–.01/–.02/–.00	.01/–.03/–.01
Service use	.15***/.09***/.19***	.15***/–.00/.01
Percs. of core service	.23**/.21***/.18***	
Percs. of facilitating services	.22*/.27***/.22***	
Percs. of supporting services	.15*/.11*/.15***	
Perceived service quality		.57***/.69***/.73***
R^2	.36/.32/.32	.40/.48/.54

Notes: Results based on three samples (ETAX/OABS/EPORTAL) are shown.
$N = 408$ (ETAX), 1,254 (OABS), 1,403 (EPORTAL).
Control variables are italicized.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 6 Predicting Perceived Service Quality

	ETAX sample	OABS sample	EPORTAL sample
Gender	.02	–.01	–.00
Age	.05	–.02	–.05*
Education	–.06	–.06**	–.06*
Internet experience	–.03	.02	.00
Weekly Internet use	–.01	–.02	–.00
Service use	.15***	.08***	.18***
Percs. of core service (CORE)	.11	.23***	.19***
Percs. of facilitating services (FAC)	.15*	.22***	.21***
Percs. of supporting services (SUP)	.21**	.06	.10*
CORE X FAC	.01	.10*	.07
CORE X SUP	.06	.02	.02
FAC X SUP	–.03	–.07	.02
CORE X FAC X SUP	.15*	.08*	.07*
R^2	.37	.32	.34

Note: $N = 408$ (ETAX), 1,254 (OABS), 1,403 (EPORTAL).
Control variables are italicized.
* $p < .05$;
** $p < .01$;
*** $p < .001$.

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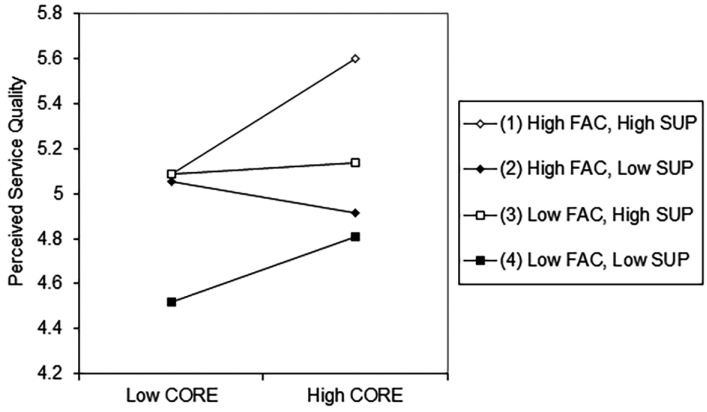
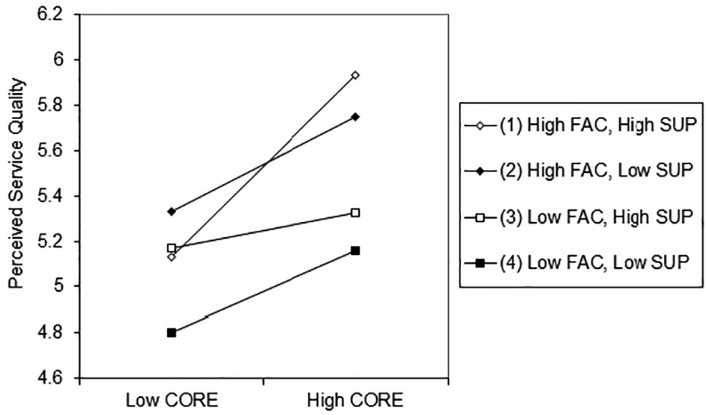


Note: CORE: core service perception; FAC: facilitating service perception; SUP: supporting service perception.

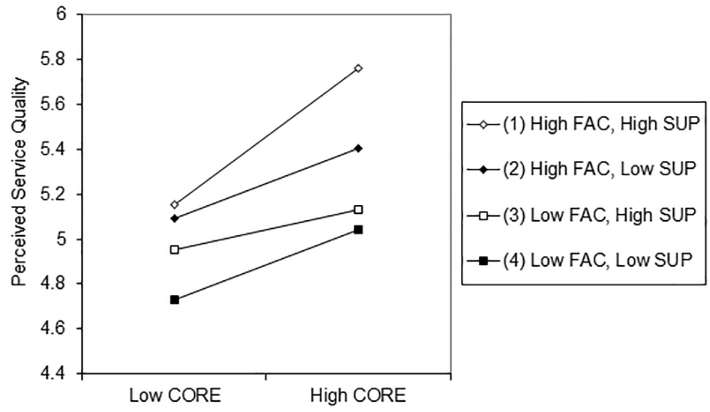
Figure 2 Three-Way Interaction among Service Perceptions (ETAX Sample).



Note: CORE: core service perception; FAC: facilitating service perception; SUP: supporting service perception.

Figure 3 Three-Way Interaction among Service Perceptions (OABS Sample).

Perceptions of a core service had the strongest positive effect (slope 1: $\beta = .30$, $p < .001$) on perceived service quality when citizens reported both perceptions of facilitating services and perceptions of supporting services to be high. When either or both perceptions of facilitating services and perceptions of supporting services were low, perceptions of a core service had a weaker or non-significant effect on perceived service quality (slope 2: $\beta = -.08$, $p > .10$; slope 3: $\beta = .03$, $p > .10$; slope 4: $\beta = .17$, $p < .05$). Similar patterns are shown in figures 3 and 4. Perceptions of a core service had the strongest positive effect (slope 1: $\beta = .43$, $p < .001$ for the OABS sample; slope 1: $\beta = .33$, $p < .001$ for the EPORTAL sample) on perceived service quality when citizens reported both perceptions of facilitating services and perceptions of supporting services to be high. The slope difference tests showed that the slope 1 (i.e., when both perceptions of facilitating services and perceptions of supporting services were high) was significantly different from the other slopes (i.e., when either or both perceptions of facilitating services and perceptions of supporting services were low) in all cases.



Note: CORE: core service perception; FAC: facilitating service perception; SUP: supporting service perception.

Figure 4 Three-Way Interaction among Service Perceptions (EPORTAL Sample).

Overall, the results provide evidence for the complementarity of the three service perceptions, thus supporting H4. The positive effect of perceptions of a core service on perceived service quality was subject to perceptions of facilitating services and perceptions of supporting services. In particular, the synergistic effect among the service perceptions was more prominent in the case of complex transactional services (i.e., ETAX), where the direct effects of the core and facilitating service perceptions became less or even non-significant when the interaction effects were incorporated (see table 5 versus table 6).

Post Hoc Analyses: Cross-sample Comparison of Design Characteristics

The main results presented earlier demonstrated that the effects of design characteristics on citizen satisfaction were mediated through the service perceptions and perceived service quality (see tables 4 to 6). We conducted two post hoc analyses on design characteristics to gain further insights. First, we compared the mean scores of design characteristics across the three samples. Table 7 presents the results of means-difference tests. In general, citizens reported a higher score in most of the design characteristics for the more complex transactional services (i.e., ETAX and OABS). This may be attributed to the fact that these transactional services are relatively more complex than information services (i.e., EPORTAL) and require the transmission of sensitive personal information. Thus, existing users (i.e., the respondents in our sample) are likely to have had a higher expectation on most aspects of the services. The only exception was accessibility, where the results showed no significant differences across the three services. A potential explanation is that given the high Internet penetration in Hong Kong, citizens have ready access to any e-government services.

Second, we examined the direct effects of design characteristics on citizen satisfaction. The omission of service perceptions and perceived service quality from the model helps identify the design characteristics that had a comparatively stronger and direct impact on citizen satisfaction. Table 8 shows that different sets of design characteristics were significant in predicting citizen satisfaction across the three samples. Considering the differences among the

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Table 7 Results of Mean-Difference Tests

	ETAX sample (1)	OABS sample (2)	EPORTAL sample (3)	p_{12}	p_{13}	p_{23}
Accuracy	5.69	5.47	5.39	.001	.000	.039
Completeness	5.61	5.37	5.22	.000	.000	.001
Self-service capability	5.46	5.32	5.12	.026	.000	.000
Convenience	5.90	5.75	5.49	.019	.000	.000
Accessibility	5.39	5.44	5.37	.361	.804	.089
User support	5.05	5.03	4.78	.726	.000	.000
Privacy protection	5.26	5.13	5.03	.043	.000	.000
Security protection	5.36	5.19	5.21	.008	.015	.727
Personalization capability	5.10	5.12	4.77	.703	.000	.000
Transparency	5.19	5.14	4.90	.436	.000	.000

Note: p_{12}: *p*-value for mean-difference test between ETAX sample and OABS sample.
p_{13}: *p*-value for mean-difference test between ETAX sample and EPORTAL sample.
p_{23}: *p*-value for mean-difference test between OABS sample and EPORTAL sample.

Table 8 Predicting Citizen Satisfaction with Service Design Characteristics

	ETAX sample	OABS sample	EPORTAL sample
Gender	.07	.04	.03
Age	−.02	−.04	−.03
Education	−.04	−.04	−.05
Internet experience	−.01	.01	−.04
Weekly Internet use	.01	−.05*	−.02
Service use	.20***	.05*	.14***
Accuracy	.08	.11*	.01
Completeness	−.03	−.03	.08
Self-service capability	.11*	−.02	.00
Convenience	.03	.15***	.09*
Accessibility	.05	.10*	.03
User support	.01	.15***	.12***
Privacy protection	.11	.06	.11**
Security protection	.20**	.01	.01
Personalization capability	.16*	.00	.06
Transparency	.01	.01	.03
R^2	.27	.22	.24

Note: $N = 408$ (ETAX), 1,254 (OABS), 1,403 (EPORTAL).
Control variables are italicized. All VIF values were below 4.2.
*$p < .05$; **$p < .01$; ***$p < .001$.

three services, the differential effects of design characteristics could be expected. On the one hand, some consistency was observed in that convenience and user support were significant in the OABS and EPORTAL samples. Citizens may place a higher value on design characteristics that allow them to use these relatively simple services with minimal time, effort, and support. On the other hand, a distinct set of design characteristics (i.e., self-service capability, security protection, and personalization capability) were significant in the ETAX sample. Citizens may expect to spend longer time on using this complex service and thus place higher importance on design characteristics that allow them to personalize and effectively complete the service, and meanwhile ensure technical safety during service use.

Discussion

The objective of this research was to examine how citizens' perceptions of service design characteristics influence citizen satisfaction with e-government services. Overall, the results provided support for our proposed research model. First, all the identified design characteristics contributed significantly to their respective hypothesized service perceptions. Second, all three service perceptions significantly influenced perceived service quality that in turn influenced citizen satisfaction. Third, the results showed that citizens' service perceptions had a significant three-way interaction in influencing perceived service quality of e-government services. Finally, the post hoc analyses revealed the differences in citizens' perceptions of design characteristics and the differential influences of design characteristics on citizen satisfaction across the three e-government services.

Theoretical Implications

Our research contributes to the literature on public administration in multiple ways. First, our research extends the understanding of citizens' perceptions and attitudes (Wright 2015), complementing the existing body of research primarily focusing on public employees (e.g., Bellé 2013) and local governments (e.g., Ganapati 2011; Young 2020). We focused our investigation on citizens and proposed a research model that relates design characteristics of e-government services to citizens' service experience outcomes. Drawing on Grönroos's (2000) service concept, we identified 10 service design characteristics (i.e., accuracy, completeness, self-service capability, convenience, accessibility, privacy protection, security protection, user support, personalization capability, and transparency) and suggested that they are inherent to three key service elements (i.e., core service, facilitating services, and supporting services). We posited that the three key service perceptions comprising various design characteristics (i.e., perceptions of: core service, facilitating services, and supporting services) influence service experience outcomes (i.e., perceived service quality and citizen satisfaction). Our results, based on a large sample of citizens who used three different e-government services, validated the proposed research model. Future research can apply our model to examine citizens' perceptions and attitudes toward other e-government services.

Second, we extend prior research that examined citizens' perceptions contributing to perceived service quality and satisfaction (e.g., Brown 2007; Kim and Lee 2012; Wirtz and Kurtz 2016). The use of Grönroos's (2000) service concept provides a multidimensional conceptualization to guide a systematic identification and validation of design characteristics. We modeled the identified design characteristics as first-order factors that form the second-order service perceptions. The examination of the hierarchical factor structure of service perceptions provides evidence of the relevance of the identified design characteristics to different aspects of a service offering. It helps distinguish between design characteristics that are essential for service use and those that are optional and serve only to improve service experience. Having this distinction helps to gain insights into the relative importance of design characteristics. Theoretically, we demonstrated the utility of Grönroos's (2000)

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service concept in identifying important service design characteristics in the e-government service context. Empirically, we demonstrated the use of hierarchical latent variable models to consolidate multiple specific constructs (i.e., design characteristics) into a few higher-order constructs (i.e., service perceptions). Future research in other public service contexts (e.g., mobile services) can use this service concept and hierarchical latent variable models to examine some context-specific design characteristics.

Third, our findings revealed the complementary roles of the service elements in influencing citizens' service experience. The traditional view suggests that the different service elements—i.e., core service, facilitating services, and supporting services—address different needs of users—i.e., primary versus secondary needs—thus contributing independently to service evaluation (Edvardsson and Olsson 1996). Our findings of the significant three-way interaction among the three service perceptions highlight the need to consider the complementarity among different service elements or design characteristics. Doing so will yield theoretical insights into the conditions under which the various service elements or design characteristics are especially prominent in influencing citizens' service experience. Future research can extend the concept of complementarity to a more networked public service delivery setting that may involve other service providers, such as private businesses and nonprofit organizations (Bryson, Crosby, and Bloomberg 2014).

Finally, we validated our research model in the context of e-government services for citizens, in which service design is challenging and citizens' online service experience has yet to be optimized (e.g., Linders, Liao, and Wang 2018; Sharma et al. 2018). The examination of the three e-government services allowed us to develop a general understanding of how citizens perceive and evaluate e-government services overall. In particular, we observed significant differences in citizens' evaluations of design characteristics and their influences on citizen satisfaction across the three e-government services. These differences may be attributed to the nature and complexity of services. Future research can adapt our model to the context of public organizations by incorporating organizational factors, such as leadership and organizational culture (e.g., Hansen and Nørup 2017), as potential contingency factors that influence public workers' evaluation of e-government services.

Practical Implications

This research offers implications for the design and delivery of e-government services. The identification of design characteristics based on the three-pronged service concept helps reveal the relevance of these design characteristics to different aspects of a service offering. Design characteristics pertaining to a core service (i.e., accuracy, completeness, self-service capability, and convenience) are those that determine the capability of an e-government service to provide its primary service and value. Thus, they are the core design characteristics of utmost importance for satisfying citizens' needs and requirements. Design characteristics pertaining to the facilitating services (i.e., accessibility, user support, privacy protection, and security protection) are essential for citizens' consumption of the primary service. Although these characteristics do not directly offer value to citizens, they must be present and serve to complement the core design characteristics. Design characteristics pertaining to the supporting services (i.e., personalization capability and transparency) are optional characteristics that further accentuate the two inherent characteristics of e-government services (i.e., as an information service and self-service). Offering such characteristics can improve citizens' service experience.

Our results underscored the need to consider the nature and complexity of e-government services when designing the elements of a service offering to achieve either service efficiency or service effectiveness. For relatively simple services (e.g., OABS and EPORTAL), citizens may not expect to spend much time and effort in using the services. Thus, although possessing all of the design characteristics, a service offering that emphasizes a few selected characteristics that facilitate efficient service use—e.g., convenience and user support—will be sufficient to satisfy citizens' needs (see table 8). For more complex services (e.g., ETAX), citizens may expect to spend more time and effort using the services. Thus, a service offering should not only satisfactorily operationalize all of the design characteristics (see table 7), but also emphasize selected characteristics that facilitate effective service use and address the secondary needs that may arise during service use—e.g., self-service capability, personalization, and security protection (see table 8).

Specific suggestions for e-government service design can be drawn from the significant findings. First, our results underscored the importance of information quality in e-government services, given that accuracy and completeness were comparatively stronger determinants of perceptions of a core service than the other two core design characteristics were (see table 4). Governments should devote efforts to ensuring the accuracy and completeness of online information. For example, accuracy of information can be ensured by deploying automated checking procedures and instituting policies on the use and maintenance of systems, whereas completeness can be ensured by making all information content and hyperlinks available as needed for users to complete specific tasks (Kim, Kishore, and Sanders 2005). Also, when contracting with technology solutions providers to design e-government services, governments should form a close partnership between the content providers and the technology solutions providers, and define clear expectations to ensure the accuracy and completeness of information (Reynaers 2014).

Second, our results showed that two core design characteristics (i.e., self-service capability and convenience) determined the ability of citizens to obtain services solely by themselves without time and location restrictions. This underscores the importance of a careful design of the user interface in enabling citizens to use the online services without having to interact with service personnel. For example, the menu design, screen layout, and interaction methods should be intuitive and consistent across different services, such that users' performance costs can be minimized (Thong, Hong, and Tam 2002). Convenience can be fostered through 24/7 uptime, an easy-to-use web interface, and fast response/download time (Meuter et al. 2000).

Third, our results underscored the importance of privacy protection and security protection in e-government services, given that they were comparatively stronger determinants of perceptions of facilitating services than the other two design characteristics

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perceptions were (see table 4). Governments can alleviate citizens' privacy and security concerns by implementing information-use policies and security protection measures. For example, citizens should be made aware of the privacy policies and be informed of how their personal information will be used. As noted earlier, security protection can be deployed in the form of security features (e.g., security policies and disclaimers) and protection mechanisms (e.g., encryption and authentication) (Kim, Ferrin, and Rao 2008). Governments should also follow the latest cybersecurity best practices and deploy more advanced technological security measures to enforce the security of online transactions (Norris et al. 2019).

Fourth, we found that accessibility and user support are two key design characteristics that help reduce the barriers to using e-government services. To lower the access barrier, e-government services can be offered through multiple channels, including wired Internet, mobile Internet, and wireless Internet. In particular, the proliferation of mobile devices has enabled governments to deliver their services via mobile platforms and reach citizens who will otherwise be left out. To lower the use barrier, careful design and effective delivery of user support are essential. Governments can offer user support in various forms, such as user instructions in plain text, interactive service demos, and an inquiry hotline, to help citizens resolve the difficulties they encounter when using the services.

Fifth, our results highlighted the importance of personalization capability and transparency in enhancing citizens' service experience, given that they were significant determinants of perceptions of supporting services (see table 4). Personalization can be achieved by allowing citizens to construct a personal profile recording their service preferences and use history. Transparency can be improved by providing citizens with a better understanding of the inner working of e-government services. Governments should allow citizens to track the service status through multiple means (e.g., email and short message service) and provide means for citizens to provide feedback and interact with the government (e.g., blogs and surveys).

In summary, the design of e-government services still presents a great challenge for governments even after years of evolution of e-government. The continuous incorporation of new and innovative technologies (e.g., social media and big data) into public service delivery will require a closer public–private partnership that allows governments to leverage external technical expertise and also benefit from other potential advantages, such as opening new sources of funding and strengthening public values (e.g., accountability, transparency, and quality) (Díaz-Díaz and Pérez-González 2016; Liu and Yuan 2015; Reynaers 2014).

Limitations and Future Research

There are two limitations that should be noted. First, online data collection may be subject to sampling bias. The participants in this study were relatively young and could be regarded as experienced Internet users. Thus, this sample may not be representative of senior citizens and inexperienced Internet users. However, as the target users of e-government services are generally Internet users, these participants are likely to be potential users of these services. Such young, experienced users are also essential for the continued use of e-government services and are likely adopters of new services (Srivastava and Teo 2009). Nevertheless, future research could target senior citizens and inexperienced users to extend our work.

Second, our work examined citizens' perceptions of design characteristics by using a field survey. This did not allow us to manipulate any of the design characteristics to examine how user perceptions vary according to actual features, e.g., user support in the form of text instructions or interactive demos. Future research could conduct controlled experiments (Grimmelikhuijsen et al. 2017; Hassan and Wright 2020) to study how the actual features of design characteristics influence citizens' service experience.

Conclusion

This research examined how citizens' perceptions of e-government service design characteristics influence their service experience. We used Grönroos's (2000) multidimensional view of service to identify 10 service design characteristics pertaining to three key service perceptions. The results demonstrated that these design characteristics contributed to the key service perceptions that in turn influenced perceived service quality and citizen satisfaction with e-government services. Overall, this research provides insights into the design of e-government services and implementation strategies to improve citizen satisfaction. The findings highlight the need to consider the complementarity of service perceptions and also the nature and complexity of services when governments operationalize individual design characteristics.

Notes

1. A list of potentially relevant design characteristics was first identified based on an extensive review of the literatures in information systems, services, and e-government. We arrived at the current list of design characteristics after a careful examination of the relevance of each design characteristic to one of the three service perceptions. Also, feedback was obtained from topic experts who had research experience in the area of e-government to refine the list and mapping of the design characteristics to the service perceptions.
2. Accuracy and completeness were found to be the two strongest antecedents of information quality in Wixom and Todd (2005). The other two antecedents of information quality are format and currency, which were not included in the research model given their lower relevance to this study and non-salient effects reported in prior research.
3. We compared the demographics of our sample with the census data of 2016 on Hong Kong's population. There was no significant difference in terms of gender (chi-square, $p > .05$), but our sample was relatively younger (chi-square, $p < .05$) and more educated (chi-square, $p < .05$). In terms of Internet experience and use, our sample was closely representative of the active adult Internet users in Hong Kong, who were aged between 25 and 34. 99 percent of users in this age group accessed the Internet every day (versus the global median at 29 percent) (Statista 2016).

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Appendix A: Measurement Items (e-Tax Sample)

Accuracy (adapted from Wixom and Todd 2005)

1. *e-Tax* provides me with accurate information.
2. The information provided by *e-Tax* is accurate.
3. There are few errors in the information I obtain from *e-Tax*.

Completeness (adapted from Wixom and Todd 2005)

1. *e-Tax* provides me with a complete set of information.
2. *e-Tax* produces comprehensive information.
3. *e-Tax* provides me with all the information I need.

Self-service capability (self-developed based on Gilbert, Balestrini, and Littleboy 2004 and Meuter et al. 2000)

1. *e-Tax* enables me to file my taxes without having to interact with anyone.
2. Using *e-Tax*, I do not have to interact with civil servants to file my taxes.
3. Using *e-Tax*, I am able to file my taxes solely by myself.

Convenience (self-developed based on Gilbert, Balestrini, and Littleboy 2004 and Meuter et al. 2000)

1. *e-Tax* enables me to file my taxes anytime, day or night.
2. *e-Tax* enables me to file my taxes from home, from the office, or at other locations.
3. It is convenient for me to file my taxes using *e-Tax*.

Accessibility (adapted from Wixom and Todd 2005)

1. *e-Tax* is very accessible to me.
2. *e-Tax* is easy for me to access.
3. I have ready access to *e-Tax*.

User support (adapted from Karimi, Somers, and Gupta 2004)

1. I get the help I need in using *e-Tax*.
2. It is easy for me to get assistance when I am having trouble using *e-Tax*.
3. Clear instructions for using *e-Tax* are available to me.

Privacy protection (adapted from Hong and Thong 2013)

1. *e-Tax* does not collect too much personal information about me.
2. *e-Tax* devotes time and effort to prevent unauthorized access to my personal information.
3. *e-Tax* devotes time and effort to verify the accuracy of my personal information in their databases.
4. *e-Tax* does not use my personal information for any other purpose.

Security protection (adapted from Curran and Meuter 2005)

1. My use of *e-Tax* to file my taxes is secure.
2. It is secure for me to file my taxes using *e-Tax*.
3. *e-Tax* is a safe service for me to file my taxes.

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Personalization capability (adapted from Hinnant and O'Looney 2003)

1. I am able to fully personalize notifications when using *e-Tax* to file my taxes.
2. I am able to fully personalize the presentation of information when using *e-Tax* to file my taxes.
3. *e-Tax* enables me to fully personalize information that I will see.

Transparency (adapted from Welch, Hinnant, and Moon 2005)

1. The working processes of *e-Tax* are transparent.
2. The government provides me with deep access to how *e-Tax* works.
3. The government provides me with in-depth knowledge about operations of *e-Tax*.
4. I have opportunities to provide feedback on *e-Tax*.

Perceived service quality (adapted from Pitt, Watson, and Kavan 1995)

1. *e-Tax* has up-to-date web technologies.
2. *e-Tax* is visually appealing.
3. *e-Tax* looks professional and neat.
4. The appearance of *e-Tax* is in keeping with the kind of services provided.
5. When *e-Tax* promises to do something by a certain time, it does so.
6. When I have a problem, *e-Tax* shows a sincere interest in solving it.
7. *e-Tax* is dependable.
8. *e-Tax* provides its services at the times it promises to do so.
9. *e-Tax* insists on error-free services.
10. *e-Tax* tells me exactly when services will be performed.
11. *e-Tax* gives prompt service to me.
12. *e-Tax* is always willing to help me.
13. *e-Tax* is never too busy to respond to my requests.
14. *e-Tax* instills confidence in me.
15. I feel safe in my transactions with *e-Tax*.
16. *e-Tax* provides me with polite feedback and content.
17. *e-Tax* has the ability to do its job well.
18. *e-Tax* gives me individual attention.
19. *e-Tax* has operation hours convenient to me.
20. *e-Tax* gives me personal attention.
21. *e-Tax* has my best interest at heart.
22. *e-Tax* understands my specific needs.

Citizen satisfaction (adapted from Bhattacherjee and Premkumar 2004, with anchors as 1 [very dissatisfied/displeased/frustrated] and 7 [very satisfied/pleased/contented])

1. I am very dissatisfied/very satisfied with my use of *e-Tax*.
2. I am very displeased/very pleased with my use of *e-Tax*.
3. I am very frustrated/very contented with my use of *e-Tax*.

Note. Measurement items for the online appointment booking service and e-government portal were modified based on the above items to fit the context. For example, an item for accuracy for the e-government portal is "The *e-government portal* provides me with accurate information."

Appendix B: Results of the Expert Survey

We examined the substantive validity of the design characteristics (i.e., the extent to which they are theoretically linked to perceptions of a core service, perceptions of facilitating services, or perceptions of supporting services) using an expert survey on 15 highly experienced scholars in the area of e-government and/or technology/service design. We provided the respondents with the list of design characteristics and service perceptions, their definitions, and the measurement scales. We asked the respondents to assign each design characteristic to one of the three service perceptions.

Two indices of substantive validity (i.e., proportion of substantive agreement (P_{SA}) and substantive validity coefficient (C_{SV})) were calculated following Anderson and Gerbing (1991).

P_{SA} was calculated using this formula: $P_{SA} = n_c/N$ where n_c represents the number of respondents assigning a design characteristic to its posited service perception and N represents the total number of respondents. The values of P_{SA} range from 0 to 1, with larger values indicating greater substantive validity.

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*C*sv was calculated using this formula: *C*sv = $(n_c - n_o)/N$, where n_c and N are defined as before and n_o represents the highest number of assignments of the design characteristic to any other service perception. The values of C_{SV} range from –1 to 1, with larger values indicating greater substantive validity. A negative value for C_{SV} would indicate that a design characteristic has substantive validity, but for a service perception other than the one posited.

P_{SA} indicates the proportion of respondents who assigned a design characteristic to its posited service perception (e.g., assigning accuracy to perception of core service). C_{SV} indicates the extent to which respondents assign a design characteristic to its posited service perception more than to any other service perception. The results show that the values of P_{SA} and C_{SV} were high (the recommended threshold is 0.5), indicating that most respondents assigned the design characteristics to their posited service perceptions (see table B1). The results confirm the substantive validity of the design characteristics.

Table B1 Proportion of Substantive Agreement and Substantive Validity Coefficients

Service perceptions	Design characteristics	P_{SA}	C_{SV}
Perceptions of core service	Accuracy	1.00	1.00
	Completeness	1.00	1.00
	Self-service capability	0.80	0.67
	Convenience	0.93	0.87
Perceptions of facilitating services	Accessibility	0.87	0.73
	User support	0.80	0.73
	Privacy protection	0.80	0.67
	Security protection	0.87	0.73
Perceptions of supporting services	Personalization capability	0.87	0.80
	Transparency	0.80	0.67

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