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Business models for digital sustainability: Framework, microfoundations of value capture, and empirical evidence from 130 smart city services

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ABSTRACT

The emerging research stream on digital sustainability examines how digital technologies enable the creation of environmental and social value. The need to finance the creation of such value calls for a business model perspective that combines value creation and value capture. To extend the digital sustainability literature in this regard, we adopt a microfoundations perspective and argue that the configuration of value creation influences the decision of users to pay for a value proposition or not, which in turn affects organizational value capture. Applying a crisp-set qualitative comparative analysis to 130 smart city initiatives in Switzerland, we develop a three-dimensional framework of business models for digital sustainability. The framework comprises 12 theoretically possible business model types, representing distinct business model configurations. We contribute to the digital sustainability and the microfoundations literatures by analyzing, explaining, and classifying the diversity of digitally enabled business models in the context of smart cities.

1. Introduction

While digital transformations may increase economic efficiency and effectiveness, they can also yield environmental and social benefits (George et al., 2021; Paiola et al., 2021). In response to unsettling ecological trends and social problems, many political and societal stakeholders are now advocating sustainable development, calling for goods and services that generate social and environmental value (cf. Palmié, Rüegger, Holzer et al., 2023). To satisfy the demand for socially or environmentally beneficial solutions, these goods and services need to be produced and their production financed. Public bodies may create and finance such products, but they are hampered by two limitations (Blanck & Ribeiro, 2021). First, they may lack the competencies and assets to create these products in the required quantity, quality, and timeliness. Second, public budgets are notoriously tight, so raising alternative funding is alleviating if not essential.

Luckily, other stakeholders can assume both tasks: Consumers acting as customers can pay for sustainable products, while companies can provide them. Solving the financing challenge means that producing sustainable goods and services can become an attractive business opportunity for private firms because their associated activities allow them to capture economic value (Geissdoerfer, Morioka et al., 2018; Palmié, Boehm, Lekkas et al., 2021). Thus, public authorities and companies share an interest in understanding what makes consumers pay for sustainable products.

The decision of customers to pay for sustainable products provides a microfoundational perspective on value capture. The microfoundations movement in the management field seeks to understand "how individual-level factors impact organizations […] and how relations between organizational variables are mediated by individual actions and interactions" (Palmié, Rüegger, & Parida, 2023, p. 2; Felin et al., 2015). Previous research on the organizational ability to capture value through the individual-level decision to pay for greater sustainability has mostly examined the effect of customers' attitudes and cognitions (i.e., micro variables) on their willingness to pay for sustainable products (Dangelico et al., 2021; Kamboj & Matharu, 2021; Wei et al., 2018). In terms of macro variables, prior research has focused on the effect of certification on customers' willingness to pay (e.g., Aprile & Punzo,

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2022; Fanasch & Frick, 2020; Harms & Linton, 2016). Apart from this notable exception, the effect of organization-level variables on organizational value capture through the decision of customers to pay for sustainability has received little attention. As far as value capture from sustainable products is concerned, the latter part of the microfoundations manifesto – to understand micro decisions as a mediator between organizational antecedents and organizational outcomes – remains almost entirely unaddressed to date.

In general, "value capture" can be understood as one of three elements of a business model (BM), alongside “value proposition” and “value creation and delivery” (Geissdoerfer, Vladimirova et al., 2018, p. 402; Palmié, Boehm, Lekkas et al., 2021; Richardson, 2008). To date, very few scholars have studied the microfoundations of BMs, and the few exceptions (e.g.,Loon et al., 2020; Santa-Maria et al., 2022) have not dealt with *customers'* individual-level decisions or actions. These blind spots are detrimental, theoretically and practically. First, a microfoundational perspective is necessary to account for individual agency and, thus, to avoid incomplete and shallow theoretical explanations (Contractor et al., 2019; Palmié, Rüegger, & Parida, 2023). Second, illumining the effect of organizational variables on relevant individual-level decisions – addressing the latter part of the microfoundations manifesto – enables scholars to provide evidence-based guidance to decision makers on what organizations can do to manage the decisions and actions of pertinent individuals (Keupp et al., 2012).

Digital technologies and digitalization provide a fruitful and relevant context for studying the microfoundations of capturing value from sustainable products (Bansal, 2019; Miehé et al., 2022). Illustrating its potential to profoundly reshape business and society, digitalization has been termed an “industrial revolution”, with implications similar to those of mechanization and electrification (cf. Rad et al., 2022). Thus, our times are not only characterized by a “sustainability imperative” but also a “digital imperative”, forcing societies and firms alike to tackle grand societal challenges and a rapidly digitalizing economy (George et al., 2021; Pan & Zhang, 2020). Scholars of the “digital sustainability” community unify these two strategic objectives instead of addressing them in silos (Guandalini, 2022).

Compared to some antecedents of sustainable development – for example, stakeholder pressures, values, and culture (cf. Buzzao & Rizzi, 2021; Horak et al., 2018), relatively few scholars have yet explored the potential of deploying digital technologies to advance sustainable development, particularly at the intersection with BM research. Di Vaio et al. (2020) review the role of Artificial Intelligence (AI) in the development of sustainable business models, Gregori and Holzmann (2020) examine how sustainable entrepreneurs embed digital technologies in their business models, and Miehé et al. (2022) analyze how firms in the mobility sector incorporate connectivity technologies into their business models to join existing ecosystems, thereby creating economic, social, and/or environmental value. Overall, extant research in this area has focused primarily on private companies and specific digital technologies but has not studied entire business model configurations. Therefore, scholars call for more comparative research exploring cross-sector cases and unraveling opportunities for public and private organizations (Guandalini, 2022). They also ask for light to be shed on the characteristics and patterns of digitally enabled BMs and how these drive social, environmental, and economic value creation (George et al., 2021; Gregori & Holzmann, 2020).

Cities represent a prominent context for exploring the digital sustainability phenomenon (Secinaro et al., 2022; Zhang et al., 2022). Cities are prominently featured in the Sustainability Development Goals (SDGs), which describe the priorities of the United Nations regarding sustainable development (Sadraei et al., 2022). Notably, SDG 11 is devoted to “Sustainable Communities and Cities” (UN, 2020). In pursuit of SDG 11, more and more cities are turning to the “smart city” concept, using “information technology to solve the spatial, economic, environmental and social issues affecting urban environments” (Mora et al., 2019, p. 2). Hence, the smart city concept signals a path – leveraging digital technologies – to the realization of SDG 11 (Bibri & Krogstie, 2017; UN, 2020; Zheng et al., 2020).

For these reasons, we analyze smart city initiatives and ask: “*In which digitally enabled business model configurations do end users pay for sustainable products, and in which do they not?*”. Drawing on contingency theory, established BM thinking indicates that the fit between BM elements is commonly more decisive than the specific characteristics of those elements (Gassmann et al., 2014). We, therefore, apply crisp-set qualitative comparative analysis (csQCA), which helps assess the configuration of BM elements rather than the isolated effects of each element (Abbate et al., 2019; Muñoz & Cohen, 2017). Analyzing 130 smart city initiatives in Switzerland, the csQCA reveals six configurations of digitally enabled BMs creating sustainable value. Three of these configurations describe cases in which end users pay for smart city services, while the other three configurations concern cases in which end users do not pay for such services.

Our results make several contributions to theory and practice. First, we follow a call from digital sustainability scholars (Cricelli & Strazzullo, 2021) and develop a framework that demonstrates the interplay of social, environmental, and economic sustainability against the differing degrees of digital value delivery. Second, we respond to a call by George et al. (2021) and Gregori and Holzmann (2020) by clearly outlining various BM characteristics and patterns leading to end-user payments or third-party payments. Lastly, we complement and extend microfoundation studies (Ferraris et al., 2022; Helfat & Peteraf, 2015; Loon et al., 2020) by treating actions and decisions of organizational “outsiders” (i.e., customers) as microfoundations in and of themselves.

2. Theoretical background and literature review

2.1. Business model: Research trajectories, definitions, and components

Business model (BM) research can be traced to the dotcom boom of the late 1990 s. Back then, internet businesses seemed to jeopardize existing business logic by offering customers seemingly “free” services (Zott et al., 2011). This explains why BM research has been heavily dominated by technology-oriented perspectives from early on (Afuah & Tucci, 2003; Amit & Zott, 2001). More strategy-oriented research has been published since 2000 (Wirtz et al., 2016). Therefore, considering strategic elements (e.g., firm performance or innovation potential) aimed at gaining competitive advantage has become increasingly important (Chesbrough, 2010; Spieth et al., 2014; Teece, 2010). A third, yet subordinate, research strand shaping BM research has adopted an organization-theory perspective on deploying BMs for business planning or interorganizational cognitions (Aspara et al., 2013; Wirtz et al., 2016). While different strands were evident in early BM research, scholars have gradually recognized a converging BM view (Wirtz et al., 2016). In line with this view, sustainable value generation can be seen as a central element of organizational strategy and digital technologies as potential enablers of operational realization. Hence, we follow the view of Wirtz et al. (2016) that in “a modern BM sphere … [the] business model can be understood as a link between future planning (strategy), and the operative implementation (process management)” (pp. 38–39).

Although the purpose of BMs has become clearer, the literature still proposes various definitions, including the scope of BMs and their underlying composition. Geissdoerfer, Vladimirova et al. (2018) demonstrate that scholars utilize BMs in differing granularity. Some describe entire organizational systems (Baden-Fuller & Morgan, 2010), others abstract the characteristics of organizational units (Osterwalder & Pigneur, 2010; Teece, 2010), and yet others apply narrower scopes (e.g., focusing on a prominent part of a BM while still designating it as a BM) (Doganova & Eyquem-Renault, 2009).

Differences are also evident with regard to the BM elements included. For instance, the *Business Model Canvas* applies a more fine-grained perspective (Osterwalder & Pigneur, 2010; Osterwalder et al., 2005). This may be particularly useful for gaining in-depth understanding of one or several BMs or for more practice-relevant exploitation. On the other hand, a large community of interdisciplinary scholars has proposed a three- or four-component conceptualization (Boons & Lüdeke-Freund, 2013; Foss & Saebi, 2017; Geissdoerfer, Vladimirova et al., 2018; Palmié, Boehm, Friedrich et al., 2021). However, most definitions focus on value (Evans et al., 2017; Geissdoerfer, Vladimirova et al., 2018). Although all conceptualizations have their merits, we follow the working definition of Geissdoerfer, Vladimirova et al. (2018, p. 402): A BM is a "… simplified representation of the value proposition, value creation and delivery, and value capture elements and the interaction between these elements within an organisational unit". In essence, *value proposition* concerns "What value is proposed through the product or service offering?" (Magretta, 2002; Teece, 2010). *Value creation and delivery* concerns "How is value created and delivered to the customer?" (Amit & Zott, 2012; Osterwalder & Pigneur, 2010). *Value capture* concerns "How is value captured through the revenue model?" (Casadesus-Masanell & Ricart, 2010; Chesbrough & Rosenbloom, 2002).

We follow the above working definition for four reasons. First, our research aims to classify similar BM configurations in a large set of different BMs instead of focusing on in-depth BM understanding. Second, a broader definition allows for the inclusion of subordinate and more context-specific compositions. Third, it enables examining the interplay of these elements and elaborating on which configurations lead to the defined outcome. Fourth, it allows exploring the efforts of the organizational unit in charge of a particular service or product offering.

2.2. A microfoundations perspective on business models

The microfoundations movement in strategy and organization theory seeks "to understand how individual-level factors impact […] emergent, collective, and organization-level outcomes […], and how relations between macro variables are mediated by micro [decisions and] actions" (Felin et al., 2015, p. 576; Palmié, Rüegger, & Parida, 2023). The microfoundations of BMs have rarely been explored. The few existing studies adopting a microfoundational perspective on BMs have focused on the capabilities and actions of founders (De Silva et al., 2021), executives and senior managers (Ferraris et al., 2022; Helfat & Peteraf, 2015), or organizational members in general (Loon et al., 2020; Ringvold et al., 2022; Santa-Maria et al., 2022). Our study extends these publications by focusing on actions and decisions of individuals outside the organization, namely customers.

Very recently, microfoundations scholars have started to investigate BMs concerned with social sustainability and environmental sustainability (De Silva et al., 2021; Santa-Maria et al., 2022). These initial efforts tell us little about how digital technologies affect the microfoundations of sustainable BMs. Our investigation of smart-city BMs complements prior work by studying sustainable and digitally enabled BMs and, thus, responds to the recent interest in "digital sustainability" (George et al., 2021; Guandalini, 2022).

2.3. Digital sustainability in business models

Recent research has coined the term "digital sustainability" (DS) to indicate the great potential of digital technologies in contributing to achieving sustainability targets on micro and macro levels (Bohnsack et al., 2022; Guandalini, 2022; Pan et al., 2022). As the term suggests, such research is situated at the intersection of digitalization and sustainability and driven by strategic objectives of digital transformation and sustainability. DS scholars are busy striving to unify these objectives. However, there is a consensus that deploying digital technologies should create social and environmental value instead of tackling digitization and sustainability in silos (Guandalini, 2022). In line with this argumentation, George et al. (2021) define DS "…as the organizational activities that seek to advance the sustainable development goals through creative deployment of technologies that create, use, transmit, or source electronic data" (p. 1000). We follow this definition.

While DS is addressed by interdisciplinary scholarship, Guandalini (2022) emphasizes the lack of focus on management. In this vein, management scholars have now begun exploring BMs in relation to DS. Di Vaio et al. (2020) systematically reviewed the role of artificial intelligence (AI) and whether it can positively affect production and consumption to meet the respective SDGs and establish sustainable resource management. Both studies focus on how to improve sustainability in the value-creation dimension of BMs. In contrast, Paiola et al. (2021) considered sustainability achievement from a value proposition perspective and showed that the IoT-based BMs of small and medium manufacturing companies create more sustainable service offerings. To the best of our knowledge, only Gregori and Holzmann (2020) have applied a holistic view to show how digital technologies enable innovating all three dimensions of a BM to create more social and environmental value.

Thus, DS is a nascent research strand with several blind spots, yet with untapped potential at the BM intersection. First, various scholars have emphasized that integrating economic sustainability into the BM perspective is as important for DS as it is for social and environmental sustainability (Cricelli & Strazzullo, 2021). In particular, private companies rely on economic sustainability to attract investors and ensure their long-term existence (Oderanti et al., 2021). However, most DS research has addressed the utilization of digital technologies to combat and mitigate climate change (Kunkel & Matthess, 2020; Ludbrook et al., 2019; Paiola et al., 2021) or to enhance social healthcare and citizen participation (Bouzguenda et al., 2019; Oderanti et al., 2021). However, the interplay of economic, social, and environmental sustainability in digitally enabled BMs remains poorly understood.

Therefore, our paper deals with the research question: "*In which digitally enabled business model configurations do end users pay for sustainable products, and in which do they not?*".

3. Methodology

3.1. Empirical setting

Smart cities provide an intriguing empirical context to investigate the configurations of BMs to achieve digital sustainability. First, cities occupy only 3 % of the earth's land surface but account for over half of the world's population, the bulk of economic activity, and the overwhelming majority of energy consumption, CO2 emissions, and resource expenses (Balland et al., 2020; Mora et al., 2019; UN, 2020). They also face pressing social conflicts, security problems, housing deprivation, and inclusion issues (Bibri & Krogstie, 2017; Gassmann et al., 2019). Cities, therefore, are crucial to achieving SDG 11, "Sustainable Cities and Communities" (UN, 2020).

Second, various scholars consider information and communications technology (ICT) and other digital technologies as a means to accelerate the transformation ambitions of SDG 11 (Appio et al., 2019; Ardito et al., 2019; Bibri & Krogstie, 2017; Zhang et al., 2022). Cities that "systematically [apply] digital technologies to reduce resource input, improve its people's quality of life, and increase the competitiveness of the regional economy in a sustainable manner" are called smart cities (Gassmann et al., 2019, p.25; see also Friedrich et al., 2021, Mora et al., 2019). Hence, smart cities apply digital technologies in the pursuit of SDG 11 and are a subset of all cities pursuing SDG 11. Technology deployment in smart cities ranges from data processing (e.g., big data analytics, artificial intelligence, and machine learning) to more physically embedded technologies (e.g., sensors, smart meters, and cameras) enabling physical products to become the so-called internet of things (Abbate et al., 2019; Di Vaio et al., 2020; Mattern & Floerkemeier, 2010; Zhang et al., 2022). In this vein, the visionary concept of smart cities, coined by public and academic discourse alike (de Jong et al., 2015; Kitchin, 2015), unifies digitalization and sustainability, as does "digital sustainability" research.

Third, smart cities – as ecosystems – involve multiple stakeholders, from service users, citizens, to universities, and from public and private organizations to the environment (Appio et al., 2019; Ferraris et al., 2020; Pee & Pan, 2022; Secinaro et al., 2021). From a BM perspective, it is crucial to understand their roles in enhancing social and environmental value creation through digitally enabled services (and to ensure these remain economically viable). For example, services aiming to contribute to SDG 11 are either provided by company-operated BMs or "city business models" (Díaz-Díaz et al., 2017; Muñoz & Cohen, 2017; Timeus et al., 2020). At the same time, citizens can actively create social and environmental value or primarily benefit from such value as end users (Bouzguenda et al., 2019; Massey et al., 2018).

3.2. Methodological approach

We identify which configurations (i.e., combinations of diverse BM elements) characterize digitally enabled and sustainable BMs that end users (i) pay for or (ii) receive free of charge. Therefore, we adopt Ragin's (2000) set-theoretic approach by employing a crisp-set qualitative comparative analysis (csQCA). The set-theoretic approach allows us to deal with a high degree of causal complexity by analyzing causal conditions in patterns resulting in causal combinations that contribute to certain outcomes (Fiss, 2011; Ragin, 2000, 2008).

Developed by Charles Ragin in 1987, this method has gained (and continues to gain) increasing popularity in management research since 2002 (Rihoux et al., 2013). In the last decade, management scholars have begun utilizing QCA to analyze BMs in various contexts (e.g., IoT platforms, coopetition, or the sharing economy; (Abbate et al., 2019; Bouncken et al., 2020; Leppänen et al., 2021; Muñoz & Cohen, 2017). One reason for this focus is the *a priori* configurational nature of BMs. For instance, Gassmann et al. (2016) called BMs a "recombination" of interrelated elements across multiple dimensions. Employing BMs as a unit of analysis for a QCA is promising because it sheds light on how to (and how not to) configure underlying causal conditions (i.e., specific BM characteristics) to support an outcome of interest.

QCA is particularly suited to our research for three reasons: First, QCA bridges qualitative and quantitative analysis. On the one hand, QCA enables identifying within-case similarities (based on in-depth case insights). On the other, it systematically reveals cross-case patterns that usually are the domain of quantitative methods (Ragin, 2000; Rihoux & Ragin, 2008). Second, QCA provides powerful tools for analyzing causal complexity. Conventional statistical techniques (e.g., linear regression analysis) do not allow rival causal factors (i.e., quantitative methods "urge the researcher to specify a single causal model that best fits the data"; Rihoux & Ragin, 2008, p. 8; Schneider & Wagemann, 2007). In contrast, QCA permits equifinality (i.e., different combinations of causal conditions – so-called paths – can contribute to the same outcome; (Rihoux & Ragin, 2008). Third, QCA emphasizes the potential of causal asymmetry (Greckhamer et al., 2018) when analyzing BMs with present versus absent outcomes of interest. This assumes that different conditions explain the absence of an outcome as do the conditions of the presence of an outcome. In sum, QCA enables systematic study of the presence and absence of outcomes. In consequence, it provides more holistic insights in order to reinforce supporting or remedy hindering conditions.

3.3. Causal and outcome conditions

According to Ragin (2000), QCA requires theoretical knowledge to define the underlying conditions and the outcome of interest. As outlined in Section 2.1, a BM can be described along three dimensions: (i) value proposition; (ii) value creation and delivery; (iii) value capture (Geissdoerfer, Vladimirova et al., 2018; Palmié, Boehm, Friedrich et al., 2021). These elements constitute a very general framework, which applies to BMs in various sectors. However, much research has emerged on context-specific BMs, including but not limited to circular BMs (Ferasso et al., 2020), sustainable BMs (Nosratabadi et al., 2019), and sharing BMs (Muñoz & Cohen, 2017). These BM all exhibit sector- or phenomena-related characteristics of their constituting components. Therefore, based on the smart-city, business-model, and digital-sustainability literatures, we identify the conditions underlying each of the three BM dimensions in order to explore digitalization and sustainability in the context of smart cities.

Our primary interest is to reveal how BM configurations (i.e., organization-level variables) impact organizational value capture. The latter variable is represented by customers' decision to pay for digitally enabled sustainability services. Thus, the value-capture dimension is the outcome variable in our analysis. This corresponds to the observation that value creation "necessarily precedes value capture" (Nickerson & Zenger, 2007; Tantalo & Priem, 2016, p. 316). We also derive six aspects constituting the value proposition and the value-creation-and-delivery component of a BM, thus serving our QCA as causal conditions. We subsequently conceptualize and define the seven BM elements in greater detail before proceeding to the empirical analysis.

3.3.1. Causal conditions

The first condition, a BM's ***social emphasis***, is one of the three sustainability pillars according to the triple-bottom-line approach (Bansal, 2005; Elkington, 1997; Evans et al., 2017). To focus BMs on sustainability, smart-city and sustainability scholars have complemented the *Business Model Canvas* by measuring social and environmental impact as an indicator of sustainability (Giourka et al., 2019; Joyce & Paquin, 2016; Osterwalder & Pigneur, 2010; Timeus et al., 2020). We include social emphasis as a condition of a BM's value proposition to assess whether that BM brings social benefits to end users (service recipients), society, or both (cf. Giourka et al., 2019). Consequently, we say a BM has a social emphasis when it improves citizens' quality of life, reduces exclusion and promotes inclusion, or enhances transparency and participation.

The second condition, a BM's ***environmental emphasis***, is the second pillar of the triple-bottom-line approach to sustainability (Bansal, 2005; Elkington, 1997; Evans et al., 2017). Scholars studying sustainable BMs began to consider their environmental impact in addition to their social impact (Bocken et al., 2014; Stubbs & Cocklin, 2008). In line with Sarmiento and El Hanandeh (2018), we argue that society's green awareness has evoked a more open-minded attitude to more eco-friendly products and services. According to Giourka et al. (2019), BMs possess an environmental emphasis when their service intends to substantially reduce the ecological footprint or energy consumption. Moreover, new or innovative BMs can significantly impact overall environmental efficiency, including better resource utilization and waste reduction (Paiola et al., 2021). Thus, we say a BM has an environmental emphasis when it addresses one or more environmental benefits.

The third condition, the ***means of value delivery***, represents a BM's value creation and delivery. It defines how the value proposition is provided and distributed to customers (Abdelkafi et al., 2013; Parida et al., 2019; Zott et al., 2011). With this variable, we assess the delivery mode of digitally enabled BMs in creating social and environmental value. The literature has investigated two forms of delivery when utilizing digital technologies. On the one hand, smart city services may be delivered in purely digital form (e.g., open-data platforms, virtual learning services, eHealth services) (Al Nuaimi et al., 2015; Hurbean et al., 2021; Oderanti et al., 2021). Such delivery implies rather asset-light resources. On the other hand, service delivery can be embedded in physical goods (e.g., smart bikes, smart streetlights, and other IoT-based products) (Bresciani et al., 2018; Brock et al., 2019; Muñoz & Cohen, 2017). Thus, with this variable, we distinguish between purely digital and physically embedded service delivery.

The fourth condition, also related to the value-creation-and-delivery dimension, provides information about the ***stakeholder(s) driving value creation***. According to Teece (2010), "business models are necessary features of market economies [...] [for] profit-seeking firms in competitive environments" (p.176). Our review of the BM literature confirms that research has focused mainly on firm-related BMs (Foss & Saebi, 2017). However, the smart city context reveals that value creation is not limited to business partners, but the concept of a "city business model" also creates value through the public partner (Ben Letaifa, 2015; Timeus et al., 2020). Thus, to adequately cover and classify all types of smart-city BM, we examine which stakeholder drives value creation (business vs public authority). We do not mean to imply that this actor necessarily implements a smart city service alone. Public services often result from multi-stakeholder collaboration (Ben Letaifa, 2015; Crosby et al., 2017). Thus, for our variable, we differentiate between business- versus public-authority-driven value creation. In accordance with Zucchella and Previtali (2019), if the focal service is developed collaboratively, our condition will indicate the "orchestrator" of the value-creation network.

The fifth condition, ***citizen involvement***, again concerns a BM's value creation and delivery. The systematic literature review by Lim et al. (2019) emphasizes the centrality of citizen involvement and empowerment in developing smart cities. Their role varies from digital participation to enhancing social sustainability or actively participating in the transition to smart energy communities (Bouzguenda et al., 2019; Cardullo & Kitchin, 2019; Massey et al., 2018). Therefore, BM scholars have described citizen engagement as a value creation element (Abbate et al., 2019; Giourka et al., 2019). In our study, this causal condition indicates whether citizens actively contribute to the value creation and delivery of digitally enabled BMs aiming to create sustainable value.

The last condition of our QCA is the ***initial financing*** needed to implement a BM. As smart city services often emerge as publicly initiated "smart city initiatives" (Neirotti et al., 2014), development and implementation can be supported by public funding (Blanck & Ribeiro, 2021). However, Muñoz and Cohen (2017) showed that alternative funding also plays a crucial role for start-ups (e.g., predominating altruistic motives and social impact). We distinguish initial financing provided by a business from that granted by a public partner. While this might represent a BM's value capture, we find that such financing does not replace regular revenue streams. Rather, it aims to initially develop and implement the envisaged smart service. Thus, this condition also belongs to a BM's value creation and delivery.

3.3.2. Outcome variable

The outcome variable, value capture, is the last dimension of a BM. Strategy scholars have argued that value creation deserves more attention as it precedes value capture (Nickerson & Zenger, 2007; Priem, 2007; Tantalo & Priem, 2016). Value creation, thus, serves value capture (the desired outcome) as input. We apply a microfoundations perspective to show how organizational variables impact relevant individual-level decisions (i.e., end-user payment). Revenue flows are pivotal for value capture (Täuscher & Laudien, 2018). We distinguish between BMs where end users pay (directly) for a smart city service and BMs where services are provided free of charge. Thus, our condition describes the revenue source. If a service is provided free of charge to consumers, a third party must be paying for its production.

3.4. Data collection and case selection

We focused on "smart city initiatives" (SCIs) and their underlying BMs in Switzerland. According to Neirotti et al. (2014), smart city ideas are implemented in smart city initiatives. These typically address a specific problem or a set of related problems in one or more service area (s), including smart mobility, smart environment, smart economy, smart living, smart government, and smart people (Gassmann et al., 2019; Giffinger & Gudrun, 2010). We chose Switzerland for two reasons. First, Switzerland was ranked by the World Intellectual Property Organization (WIPO) as the world's number one innovative economy in 2020 for the eighth consecutive year (Cornell University, 2020). Smart city initiatives are "examples of transformative innovation at the urban level" (Bundgaard & Borrás, 2021, p. 5) and, therefore, we argue that innovativeness is a requirement to establish smart city services. Second, Switzerland's size allows us to analyze a national smart-city-initiative landscape instead of just exploring specific cities or sector-specific cases.

We identified a large pool of smart city initiatives in two steps. First, we drew on a bi-yearly survey conducted by a partner university. The survey gathered information from city governments on current initiatives. While all 171 Swiss cities were contacted in 2019, complete information was provided by 29 cities (response rate: 17.0 %), producing an initial set of 134 valid SCIs. Second, we complemented the dataset from Step 1 by conducting online research with search terms such as "smart city" and "sustainable city" and with various service areas ("smart mobility," "smart government," "smart economy," "smart people," "smart environment," and "smart living") (Giffinger & Gudrun, 2010). Among the 142 cities that did not complete the survey questionnaire in Step 1, we identified 22 cities where further SCIs occur. These 22 cities accounted for 57 SCIs. Combining the results from Step 1 and Step 2 yielded a total of 51 cities and 201 SCIs. While these projects were all urban initiatives, we found 51 multi-urban initiatives (i.e., not limited to one city), generating 252 identified cases in total.

In-depth data collection and coding lasted from August 2020 to March 2021 (updated in July and August 2021). This process was conducted in three sequential steps. First, we collected detailed information about all three BM dimensions (value proposition, value creation and delivery, value capture) for each of the 252 cases. Obtaining appropriate and triangulated primary data on smart city initiatives for so many cases is time-consuming and subject to much uncertainty. While this requires the perspective of numerous stakeholders, a decent response rate remains unpredictable. Inspired by prior BM research (Muñoz & Cohen, 2017; Palmié, Boehm, Friedrich et al., 2021; Täuscher & Laudien, 2018), we collected our case data from publicly available (i.e., secondary) sources (e.g., media articles, project websites and reports, municipal government press releases). For each case, we created a separate folder including evidence that would enable analysis of all three BM dimensions. We added textual data – also in a second iteration – until we achieved information saturation (587 documents in total).

Second, we applied *a priori* coding based on theoretical concepts outlined in sections 2 and 3.3. (Stemler, 2000, p. 2). Building on the causal condition and outcome variables outlined above, five research assistants reviewed all case-related information and extracted relevant codes regarding the six causal conditions as well as the outcome variable. To gain an in-depth overview of all cases, we created an Excel table with 252 case rows and ten columns. The table provides detailed information on the six causal conditions, the outcome variable, and other case-specific information.

Third, we inductively investigated our qualitative database. Our first round of exploration revealed that we lacked sufficient data on at least one of the three BM dimensions for 59 smart city initiatives. Furthermore, we decided that planned projects are unsuitable as empirical evidence because their implementation is still uncertain. Concerning pilot projects, value capture proved to be somewhat premature. For example, most of the autonomous driving shuttles in the public transport sector served to stimulate technological acceptance among citizens. Therefore, the related services were free of charge, and the project was limited to a specific time. Thus, to avoid distortion regarding the value capture of BMs in smart cities, we decided to focus on fully implemented cases (i.e., in their operation mode). This decision reduced our large case pool to a final dataset of 130 valid and robust cases.

3.5. Dichotomization of conditions

QCA requires the calibration of raw data into set-membership scores ranging from full membership (represented by a score of 1.0) to full non-membership (represented by a score of 0.0) (Ragin, 2008). While fuzzy-set QCA demands more fine-grained gradation of membership (i.e., ranging from 0.0 to 1.0), csQCA only distinguishes membership and

Table 1
Criteria for Membership Scores and Coding.

Outcome Variable	***Value Capture Dimension***	
Customer Payment	1.00	End user pays for service
	0.00	End user does not pay for service
Causal Conditions	***Value Proposition Dimension***	
Social Emphasis	1.00	Strong focus on offering social value
	0.00	No/weak focus on offering social value
Environmental Emphasis	1.00	Strong focus on offering environmental value
	0.00	No/weak focus on offering environmental value
	Value Creation & Delivery Dimension	
Purely Digital Value Delivery	1.00	Value delivery is completely digital
	0.00	Physically embedded value delivery
Business-Driven Value Creation	1.00	Value creation is driven by a business
	0.00	Value creation is driven by a public organization
Citizen Involvement	1.00	Citizens are involved in value creation[1]
	0.00	Citizens are not involved in value creation
Initial Financing	1.00	Initial financing by a private organization
	0.00	Initial financing by a public organization

[1]The citizens involved in value creation are not necessarily the consumers of the resulting good or service. An illustrative example of a service that is created with citizen involvement other than service users is a volunteering platform where volunteers (other citizens) help elderly people in their daily lives (service users).

non-membership (i.e., binary codes, 0.0 or 1.0) (Greckhamer et al., 2018), making it more robust. Thus, csQCA calibration dichotomizes the selected variables into causal condition sets and the outcome set (Rihoux & Ragin, 2008). Based on our first coding results (Section 4.4.), two researchers independently coded whether the causal conditions and the outcome were present (scored with 1.0) or absent (scored with 0.0). The coders subsequently discussed those cases whose assessment yielded inconsistencies. If necessary, they jointly rescreened and agreed on respective case information. Table 1 indicates the specific criteria used to code the 130 cases.

3.6. *Crisp-set analysis*

We divided the crisp-set analysis of our calibrated data into three steps. First, we used the fsQCA software (version 3.1b), which automatically constructed a truth table. A truth table reveals a list of all logically possible combinations of causal conditions with 2^{k} (k = the number of conditions) configurations (Greckhamer et al., 2018). Our research resulted in 64 theoretically possible configurations, and our 130 cases fell into 25 of these configurations. Since "causal symmetry cannot be assumed, meaning that the presence and the absence of the outcome, respectively, may require different explanations" (Rihoux & Ragin, 2008, p. 9), we proceeded our QCA with two populations. We analyzed the population in which the outcome is present where end users pay for the service, and the population in which the outcome is absent where the service is offered free of charge to end users.

Second, we followed prior research by applying consistency and frequency thresholds to reduce the number of rows in our truth table (Muñoz & Cohen, 2017). A *consistency score* for crisp sets indicates the proportion of cases that fulfill the outcome, whereas a *coverage score* indicates the proportion of cases fulfilling the outcome while being captured by the configuration (Greckhamer et al., 2018). Following Fiss (2011), we selected a lowest consistency threshold of ≥ 0.8, which is more conservative than a threshold of 0.75 (Ragin, 2008). In line with Haefner et al. (2021), we used two cases per solution path as the minimum frequency threshold to ensure at least 75 % of our sample was preserved after cut-off. For the outcome "end user pays" ("end user does not pay"), five (six) rows of the theoretical configurations and 30 (68) cases exceeded our defined thresholds. Table 3 in the appendix provides an excerpt of the generated truth table.

Third, the software created three kinds of solution for each population since the QCA method distinguishes complex, parsimonious, and intermediate solutions (Fiss, 2011; Ragin, 2008). The complex solution

Table 2
Business Model Configurations Capturing vs Not Capturing Value from End Users.

	Configurational Model I			**Configurational Model II**		
Outcome Variable	Value Captured From End User			Value Not Captured From End User		
	Solution			**Solution**		
Causal Conditions	**1**	**2**	**3**	**4**	**5**	**6**
Value Proposition						
Social Emphasis		●	⊗		●	●
Environmental Emphasis	•	●	●	●	⨂	⨂
Value Creation & Delivery						
Purely Digital Value Deivery	⊗	⨂	●	⨂	•	
Private-led Value Creation	•	●	⊗	⨂		⊗
Citizen Involvment	⊗	●	⊗	⊗	⊗	•
Initial Private Financing	●		⊗	⊗	⊗	⊗
Consistency	1	1	1	0.89	0.94	1.00
Raw Coverage	0.2	0.14	0.26	0.3	0.22	0.26
Unique Coverage	0.2	0.14	0.26	0.3	0.22	0.26
Overall Solution Consistency			**1.00**			**0.94**
Overall Solution Coverage			**0.61**			**0.79**

only displays configurations with empirical evidence. It does not take into account counterfactuals for logically possible configurations with no case existence. In contrast, the parsimonious and intermediate solutions incorporate the so-called "remainders" (Misangyi & Acharya, 2014). This means that an algorithm is utilized "based on a counterfactual analysis of causal conditions, […] allowing for categorization of causal conditions into core and peripheral causes" (Fiss, 2011, p. 403). While the parsimonious solution comprises "easy" and "difficult" counterfactuals, the intermediate solution is based only on "easy" counterfactuals navigated by the researchers' theoretical and substantive knowledge (Fiss, 2011; Misangyi & Acharya, 2014; Ragin, 2008).

We follow current conventions (Abbate et al., 2019; Ragin & Fiss, 2008) and report the presence and absence of digitally enabled BM conditions leading to end-user-paid services (versus non-end-user-paid services) based on parsimonious and intermediate solutions. In the configurational chart (Fiss, 2011), displayed in Table 2, we indicate whether the solution path consists of core or peripheral condition(s). In the charts, black circles (● ●) denote the presence of conditions and crossed white circles (⊗ ⊗) their absence. Large circles (● ⊗) indicate core conditions and small circles (● ⊗) peripheral ones. Empty fields mean that a condition is irrelevant for explaining the outcome of interest (i.e., the condition is either present or absent). Accordingly, core conditions are part of the parsimonious and intermediate solutions, while peripheral conditions belong to the intermediate solution, yet not to the parsimonious solution. Hereafter, the reported consistency and coverage measures refer to the intermediate solution.

4. Results

4.1. Paths for smart city business models capturing value from end-user payments

Table 2 shows the results of the first QCA (i.e., the digitally enabled BM configurations with sustainable value leading to the outcome "end user pays"). The set-theoretic minimization of QCA indicates three BM configurations where the respective organizations capture value directly through end-user payments. The "overall solution consistency" of 1.0 shows that the outcome is present ("end user pays") in 100 % of the cases covered by the three solution paths. This demonstrates a strong set-theoretical relationship between the overall solution and the outcome, implying a high validity of this configurational model (Greckhamer et al., 2018; Ragin, 2006). The "overall solution coverage" of 0.61 denotes that all three configurations account for 61 % of all cases coded with a present outcome ("end user pays"). According to previous QCA studies, this value is substantive (Abbate et al., 2019; Fiss, 2011; Greckhamer, 2016). At the same time, it is essential to emphasize that other possible BM paths not covered by our configuration model exist where end users pay. Moreover, configuration model I shows that neither a necessary nor a sufficient condition leads to the outcome, "end user pays." Below, we present and interpret the individual configurations.

4.1.1. Business model solution 1: Environmentally and digitally enhanced BMs

Solution 1 comprises the present core condition Initial Financing by Private. Moreover, it combines two present peripheral conditions, Environmental Emphasis and Value Creation led by Private, and two absent peripheral conditions, Purely Digital Delivery and Citizen Involvement. At the same time, Social Emphasis is irrelevant to this path. This unique combination of conditions describes BMs focusing on *environmental services* that utilize *digital technologies to enhance physical products*. For example, *Nextbike, Mobility,* and *Voi* have built their BMs based on the Internet of things (IoT). For this purpose, businesses deploy *inter alia* information and communication technology (ICT) to upgrade products such as (e-)cars, e-scooters, or (e-)bikes and enable them to interact with users, access Internet services, and connect with each other (Mattern & Floerkemeier, 2010).

From a value proposition perspective, providers encourage collaborative instead of individual consumption to achieve higher utilization of durable goods. Their service offerings, therefore, enable customers to use rather than possess such products. This contributes to a more resource-efficient utilization of goods.

From a value creation perspective, private companies primarily initiate and lead these BMs. These actors, often young start-ups, are not funded by public partners but by private equity funds or venture capitalists. Sufficient market demand and high market potential may be relevant reasons for these investors. Moreover, this BM configuration does not require citizen involvement to create or deliver the service. However, it heavily relies on digital technologies embedded in physical infrastructure. Primarily, this ensures vehicle connectivity to track routes and parking locations for new pick-ups. Second, it provides an app-based service solution. The digital service allows users to search for the nearest vehicle, access and lock it, and complete the ride with cashless payment.

From a value capture perspective, service providers generate revenue from pay-*per*-use models (e.g., *Voi, Lime,* and *Tier*). Others (e.g., *PubliBike* and *Mobility*) complement pay-*per*-use with an annual or customized subscription model to cater to different user groups and user needs (e.g., frequent riders). We classify this configuration as business-to-customer (B2C) BM, focusing either on eco services or on IoT-driven opportunities.

4.1.2. Business model solution 2: Citizen-engaged sustainability BMs

Solution 2 consists of five core conditions, of which Initial Financing remains irrelevant. The four present core conditions, Social Emphasis, Environmental Emphasis, Value Creation led by Private, and Citizen Involvement, are complemented by the absent core condition Purely Digital Value Delivery. This constellation of conditions describes BMs that concentrate on *environmental and social services* by *actively engaging citizens*. Unlike BM configuration 1, citizen involvement is crucial to this type of BM. This is especially intriguing because it supports extant research, which integrates a multi-stakeholder perspective into smart city initiatives and outlines BM adaptions to enable and sustain citizen engagement (Ferraris et al., 2020; Massey et al., 2018). For example, *Klimaschule by myblueplanet* and *carvelo2go* are privately run BMs that actively incorporate citizens into their BM's value creation and delivery. For example, *carvelo2go* relies on support from so called "hosts" serving as pick-up and drop-off stations for the shared e-cargo bikes. In contrast, *Solar Community* and *Partizipative Solarenergie* involve citizens as financial investors (who, as their customers, profit from renewable energy services).

From a value proposition perspective, providers offer services that allow customers to reduce their carbon footprint by propelling behavioral change and by utilizing more environmentally friendly mobility or energy services. Moreover, these BMs tackle social issues by making service offerings more inclusive. Thus, they target people who cannot afford to purchase such products but who still appreciate the resulting services. Besides citizen involvement, deploying digital platforms is an additional component of their BM's value creation and delivery. For example, *Taxito's* peer-to-peer (P2P) platform brings together drivers with empty seats and passengers looking for a ride.

From a value capture perspective, such BMs apply various revenue mechanisms to generate income. Participatory energy communities use crowdfunding, whereas mobility providers such as *carvelo2go* and *Taxito* stick to pay-*per*-use. At the same time, *Klimaschule by myblueplanet* relies on parents voluntarily "paying what they want" for their children to benefit from climate-responsible education. According to the Robin Hood revenue distribution scheme of Gassmann et al. (2020), higher-income families typically cross-finance children from low-income families. We classify this configuration as a business-to-customer (B2C) BM, creating social and environmental value through citizen-engaged services.

4.1.3. Business model solution 3: Digitalized and automated BMs

Solution 3 comprises two present core conditions, Environmental Emphasis, and Purely Digital Value Delivery, and of four absent peripheral conditions, Social Emphasis, Value Creation led by Private, Citizen Involvement, and Initial Financing by Private. This combination of conditions describes BMs focusing on *digitalizing and automating their hitherto physical service offerings.* Transforming physical services into smart services to increase effectiveness and efficiency in their service offering is crucial for this BM configuration. For example, public organizations are increasingly investing in digital infrastructure and deploying service websites. This adoption, concerning a BM's value creation and delivery, enables public organizations to offer citizens complementary online services (e.g., online construction permits, e-residence applications, or app-based public services). With public organizations leading value creation, it is not surprising that this BM configuration is funded by public money, at least initially. However, this does not exclude public partners commissioning private partners to build digital infrastructure, interfaces, and back ends. Furthermore, public organizations do not rely on citizen involvement to create and deliver digital services.

From a value proposition perspective, such BMs provide customers with greater flexibility regarding completion, as well as cost and time savings, due to eliminated rides to authorities and on-site waiting times. However, the review paper by Kaur and Garg (2019) on social sustainability assessment criteria found that this added value is not linked to social sustainability. However, digital instead of physical services enable customers profit from efficiency and transact in a more resource-conserving way. This impact might be due to reduced energy consumption or decreased resource deployment (e.g., when digital services avoid physical arrivals or involve less paper prints).

From a value capture perspective, public organizations generate direct revenue from pay-*per*-use models. Depending on the degree of automation, they profit indirectly from faster processing and cost savings after investment amortization. We classify this configuration as a public-to-customer (P2C) BM, focusing on purely digital web services.

4.2. Paths for smart city business models not capturing value from end-user payments

Table 2 shows the results of the second QCA (i.e., the digitally enabled BM configurations with sustainable value leading to the outcome, "not paid by the customer"). The set-theoretic minimization of QCA describes three BM configurations offering smart city services that end users receive free of charge. Here, the "overall solution consistency" of 0.94 shows that the outcome is absent ("end users do not pay") in 94 % of the cases covered by the three solution paths. In comparison, the remaining 6 % of cases fulfilling the identified conditions lead to the presence of the outcome ("end users pay").

Configuration model II demonstrates the strong set-theoretical relationship between the overall solution and the outcome, implying a high validity of this configurational model (Greckhamer et al., 2018; Ragin, 2006). At the same time, the "overall solution coverage" of 0.79 means that all three configurations account for 79 % of all cases coded with an absent outcome ("end users do not pay"). We also analyzed the necessary conditions with a consistency benchmark of ≥ 0.90 (Greckhamer et al., 2018; Ragin, 2008). Results show that the absence of initial private financing (hence, provided by the public partner) is a necessary condition for the absence of the outcome ("end users do not pay"). In other words, public partners must initially finance BMs where end users receive services free of charge. Below, we present the individual configurations and offer an interpretation.

4.2.1. Business model solution 4: Environmentally improved public BMs

Solution 4 combines the present core conditions, Environmental Emphasis, with two absent core conditions, Purely Digital Value Delivery and Value Creation led by Private. Additionally, this configuration has two absent peripheral conditions, Citizen Involvement and Initial Financing by Private. Social Emphasis remains irrelevant for this BM configuration. This unique combination of conditions describes BMs aiming to *improve environmental sustainability in public spaces*. Like BM configuration 1, the value propositions are associated with a physical product or physical service but are often modified to a smart product. For example, *LED lighting on demand* deploys resource-saving LED lamps to reduce energy consumption. At the same time, lights require appropriate ICT to communicate and connect. These capabilities ensure additional resource efficiency (i.e., streets are not lit permanently but only when necessary).

Others BM examples (e.g., *smart parking guidance*, *solar connectivity and charging bench*, *smart grid solutions*) create and deliver value predominantly by a public partner (e.g., local authority). However, such projects, which are often infrastructure related, are mostly tendered by public authorities, while private companies carry out the implementation. Thus, the initial financing is ensured by public funds. The absence of citizen involvement also characterizes this BM configuration.

From a value capture perspective, such BMs do not generate revenue from their end users because the entire society is benefiting from this environmental value creation. However, public organizations are still able to initiate such services and put them out to tender. Thus, private companies can capture value by diverse business-to-public BMs (Brock et al., 2019). Therefore, we classify this configuration as a business-to-public (B2P) BM, focusing on IoT-driven services that enhance products and services in public space.

4.2.2. Business model solution 5: Platform-enabled digital service BMs

Solution 5 comprises two core conditions: Environmental Emphasis (absent) and Social Emphasis (present). Purely Digital Value Delivery is a present peripheral condition, while Citizen Involvement and Initial Financing by Private are absent peripheral conditions. Value Creation remains irrelevant for this configuration. This combination of conditions describes BMs focusing on *digital service offerings enabled by different digital platforms.*

From a value proposition perspective, the digital services involved tackle social sustainability because they increase transparency, provide accessibility to publicly generated or collected data, and propel the meaningful reusability of smart city data. For example, *Open Data SITG, Open Data Platform, or Géoportail Information Systems* are digital platform services aiming to coordinate, centralize, widely disseminate, and provide access to data relating to specific territories. While employing data platforms is one way of creating and delivering a BM's value, open-source platforms (e.g., *QWAT*) enable access to open-source water management software. Other services (e.g., *Könzi App, Gemeinde App, City App*) focus on app-based information sharing. Although many of these BMs are operated by municipalities or cantonal authorities, this BM configuration is characterized by ambivalent value creation. One case in point is the privately initiated, developed, and operated *Crowd Management App*. This type of BM requires no active citizen engagement, but initial public financing is crucial.

From a value capture perspective, end users do not pay for such services. Considering direct revenue opportunities, Duval and Brasse (2014), however, found that open data platform operators could ensure economic viability. The authors propose either a subscription model that enables access to elaborated metadata or third-party revenue via advertising. Indirect economic prosperity might emerge from realizing the innovation potential of taking advantage of publicly available big data. In particular, machine learning, as an advanced digital technology, promises efficient open-app developments (Hurbean et al., 2021). Therefore, we classify this configuration as a business-to-anyone (B2X) or public-to-anyone (P2X) BM, focusing on platform services to advance

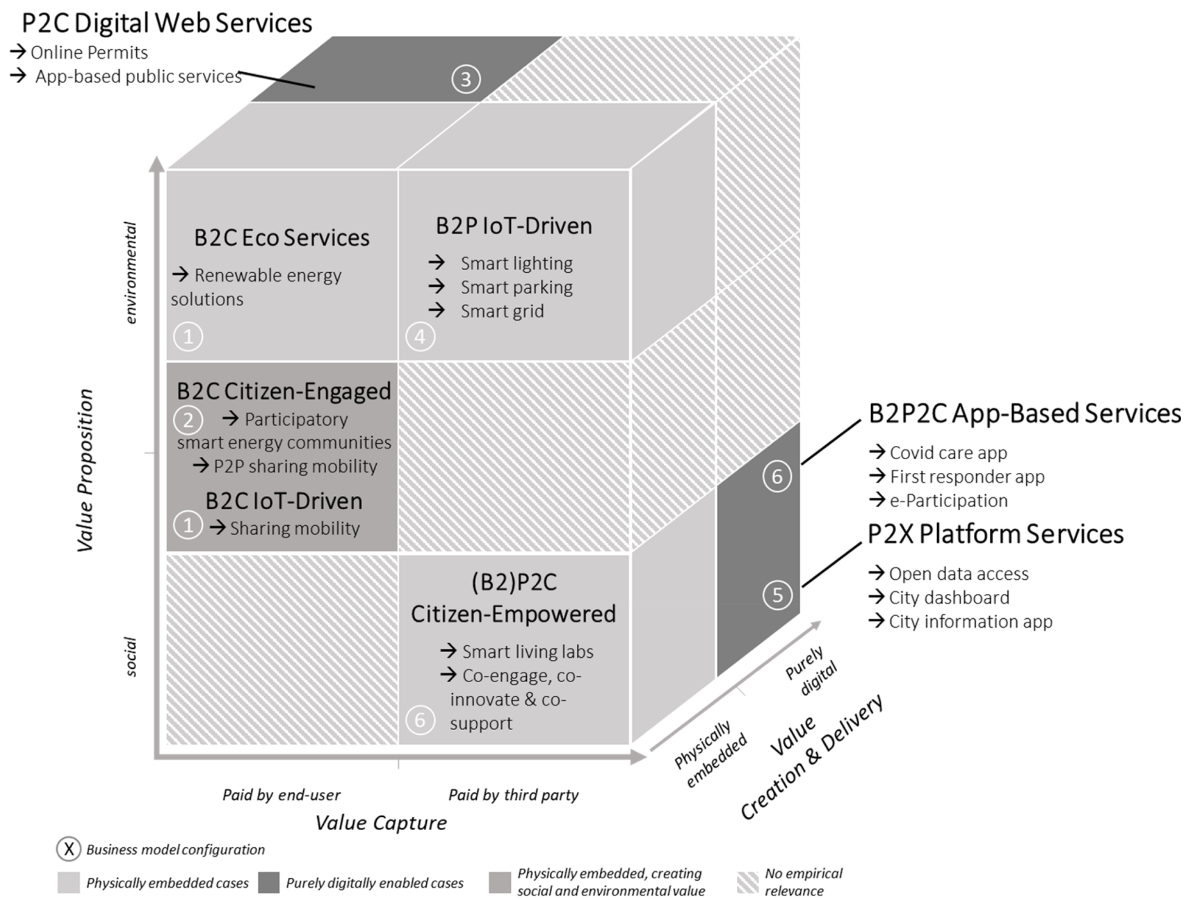

Fig. 1. Framework of BM types for digital sustainability.

social sustainability.

4.2.3. Business model solution 6: Citizen-engaged social sustainability BMs

Solution 6 consists of two core conditions: Social Emphasis (present) and Environmental Emphasis (absent). It is complemented by three peripheral conditions: Citizen Involvement (present), as well as Value Creation led by Private and Initial Financing by Private (both absent). Value Delivery remains irrelevant for this configuration. This constellation of conditions describes BMs that concentrate on *social services* by *actively engaging citizens*. Like BM configuration 2, citizen involvement is crucial to this type of BM.

From a value proposition perspective, this BM offers social services that positively impact (e.g., healthcare) or actively empower citizens to shape and co-create future living. For example, *CovidCareApp, First Responder App, or SmartXme* provide digitally enabled smartphone services with the vision of enhancing social well-being. On the other hand, participatory activities (e.g., *e-mitwirkung* or *Budget Participatif*) strengthen the vision of more "citizen-centric" smart cities (Cardullo & Kitchin, 2019).

From a value creation and delivery perspective, the latter BMs exclusively employ digital citizen participation by deploying ICT (Bouzguenda et al., 2019). However, since value delivery is an irrelevant condition for this BM configuration, it also includes such BMs that offer physically embedded services (e.g., *Lugano Living Lab, Engage Winterthur, Open Geneva, Quartiers solidaires*). These BMs rely on engaging with various citizen groups and focus on various physical activities (e.g., co-designing, co-creating, co-innovating, co-supporting). In these cases, ICT is utilized primarily as a communication tool to raise awareness and attract more citizens. These BMs are primarily led and orchestrated by public partners to gain citizen legitimacy for future project initiatives or to offset the lack of social services on the market side by actively initiating such ventures. However, similar to BM configuration 4, we see that private companies often provide support in developing and implementing these services. This BM configuration also relies on initial funding by public partners.

From a value capturing perspective, this BM configuration does not profit from end-user payments. One reason is that end users are often the citizen-engaged people as part of BM's value creation. Therefore, public partners act as a driving force and often as a target group for private companies to establish socially sustainable services. However, public investment can pay off. First, instigating vibrant ecosystem building can advance future innovation development. Second, app-based services generate additional data that may serve for various purposes. Thus, we classify this last configuration as a public-to-customer (P2C) BM, focusing on citizen-empowered and business-to-public-to-customer (B2P2C) app-based social value generation.

5. Discussion and Conclusion

Many actors from science, industry, governments, and society have started to envision a socially and environmentally more sustainable world. With the overwhelming majority of economic, social, and environmental activity occurring in cities, the UN's SDG 11 ("Sustainable Cities and Communities") in particular calls for urgent action (UN, 2020). Despite their common desire for an environmentally friendly and socially just future, factual and opportunity costs of taking action deter many stakeholders from fully embracing SDG 11 and other sustainable development goals. From a commercial enterprise perspective, transforming conventional, economically self-sufficient BMs requires incentives or a suitable appropriation model (George et al., 2021). From a public administration perspective, notoriously tight budgets limit the capacity to act (Blanck & Ribeiro, 2021).

Digital technologies are now widely being adopted by organizations to increase the effectiveness and efficiency of many business and administrative processes – for example, in the form of automation, big data analysis, or to leverage highly scalable digitally enabled services (Di Vaio et al., 2020; George et al., 2021; Ludbrook et al., 2019). The "smart city" concept, among others, illustrates that digital technologies can increase efficiency and effectiveness in not only economic but also in social and environmental terms. According to this concept, a "smart city" is defined as a city that "systematically applies digital technologies to reduce resource input, improve its people's quality of life, and increase the competitiveness of the regional economy in a sustainable manner" (Gassmann et al., 2019, p. 25). In line with this concept, recently emerging research on "digital sustainability" aims to unify digitalization and sustainability. Adopting a BM perspective on digital sustainability, we develop a framework of digitally enabled BMs. It reveals in which BM configurations end users pay for sustainable goods and services. By applying qualitative comparative analysis (QCA) and a configurational BM perspective to 130 smart city initiatives, we uncover six empirically relevant BM configurations concerned with digitalization and sustainability. Our study makes important contributions to the academic literature and carries several significant implications for management and administration practice.

5.1. Theoretical implications

First, we advance research on digital sustainability by outlining twelve possible BM types that deploy digital technologies to advance sustainability. The framework in Fig. 1 demonstrates the interplay of social, environmental, and economic sustainability on the one hand, and digitalization on the other by building on four differentiating variables: (i) whether the value proposition focuses on social improvements or not; (ii) whether the value proposition focuses on environmental improvements or not; (iii) whether it is paid by the end user or not; and iv) whether the service delivery occurs purely digitally or is physically embedded. The six BM types in the front row of the cube comprise services that are physically embedded, whereas the six BM types in the back row feature purely digital services. While the upper and lower rows indicate services focusing either on social or on environmental enhancements, the middle row covers services that contribute to social *and* environmental sustainability at the same time. This case is demonstrated, for instance, through citizen-engaged BMs in configuration 1 or IoT-driven BMs in configuration 2. Notably, the cases in our empirical analysis represent only six of the 12 theoretically possible BM types. The other six possibilities show no empirical relevance based on variables of our configurational model. Sustainability scholars and practitioners consistently emphasize the importance of identifying suitable BMs for a successful transition toward greater sustainability (e.g., Geissdoerfer, Vladimirova et al., 2018; MacArthur, 2013; Ranta et al., 2018). Similarly, digitalization scholars and practitioners note that "digital technologies spawn new pathways for creating and delivering value [..., may] make existing business models obsolete and uncompetitive [...,] and hence call for new or adapted business models" (Palmié et al., 2022, p. 2). Reflecting this consensus among its two foundational streams, the scholars in the emerging literature on digital sustainability have repeatedly called for more research on BMs that allow public and private organizations to create social and environmental value alongside economic sustainability by deploying digital technologies (Cricelli & Strazzullo, 2021; George et al., 2021; Guandalini, 2022). Our study responds to these calls.

Second, we identified various significant characteristics with respect to the individual BM configurations that lead to end-user payments versus third-party payments. For example, we find that ***company-operated BMs (B2C***) tend to capture value by their end users when their service offering is environmentally and socially or exclusively environmentally beneficial and when it is embedded in physical infrastructure. On the contrary, ***municipality-operated BMs (P2C***) capture value from end users when they offer environmental services that are purely digital. This finding assuages the concern that public and private organizations may be competing with each other to exploit their potential (Merrill et al., 2019). Looking at the BM configurations that do not capture value from the end user, we reveal BM configurations that are either ***municipality operated (P2C)*** or municipality driven or initiated, but still implemented by private partners, such as in ***business-to-public(B2P)*** or ***business-to-public-to-customer (B2P2C)*** BMs.

Third, we contribute to the microfoundations literature by studying the microfoundations of BMs. Even though the microfoundations movement in strategy and organization theory has been growing for the last 10 to 15 years (Felin et al., 2015; Palmié, Rüegger, & Parida, 2023), the microfoundations of BMs have received rather little attention so far. Whenever the existing literature has studied the microfoundations of BMs, it has focused on capabilities and actions of "organizational insiders", such as founders, executives, managers, and employees (De Silva et al., 2021; Ferraris et al., 2022; Helfat & Peteraf, 2015; Loon et al., 2020; Ringvold et al., 2022; Santa-Maria et al., 2022). By noting that the microfoundations represented by these organizational "insiders" include their relations and interactions with organizational "outsiders" (e.g., Ferraris et al., 2022; Santa-Maria et al., 2022), some of the studies examining the microfoundations of BMs looked beyond the boundaries of the firm. We complement and extend these studies by treating actions and decisions of organizational "outsiders" (i.e., customers) as microfoundations in and of themselves. Turning the attention to customers is important as the predominant focus on "organizational insiders" has favored the emergence of knowledge on the microfoundations of value creation at the expense of knowledge on the microfoundations of value capture, causing imbalances in our knowledge about the microfoundations of BMs.

Fourth, we specifically add to the even scarcer and very recent research on the microfoundations of sustainable BMs (De Silva et al., 2021; Ringvold et al., 2022; Santa-Maria et al., 2022). With the notable exception of the study by Ringvold et al. (2022) of a BM-delivering digital health service, digital technologies did not play a major role in most of the cases covered in this emerging literature. Our investigation of smart-city BMs complements these initial efforts by studying sustainable BMs that are digitally enabled, responding to the recent interest in "digital sustainability" (George et al., 2021).

5.2. Practical implications

Besides our theoretical contributions, which highlight the interplay of the three sustainability pillars and the degree of digital value delivery (cf. Fig. 1), our study carries practical implications of interest to companies, municipalities, and governments.

Our research has two main implications for private enterprise. First, the private sector needs to understand that "no value capturing from end users" does not equal "no market potential." Our findings demonstrate that public partners are willing to assume responsibility for making public space and life more ecologically and socially sustainable. Therefore, two types of BM emerge from our research for private enterprise: business-to-customer BMs are illustrated by configurations 1 and 2, business-to-public BMs by configurations 4 and partly by 6. Second, most privately operated BMs utilize physically embedded digital technologies (as empirically supported by BM 1 and BM 2) to create exclusively pro-environmental or simultaneously pro-social and pro-environmental services. Examples include making vehicles or streetlights smarter (Brock et al., 2019; Ma et al., 2018). As private organizations rather tend to focus on exclusively pro-environmental services or on simultaneously pro-social and pro-environmental services, there are other smart-city services that might possess hitherto untapped market potential. For instance, while public organizations already capture value from end users through purely digital, pro-environmental services (BM 3), their market potential might also be exploited by private organizations. For some kinds of service (e.g., purely digital, exclusively pro-

Table 3
Truth Table with "Paid by Customer" as Present Outcome (only listed when empirical evidence present).

V1_soc	V2_env	V3_VDelivery	V4_VCreation	V5_Citizen	V6_Finance	no. of cases	raw/PRI/*SYM* consist.
0	1	0	0	0	0	21	0.14
1	0	1	0	0	0	16	0.06
0	1	1	0	0	0	13	1
1	0	0	0	1	0	11	0
1	0	1	0	1	0	10	0
1	1	0	1	0	1	8	1
0	1	0	1	0	0	8	0.75
0	0	1	0	0	0	8	0.25
1	1	0	0	0	0	6	0
0	0	0	0	0	0	5	0.4
1	1	0	1	1	1	4	1
1	0	1	1	0	0	4	0
1	1	0	1	0	0	3	1
0	1	0	1	0	1	2	1
0	0	0	1	0	0	1	1
1	0	1	0	0	1	1	1
0	0	0	1	0	1	1	1
0	0	1	1	0	1	1	1
1	0	0	1	1	1	1	1
1	0	0	0	0	0	1	0
1	1	1	0	0	0	1	0
1	1	0	1	0	0	1	0
0	1	1	1	0	0	1	0
0	0	1	0	1	0	1	0
0	1	1	1	1	0	1	0

environmental, or simultaneously pro-social and pro-environmental services), we do not observe any actor who is producing and capturing value from them. In Fig. 1, these are situated in the upper right corner in the back (environmental, purely digital, paid by third party) or in the middle row on the right in the front or back (social and environmental, physically embedded or purely digital, paid by third party).

Moreover, our research provides valuable insights for municipalities and governments. Primarily, our findings corroborate the challenge that companies face when they seek to capture value from end users in creating social value. In Fig. 1, this refers to the lower left corner in the front and back (the latter is not visible in the illustration). While these BM types are theoretically conceivable, we do not see empirical manifestations of them. In other words, based on our analyses, there are neither purely social services that end users pay for, nor social services that are physically embedded that end users pay for. This, however, does not imply that public organizations must generate social value all by themselves. For example, private companies often develop and implement app-based services as in BM configuration 6. Still, policy makers and municipalities need to be aware of their roles as initiators, orchestrators, and often investors aiming to create more socially sustainable cities. Alternatively, novel and specifically targeted incentivization schemes could promote greater value creation in specific business application fields.

5.3. Limitations and future research

As with all research, our study has limitations. Focusing on smart cities, we have derived BMs from smart city initiatives. Regardless of their connection to smart cities, many other initiatives, projects, and services contribute to making cities smarter, to more sustainable living or, ideally, to both. Moreover, our study is limited to Switzerland and offers no insights into how digitalization and sustainability are evolving in other countries. According to Kitchin (2015), diverse histories, cultures, and political economies can differently impact urban development.

Further research could pursue two potential directions. First, we encourage scholars to follow the previous work of Sandulli et al. (2017) by applying a multi-case perspective on smart city developments. More in-depth case knowledge for each of the twelve theoretically BM types outlined in our framework would enable investigating the within-case and cross-case specificities either driving or impeding actors from taking sustainability actions as they deploy digital technologies. These insights could be of particular interest to policy makers – for instance, to improve and align incentive schemes and funding programs. Second, in order to refine our value-capture dimension and, thus, the economic pillar of sustainability, future research might explore BMs not paid by end users. While we have included initial financing as a relevant condition for implementing digitally enabled BMs able to create sustainability, scholars could explore the underlying financing and revenue mechanisms required to ensure the prolonged existence of such BMs and the scaling of smart solutions (Palmié, Parida, Mader & Wincent, 2023). Our research is merely a first step toward a better understanding of how digitally enabled BMs create sustainable value in the context of smart cities. We hope that our research stimulates much more work along these lines.

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CRediT authorship contribution statement

Barbara Bencsik: Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing. **Maximilian Palmié:** Supervision, Conceptualization, Funding acquisition, Writing - original draft, Writing - review & editing. **Vinit Parida:** Conceptualization, Writing - review & editing. **Joakim Wincent:** Conceptualization, Writing - review & editing. **Oliver Gassmann:** Supervision, Conceptualization.

Declaration of Competing Interest

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.

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Appendix

Table 3.

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