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The Smart City Business Model Canvas—A Smart City Business Modeling Framework and Practical Tool

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Abstract: Cities are challenged with increasing population growth and need to implement smart solutions to become more resilient to economic, environmental, and social challenges posed by ongoing urbanization. This study reviewed business model development frameworks and developed a practical tool to help cities assess business models by adapting components of the Business Model Canvas (BMC) and adding new ones that operationalize the smart city dimensions. The Smart City BMC (SC-BMC) proposed provides a practical framework that supports developing and communicating a more holistic and integrated view of a smart city business model. It also supports creatively innovating toward more sustainable value creation. As a framework, the SC-BMC bridges sustainable value creation for business model development and smart city innovation.

Keywords: smart cities business models; sustainable business models; business model innovation

1. Introduction

Today, 55% of the world's population lives in urban areas, and this proportion is expected to increase to 68% by 2050. The United Nations Projections show that urbanization, "the gradual shift in the residence of the human population from rural to urban areas", combined with the overall growth of the world's population in urban areas (from 751 million in 1950 to 4.2 billion in 2018) could add another 2.5 billion people living in urban areas by 2050 [1]. In response to the above trends, cities are confronted with the challenge to provide citizen-focused, high-quality services enabled by innovative information and communication technologies (ICT) and the Internet of Things (IoT). Cities face the challenge of facilitating increased economic opportunities encouraged by the population increase while improving quality of life by reducing the city's environmental footprint, increasing public sector productivity, improving safety and smart mobility, increasing energy efficiency, improving air quality, security, etc., which each require a combination of public and private sector investments. However, smart city investment cases differ from regular private business development and public sector management. As both costs and benefits, as well as uncertainties and risks, emerge and end up with different parties, which are not always and automatically involved in the decision-making process, city leaders must develop a clear smart city investment agenda and creatively design the business models to share costs, benefits, and risks among public, cooperative, and market actors. In navigating this complexity and

to help such visionary city leaders mobilize and communicate with their constituency and the many stakeholders involved, we proposed that they map their proposed investment projects onto a business model canvas that is adapted to their purpose. In this paper, we developed such an adapted canvas that can be used for deriving business models for smart cities solutions.

Currently, many smart city solutions center around novel technologies that include low-cost, long-battery life IoT sensors that gather data at a consumer, corporate, or industrial level [2]. Making a city smart does not always involve integrating all new infrastructure, but instead involves enhancing the technology already installed with big data gathered and data analytics from connected devices and sensors that support smart city applications. The success of smart city projects and applications, however, is very much based on citizens' adoption and usage, supporting decision-making and incentivizing behavioral change [3]. Hence, citizens and residents are a focal point for the design of smart city solutions: They are going to be the end users, and solutions need to have a clear benefit in their everyday lives. Strategies that engage multiple stakeholders, including the end users, in collaborating to co-create mutual and shared benefits are now increasingly applied in developing novel smart city solutions [4,5]. Co-creation is democratizing the development of new solutions for smart cities, as the end users are engaged from the very beginning of the problem identification and design specifications.

Smart city projects are supported by governments who set up the key enablers in terms of providing the necessary infrastructure, incentives, and procurement methods for novel technologies, e.g., the 5G network for realizing smart applications that make use of real-time data, tax incentives for solar roof installations, or a data platform for real-time parking data. The transition process to a smart city requires the reformulation of urban structures, strategies, policies, ecosystems, and technologies and calls for novel business models. These should encompass the complexity of the urban system and continuously operate on its potential [6] in better addressing the social, economic, and environmental changes resulting from the population density increase.

Comprehensive knowledge on designing business models for smart cities is therefore essential to systematically assess the most relevant aspects of investment propositions stimulating and fostering communication and engagement of relevant stakeholders who could potentially liaise the replication and large-scale roll-out of smart cities solutions. The literature provides us with several well-elaborated and verified frameworks for characterizing business models, design methods, and tools to develop, evaluate [7], and enhance a business model [8]. Although studies revealed different types of smart cities business models, these models have limited transferability [9]. This limited transferability is because a successful business model built on specific context conditions may not fit the economic, environmental, technological, and social context conditions of different cities [10]. Neglecting such differences could limit the spread of successful business models and consequently have a negative impact on the sustainable roll-out of urban smartification.

There are limited studies that provide satisfactory answers to the following question: What components should a smart city business model canvas cover to be applicable in different cities? To attempt to provide an answer to this question, to the extent that this is feasible in an integrated way, consolidating the various and most of the times complex and interreacting features of smart cities, this study considered the smart city value modeling. Additional elements to the Business Model Canvas (BMC) were considered that bring into focus the complex nonmonetary costs, benefits, and risks that are essential for any SC venture and help ventures and the public sector managers communicate these effectively to stakeholders as a new contribution to the development of business model theory. Conceptualizing the framework of a Smart City Business Model Canvas in a generic format to be applicable to the various smart city domains, i.e., energy efficiency in buildings (residential and nonresidential) and energy systems integration (electricity, heating, cooling), mobility and transport, ICT, security, and health [11], this study provided a review on business model frameworks and conceptualized a framework to support practitioners in the transition process toward facilitating smart solutions replication and roll-out. The proposed framework built on the BMC and studied adaptations

of the BMC found in literature, such as the BMC adapted for mission driven organizations [12], the BMC adapted for encompassing aspects of environmental sustainability and social inclusiveness [13], and the BMC adapted for the European Project, "Replicate", aiming to enhance the transition process to a smart city in three EU cities [14]. It also reviewed smart city trends and business model frameworks designed to encompass co-creation aspects and network centric approaches. It provided an elaborated framework with components adapted to the BMC addressing the needs and trends for realizing smart city projects. The proposed Smart City Business Model Canvas framework helps actors in the smart city ecosystem articulate how they aim to co-create, deliver, and capture the value of smart city services that are economically viable, environmentally sustainable, and socially inclusive. The initiator of a SC-BMC analysis can be the city itself, as well as private and public actors involved in the ecosystem, and especially those actors that promote smart city solutions should participate in the process of developing the SC-BMC. The remainder of this paper first presents the smart city trends that are relevant to Business Model development in Section 2. Section 3 presents our synthesized Smart City Business Model Canvas.

2. Smart City Development and the Business Model Canvas

In order to answer the question of how business modeling can be applied to smart cities, we focused on the universally applicable components needed to develop a smart city business model. A narrative, conceptual review of business model frameworks was performed. Then, new business modeling components were proposed for integration in the framework of existing BMCs informed by trends and specificities of smart city solutions. The process was divided into three steps: (1) Identification of the state of the art on business model frameworks that may be a useful starting point for smart cities, (2) categorization of the body of literature according to the components of business model structure and smart cities principles, and (3) synthesis and development of the framework for a smart city value creation canvas for business modeling. This section will develop the steps presented in Figure 1 below.

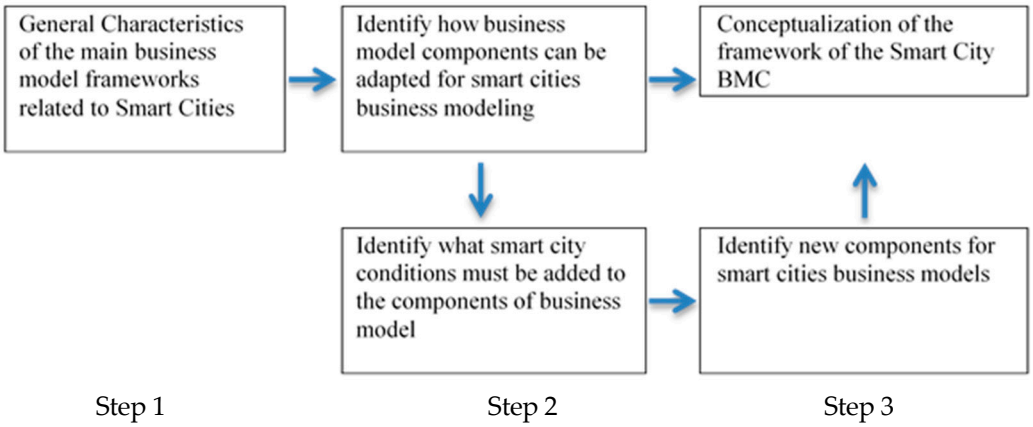

Figure 1. Developing a framework for the Smart Cities' Business Model Canvas.

The first step requires scanning the literature on smart city trends and conceptual frameworks to categorize smart cities business models. This literature review was conducted by accessing detailed scientific databases (e.g., Science Direct, Scopus, Google Scholar, etc.). First, a generic search was performed with the application of (combinations of) keywords, i.e., "smart cities" AND "trends", "smart cities" AND "business model", "sustainable business model", AND "smart cities", and so forth. The most relevant papers were selected according to their title and their abstracts were assessed to examine whether they fell within the scope of the study. Already available reviews on similar areas of expertise were then identified to extract available information. The papers that passed this initial

filtering process were further reviewed (full paper review) and are summarized below under Smart City Trends and Business Model Canvases.

Smart City Trends

Multiple definitions exist for smart cities [15]. For the purposes of this study, we adopted the UK Department for Business, Innovation and Skills' (BIS) definition of smart cities, arguing that smart cities are more of a process, rather than a static outcome, in which increased citizen engagement, hard infrastructure, social capital, and digital technologies make cities more livable, resilient, and better able to respond to challenges [16]. In these terms, making a city smart enables the people who live and work there to be served better. The literature furthermore suggests that smart cities are moving to a next stage—the so-called "Smart City 2.0"—in which infrastructure and technologies are no longer the main focus of development [17].

The new generation of smart cities taps into the wisdom of their citizens, visitors, and businesses in an interconnected ecosystem built on a sensor rich physical infrastructure and genuine and inclusive engagement activities. The focus in smart city development has shifted to: (1) The people, providing benefits for improving quality of life for residents and visitors; (2) the provision of conditions for economic competitiveness to attract investors, industry, and talent; and (3) the provision of environmental and social consciousness with a focus on sustainability. Below, we elaborate on these three pillars to develop a smart city business model framework.

Many studies provided a definition for the Business Model (BM) [18,19]. A common definition of BM is "how a business creates, delivers and captures value to customers" [20]. In this study, we defined business models for smart cities as "creating, delivering and capturing value derived from co-creation impacting the economic, environmental and social potentials of smart cities in establishing competitive advantages", adapted from the definition of Silva et al. [21].

The literature shows that firms bring novel technologies for smart cities to the market, applying new business models for smart urban solutions in the domains of security, healthcare, mobility, energy, water, waste, engagement, and community. For instance, Ahlgren et al. [22] examined customer-side business models offering photovoltaic energy to residential customers. Karakaya E. [23] explored the link between the business models of suppliers of PV systems and their diffusion at the micro- and mesolevels. In the diffusion process, firms act as change agents at microlevel, while forming the necessary market structure at mesolevel. Overholm [24] explored third-party ownership business models for residential solar panels, while Strupeit and Palm [25] showed that novel business models in Germany, Japan, and the United States enable and catalyze the deployment of customer-sited PV systems. McKinsey presented examples of business models in mobility and social connectedness [26]. Pramanik et al. [27] proposed a big data-enabled smart healthcare system framework that offers theoretical representations of an intra- and interorganizational business model in the healthcare context. Schiavone et al. [28] investigated how a metropolitan city must organize and reconfigure the building blocks of its business models to become a smart city.

In all these cases, business models have been developed in different markets depending on the local context. Effective solutions are a combination of different technologies, which are adapted to the needs of the city and are affected by factors such as costs, financing considerations, return on investment, adoption and retention rates of users and stakeholders, and social, environmental, economic, and climatic conditions of the city. This implies that copying solutions to different context conditions will not necessarily produce the same results in other cities. Firms must adapt their business model to local circumstances and cities, therefore, need to articulate the needs across sectors, design solutions that address the specific potential end users, and provide the right incentives to each stakeholder involved. The realization of smart city solutions is then dependent on how the business case will finally be built. In the literature, however, there is a lack of a business model framework to determine clear paths to steady revenues for smart city projects encompassing the specific characteristics of each city. Such a framework is necessary to build business cases that can consider the specific conditions of each city

and its unique capabilities in terms of available resources and applicability of technologies. We now conclude our first step in the process. The literature provided us with a range of useful starting points for the development of smart city business models. These business model frameworks all differ in their details, but share a common core on which we built our own smart city extensions.

The second step identifies how the idea of smart cities and their requirements can be applied to the existing components of business modeling, i.e., key activities, value proposition, customer segments, customer relationships, cost structure, and revenue structure. A widely used framework for structuring business models is the business model canvas (BMC) developed by Osterwalder and Pigneur [19]. Here, we proposed using the BMC as the basis for developing a smart city-specific business modeling framework by adding components related to smart cities. The BMC was chosen due to its strong academic foundation, ease of practical application, ease of presentation of complex components, and broad recognition. The BMC is a framework composed of nine building blocks, each analyzing components of the process of creating, delivering, and capturing value (see Figure 2):

- Customer Segments: For whom is the organization creating value? What products and services are the organization offering to each customer segment?
- Value Proposition: What value is the organization delivering to its customers? Which customer pain-points are the organization addressing?
- Channels: Which channels are the organization using to reach the desired customer segments? How are those channels integrated? Which ones are the most cost-effective?
- Customer Relationships: What type of relationship does the organization maintain with each customer segment? What are the expectations of the customers? How does the organization establish those relationships?
- Revenue Streams: How does the organization make money? Who are the customers willing to pay and for what benefit? How do they prefer to pay? How are they currently paying? How does each stream add up to the total revenue, i.e., asset sale, subscription fees, leasing, licensing, advertising, etc.?
- Key Activities: What are the key activities the organization's value proposition require?
- Key Resources: What key resources does the organization's value proposition require?
- Key Partners: The organization's key partners and suppliers. Which key resources do the organization acquires from them? Which key activities does the organization's partners perform?
- Cost Structure: What are the most important cost drivers in the organization's business model? Which key resources and activities are most expensive?

This structure of the BMC allows organizations to develop innovative business models by redesigning the contents of any one of its nine blocks to uncover new business opportunities and turn customers' needs into profitable activities.

The BMC construct was adapted by Blank [12] to address the needs of business modeling in mission-driven organizations, including nonprofit organizations. In this respect, components of the BMC were adapted to better reflect and suit the scope and purpose of mission-driven organizations. In the standard BMC, the focus is on appropriation of the value created, and this appropriated value should exceed the cost of delivering it to the customers. In mission-driven organizations such as nonprofits and governmental agencies, however, the aim is not to maximize, or even make a profit, but to mobilize resources and minimize the budget needed to solve a problem. More often than not, such organizations create value for stakeholders, i.e., citizens, or other support organizations that they cannot—or can only very partially—appropriate. To address this, Blank relabeled the terms customer segments, cost structure, channels, customer relationships, and revenue streams, as presented in Table 1.

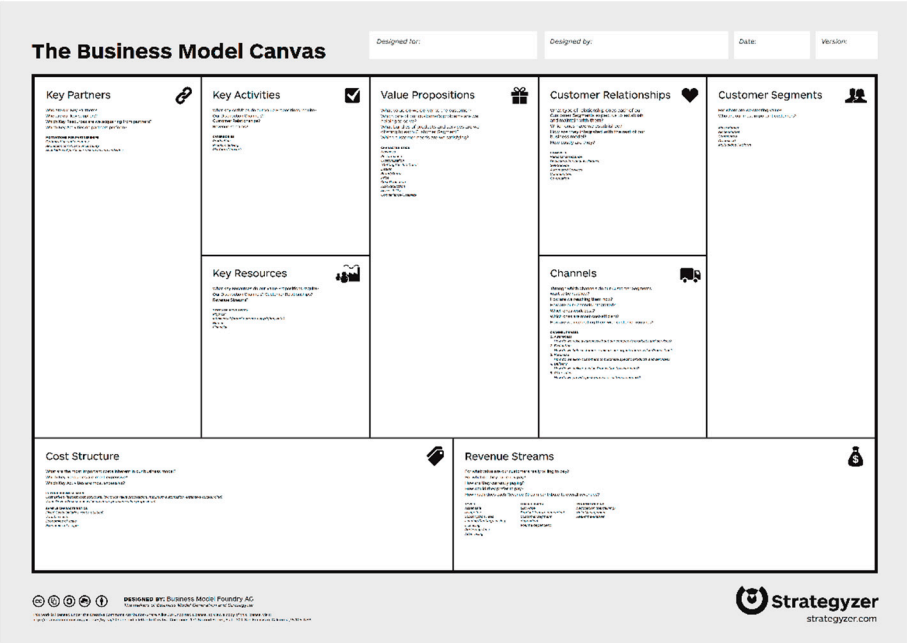

Figure 2. The Business Model Canvas. Source: Osterwalder and Pigneur [19].

Table 1. BMC Adapted for Mission Driven Organizations.

BMC	Mission Driven BMC
Customer Segments	Beneficiaries *Mission Driven* organizations create value for citizens or other support organizations not with the aim to earn money
Cost Structure	Mission Cost/Budget *Mission Driven organizations have budgets instead of revenues that match their cost structure*
Channels	Deployment *Mission Driven organizations ask how to deploy a pilot into a scalable solution with number of users, units in the field*
Customer Relationships	Buy–in Support *Mission Driven organizations need "buy-in" organizations such as legal, policy, procurement to support projects*
Revenue Streams	Mission Achievement (Other than generating profits) *Mission Driven organizations have a mission that needs to be fulfilled other than generating profits instead of generating profits*

However, the mission-oriented organization BMC does not capture an important smart city aspect, namely the value that can be created and captured by the network character of integrated solutions as, for instance, the installation of PV panels in households of a community generating electricity for self-consumption but also coupled with a demand response, ICT-enabled program for trading excess energy behind the meter providing electricity to vulnerable populations in the city at lower prices. This integrated solution involves technologies and services from more than one actor and the participation of citizens organized in communities, as well as the city, to facilitate the solution.

Joyce & Piquing [13] adapted the standard BMC to encompass the notions of environmental sustainability and social inclusiveness in addition to the economic viability aspect that it was originally designed for. In their approach, the environmental layer was based on a lifecycle analysis that measures a product or a service's environmental impact over all stages of its life. Similarly, the social layer built upon the value created for a group of stakeholders and includes a social life cycle assessment. In the smart city context, actors are engaged in activities to improve urban infrastructure and services, aiming at a better environment, social, and economic conditions, improving the attractiveness

and competitiveness of cities [29–31]. As such, environmental and social impacts and benefits are components that also characterize smart city projects, and these should therefore be included when developing business models for smart cities. Therefore, regarding the environmental and social aspects in smart city business models, we proposed linking them to specific Key Performance Indicators (KPIs).

Angelakoglou et al. [32] provided a framework for the selection of KPIs to evaluate smart city solutions, including a repository of seven environmental and seventeen social KPIs with the corresponding levels of assessment, stakeholder's group of interest, and suggested threshold/targets to reach sustainable performance. Indicative examples of environmental KPIs include carbon dioxide emission reduction, increase in local renewable energy generation, reduction in annual final energy consumption, and decreased emission of particulate matter. Respectively, examples of social KPIs include consumer's engagement, social compatibility, ease of use for end users per solution, local job creation, and increased citizen awareness. To ensure a uniform monitoring of the urban smartification throughout Europe, these KPIs were mainly extracted from the Smart Cities Information System (SCIS) [33] and CITYkeys [34] platforms, promoting the cooperation and exchanging of know-how among smart city projects.

In a smart city context, value creation is shifted from products and technologies themselves to the services provided to users. Therefore, a service-dominant business model is prominent in the business modeling design and the value creation logic [35]. In a service-dominated approach, values shift to the provision of services instead of the development of goods and have a relational, rather than a transactional, exchange. The standard BMC maps out how a firm generates, delivers, and appropriates value for, to, and from consumers. Meanwhile, in a smart city context, value is generated in a network of multiple actors belonging to academia, industry, government, public, and the social impact investment sector known as the Quintuple Helix Model [36]. Together, these actors form the smart city ecosystem. In the case of smart cities, business modeling therefore demands a network-centric value proposition which includes all actors in the ecosystem as value co-creators [35,37]. In the network-centric approach, a network of actors creates an integrated solution, where the user's value in the products or the services produced is validated only if the customers adopt the solutions [38]. We therefore used the network-centric value proposition and a service-oriented business model canvas to describe the value created by the network for each actor separately in a smart city context.

Moreover, in smart city context, citizen and user engagement are fundamental to successful value creation. Co-creation is an effective way to ensure such engagement from the early design stages onward. Co-creation is distinguished from other participation initiatives, as actors are involved at the very beginning of the decision-making process, starting with the identification of the problem, and are empowered in developing policy, programs, and improving services [38]. In the private sector, co-creation is used to invite ideas from customers on the features of products and services that a company wants to create and bring to market. By capitalizing on their customers, feedback companies maximize customer value. Public and nongovernmental organizations are also increasingly recognizing co-creation as an effective tool, especially in the smart city ecosystem, to co-create value and deliver integrated solutions [39]. Actors in the smart city ecosystem therefore need to collaborate as a partnership to co-create value [40]. Such collaboration is often initiated or catalyzed by the city and can involve regulating, convening key actors, offering subsidies, or partly financing.

Nenonen and Storbacka [41] proposed a business model construct that facilitates and captures which kind of resources each actor in the value network can offer and describes the interface through which actors interact to co-create value. Nenonen and Storbacka focused on which design principles, resources, and capabilities of the network actors are explicitly described for an in-depth understanding of how actors are likely to be involved in the co-creation process. In this paper, we adopted the 'offering' component of the Nenonen and Storbacka framework, referring to what each actor contributes in the co-creation process and how this offering can vary and complement the offerings of other actors in the smart city network devising smart solutions. Offerings include resources, such as technology, intellectual property rights, or capabilities like R&D or the development of products and

services. We also adopted the operations component, which refers to the management of recourses, i.e., infrastructure, suppliers, and partners, and to the capabilities of sourcing, production, and delivery of processes for co-creating value. Offerings and its configurations, along with operations, address the interface where actors in the smart city ecosystem orchestrate recourses and capabilities defining how value is co-created. Offerings can be orchestrated by the city and utilized in refining operations by the venture offering the smart solution.

A final fundamental enabler in smart city conceptualization and development is the ICT infrastructure and the IoT. IoT allows for integration of different urban systems through sensors and devices that are connected, while open access to such data on platforms simultaneously facilitates citizen engagement. In smart cities, some of the most widespread ICT solutions are energy management systems, traffic control systems, smart grids, urban data platforms, mobile applications, etc. The data produced by the connected infrastructure and the data that is now produced on how citizens interact with this infrastructure in smart cities is growing exponentially, and the value of this information remains underutilized. The volume of data generated in smart cities can be used to promote and foster new business ideas and ongoing innovation that can consequently contribute to increasing the quality of life for the citizens while creating sustainable business opportunities for entrepreneurs [42]. We therefore considered the exploitation of data generated by the IoT and available on the ICT infrastructure supporting smart cities as an important element in the smart city business model canvas. As smart, data-based value propositions can generate complementary benefits and attract private investment, smart city business models should address the ownership of data and legal issues for data privacy in the design phase of the solutions deployed. An extra component was thus proposed to complement the value proposition in the SC-BMC, where the value of the data generated offers a multiplier effect in creating new business opportunities and increasing quality of life.

In our third step, we synthesized what was proposed in the previous paragraphs as important elements in the business models related to smart city solutions. Our next section presents how the business model components can be adapted to the smart city principles for creating value. Below, we propose the Smart City Business Model Canvas (SC-BMC) as a framework to support creative development, visualization, and communication of sustainable smart city business model innovations. The SC-BMC builds on Osterwalder & Pigneur's [19] original business model canvas, borrows from the BMC for mission-driven organizations [12] and from the 'Triple Bottom Line' BMC [13], and incorporates importance of using a network centric approach where the quintuple helix actors co-create value and utilize data that adds value to the network of actors and other stakeholders such as new ventures.

3. Conceptualizing the Framework of the Smart Cities Value Canvas

The conducted study revealed additional components for carrying out the business modeling process in the smart city context and presents the Smart City Business Model Canvas (SC-BMC) framework. This section describes the novelties and additions of components to the BMC to suit the smart city needs. The new components proposed for the SC-BMC are marked with an asterisk (*), while the adaptation of the BMC components in the smart city context are discussed. The SC-BMC was designed to suit both public and private actors conducting the activity of business modeling in an iterative way, and can be used to reveal creation, delivery, and capture of value for all engaged actors in the ecosystem. This study emphasized that it is the network of actors—and not the city or one venture alone—that creates, delivers, and captures value. In that sense, while the BMC was aimed at helping individual firms to fit their BM to circumstances, customers, and markets, the SC-BMC was shifted to assist a group of actors aiming to deliver value to a more diverse set of end users in a collaborative effort. Mapping out this network early on should precede the entire SC-BMC canvassing exercise. The SC-BMC building blocks presented in Figure 3 are: 1. Network Beneficiaries, 2. Value Proposition, 3. Data*, 4. Deployment Channels, 5. Actor Relationships, 6. Revenue Streams, 7. Key Resources and Infrastructure, 8. Key Activities, 9. Key Actors, 10. Key Actors Offerings, 11. Key Actors Co-Creation

Operations, 12. Budget Cost, 13. Environmental Impacts: Costs and Benefits, and 14. Social Impacts: Values and Costs.

Smart City - Business Model Canvas

Key Actors

Who are the smart city network key actors?
(Completed by the solution provider in collaboration with the City)

- *Actor 1 (city)*
- *Actor 2 (end-user)*
- *Actor 3 (core partner)*
- *Actor 4 (supporting partner)*

Who are the key suppliers?
(Completed by the smart city solution provider)

- *Supplier 1*
- *Supplier 2*
- *Supplier 3*

Key Activities

Which key activities are required to realize the value proposition (i.e. build distribution channels, customer relationships, revenue streams, build products/services/platforms, install equipment)

(Completed by each actor involved in realizing the smart city solution)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Value Proposition

What value does each actor delivers?
Which of the end users' problems is the smart city project helping to solve?
What bundles of products and services does the project offers to each end user?
Which end-users needs is the project satisfying? (i.e. performance, customization, price, getting the job done, cost reduction, risk reduction, accessibility, convenience/usability)
What are the respective target values/thresholds/KPIs to be reached?

(Completed by each actor involved in the smart city project creating value)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Actor Relationships

Which type of relationship does each actor expect within the network?
Which ones are established?
How are they integrated with the rest of our business model?
How costly are they?

(Completed by each actor involved in realizing the smart city solution)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Network Beneficiaries

Which target users is the value created for?
How the target users benefit from the value created and what are their needs?
What specific values each network beneficiary gets? (i.e. Community, business, research organizations, decision-making bodies/government and non-profit).

(Completed by the smart city solution provider in collaboration with each actor involved in realizing the project)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Key Actors Offerings (*)

What offerings does each actor deliver? (i.e. technology, development of products/processes/services, R&D, Citizen Engagement)

(Completed by the smart city Key Actors in collaboration with the city)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Key Actors Co-creation Operations (*)

Which key operations do the key actors perform? (i.e. sourcing of materials, systems's design, operation and monitor and impact monitoring of the smart city solutions, deliver value, city coverage and links to other stakeholders e.g. innovation hubs)

(Completed by the smart city Key Actors in collaboration with the city)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Key Resources and Infrastructure

What key resources are required to realize the Value Proposition (buildings, vehicles, machines, systems, point-of-sale systems, and distribution, networks)
Our deployment channels?
Our actor relationships?
Revenue streams?

(Completed by the smart city solution provider in collaboration with the city)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Data (*)

What data will be made available from the services designed?
To whom and under what conditions? Availability and types of Open Data (i.e. energy efficiency, climate indicators, traffic etc)

(Completed by the smart city solution provider in collaboration with the city and actors involved)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Deployment Channels

Through which channels do our customers want to be reached?
How are we reaching them now?
How are our channels integrated?
Which ones work best?
Which ones are most cost efficient?
How are they integrating with the customer routines?

(Completed by the smart city solution provider in collaboration with the city and actors involved)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Budget Cost

What are the most important costs inherent for each actor deploying a smart city solution?
Which key resources are the most expensive?
Which key activities are the most expensive?
What cost can be covered by each actor?
Is there opportunitiy for blending public funding with private financing? Which costs are covered by each mechanism?
(Completed by the smart city solution provider in collaboration with the city)
Actor 1 (city):
Actor 2 (end-user):
Actor 3 (core partner):
Actor 4 (supporting partner):

Revenue Streams

For what value are the network beneficiaries really willing to pay?
For what do they currently pay?
How are they currently paying?
How much would they prefer to pay?
How much does each revenue stream contributing to overall revenues?
Which actors have revenues?
What are the non-monetary revenues?

(Completed by the smart city solution provider in collaboration with the city)
Actor 1 (city)
Actor 2 (end-user)
Actor 3 (core partner)
Actor 4 (supporting partner)

Environmental Impacts: Costs and Benefits

What is the ecological cost of the smart city solution? (i.e. Greenhouse gas emissions, land use, energy and water used)
What is the ecological benefit of the smart city solutions?
% of reducing energy consumption
% reducing the environmental footprint

(Completed by the smart city solution provider and the smart city)

Social Impacts: Values and Costs

What is the negative social value generated by the Smart City Solutions?
(i.e. Social exclusion, digital illiteracy, accessibility to advanced services etc.)
What is the positive social value generated by the Smart City Solutions?
(i.e. Growth, job creation, air quality, less traffic etc.)

(Completed by the smart city solution provider and the smart city)

Figure 3. The Smart City Business Model Canvas.

3.1. Network Beneficiaries

In the BMC, network beneficiaries refer to the customer segments, i.e., the groups of end users whose needs are addressed. This component was adapted from the mission-driven organizations' BMC [12], recognizing the more complex relations than that of a customer and an organization offering a business solution. In the case of the SC-BMC, the network beneficiaries maps all the target users in the network of the smart city ecosystem for whom value is created and whose needs are addressed through a smart city project. These network beneficiaries are thus identified early in the process and engaged in the co-creation of the smart city solutions. Network beneficiaries can include community, business, research organizations, decision-making bodies (government), and nonprofits.

3.2. Value Proposition

In the BMC, value proposition refers to the benefits offered to a specific customer segment. In the case of the SC-BMC, value proposition refers to the benefits each actor in the network creates for a single or multiple end user in the network. The value proposition addresses the specific needs of one or more end user groups and provides a clear explanation of how these needs will be satisfied, stating the bundle of products and services offered to each user. The fulfillment of these needs can be validated through the utilization of appropriate KPIs and respective threshold/target values to be reached. For instance, for city administration, smart city projects respond to the critical need of rapidly reducing GHG emissions and adapting to climate change by demonstrating solutions that increase RES utilization (e.g., value created by solutions that partly work toward achieving a target of >50% of local energy generation from RES and/or a CO_2 emission reduction >40% until 2030 in comparison with 1990 levels). From a citizen perspective, smart city projects can reduce energy bills and improve air quality (e.g., smart city solutions that work toward reaching 20 10 μg/m3 and 10 μg/m3 annual mean concentration for PM_{10} and $PM_{2.5}$, respectively, in accordance with World Health Organization guidelines).

The value created for each network end user can be related to the solution's novelty, performance, customization, "getting the job done", price/cost reduction, risk reduction, accessibility, and convenience/usability, addressing the various smart city domains such as mobility, security, healthcare, energy, water, waste, economic development and housing, engagement, and community [19]. Relevant examples of those attributes to value creation in smart cities include:

Novelty: Offering a new set of services enabled by the use of ICT and IoT from installed sensors, i.e., sensing vehicles providing more safety, energy consumption and flow providing reduced bills and energy resilience, traffic management providing less emissions and quality of life, free parking spaces reducing trip times, public lighting reducing energy consumption, etc.

Performance: Offering improved product or service performance, i.e., reducing the curtailment of renewable energy generation with energy storage solutions, making buildings more energy efficient.

Customization/Design: Offering tailored solutions to specific needs of a network actor, for example, preserving the cultural heritage characteristics of buildings while installing innovative PV/PVT technologies for harvesting solar or thermal energy.

Getting the Job Done: Offering help to a network actor for getting certain jobs done, i.e., providing a digitalized way for raising and ensuring end user awareness, adoption, and engagement.

Price/Cost Reduction: Offering similar value at a lower price, e.g., reducing the cost of gathering information on usage patterns can lead to faster optimization of existing systems, offering cheaper energy from orchestrating renewable energy assets with the use of ICT and IoT, offering grid resilience avoiding big infrastructural work or reducing energy bills, or reducing levelized cost of energy with car sharing

Risk Reduction: Reducing risk on cybersecurity vulnerabilities in smart cities, i.e., prioritizing cybersecurity to protect sensitive assets, reducing energy dependency on fossil fuels, maximizing the efficient use of renewables in combination with storage systems.

Accessibility: Offering products/services to end users who lacked access previously, i.e., providing sufficient access to good public transit alternatives or introducing access to car sharing scheme and encourage people to shift away from private vehicles. Telemedicine may provide access to quality healthcare in low-income cities or relieve pressure on overburden traditional healthcare systems in high-income cities.
Convenience/Usability: Offering ease of use and convenience, i.e., knowing which parking spaces are free in the city center, offering tools for understanding and customizing home energy consumption, and adapting consumption patterns to reduce energy bills.

The dimensions of value proposition above help the SC-BMC initiator explicitly describe how the identified need is addressed and in what ways the solutions can be refined or can be integrated with others to maximize efficiency.

3.3. Data (*)

Data is becoming increasingly essential in the realization and improvement of smart cities. Data from sensors and connected infrastructure and devices in real-time, as well as data generated on how end users interact with the infrastructure and connected devices, allow for analysis and utilization, creating business opportunities and ongoing innovation while improving city living. Examples of the usability of open data widely vary from how to travel using public transportation, unmanned traffic management, control of air quality, etc. Specifically, for smart city solutions, it is important to make explicit how the solution will tap into the available data, as well as contribute new data to the available pool.

3.4. Deployment Channels

Deployment channels refers to the channels component in the original BMC, which describes how a company communicates, distributes, and sells its services and products to customers. Through what channels the beneficiaries are most likely to learn about a smart city solution and whether they decide to adopt and use it can vary. The channels component of the BMC should therefore be adapted to the smart city context by relabeling it "deployment channels", which represent three dimensions: (a) The technological basis and the digital infrastructure necessary for developing the smart city applications, (b) the smart city applications already in use that can be capitalized in bringing new services to users, and (c) the ways/measures of communicating and distributing the values created by the different actors to the end user, offering them the opportunity to purchase services. In addition to the communication channels, deployment channels also cover the channels through which one aims to actually deliver the services to end users, provide post purchase end user support, etc., as well as increasing awareness, usage, and satisfaction utilizing the various actors existing channels or technologies and services available in a smart city.

3.5. Actor Relationships

In the BMC, actor relationships represent the type of relationships a company needs to establish with identified customer segments, i.e., whether relationships will be personal or automated. In the SC-BMC, actor relationships represent all the actors in the network and their linkages to the offered services. In this cell, explicit attention is also given to the relationships that need to be established for facilitating continuous co-creation practices of actors involved in the smart city ecosystem and the resulting interrelationships that need to be orchestrated so that value is co-created, i.e., end users evaluate or participate as owners in the value creation.

3.6. Revenue Streams

Revenues in the BMC refer to the value which customers are willing to pay. In the SC-BMC, the public sector actors face different budget constraints, and for them, revenue streams can be broadened

to social value creation (nonmonetary benefits). Upgrading infrastructure, technology, and turning public city data open can create new value chains and opportunities in a sustainable manner [43,44]. Cities, apart from reducing operating costs or nonmonetized benefits, can also generate ongoing revenues, which can justify the high upfront investments of solutions, i.e., revenues from advertising space at info kiosks installed around a city to provide information for restaurants and attractions, events that may also include the generation of service fees for selling tickets directly through these info kiosks, or revenues from providing usable data insights. Indeed, all private actors involved have to turn a profit to sustainably commit to the integrated smart city solutions. Revenues for private actors can derive from, i.e., usage fees (i.e., end users pay for energy units from renewable sources), subscription fees (i.e., a startup pays fees for having access to databases for exploiting real time data from sensors installed for motoring air quality), lending/renting/leasing (i.e., granting an investor trade excess energy produced by the PV systems on buildings for a fixed period in return for fee) or brokerage fees (i.e., trading energy units through block chain technology).

3.7. Key Resources and Infrastructure

In the BMC, key resources refer to the most important assets necessary for a business model to create and offer a value proposition, reach markets, and maintain relationships with customers while earning revenues. In the case of SC-BMC, the key resources also refer to physical, human, intellectual, and financial assets. Physical assets include buildings, energy grid, public transport vehicles and systems, wireless networks, waste management systems, etc. Human assets encompass the political will toward transition to smart cities, the retention of all stakeholders to operate the city at its full potential, the creation and nurture of a culture of innovation among citizens which makes them less resistant to change, the raise in awareness of smart solutions benefits, and the engagement of end users, which makes the investments in smart technologies and services attractive to financiers and investors, supporting new companies to build novel business concepts and start new ventures. Intellectual assets include patents and legal, regulatory framework innovation procurement systems that create the conditions necessary for deployment and wide-scale roll-out of smart city solutions. Financial assets include access to capital and grants to realize smart solutions and tax incentives and rewards to incenticize the end users to adopt new behaviors.

3.8. Key Activities

Key activities refer to those activities a company needs to undertake in order to realize its business model. In the SC-BMC, key activities refer to the management and delivery of activities of the actors involved in the smart city solution, capitalizing on the offerings by each network actor and working toward realization using co-creation practices. The city provides the platform for discussing and devising ways of collaboration among actors and the city itself. Activities that can combine the dynamics of the different players and their business operations, are managed in order for the city to organically grow into smarter by adding layers of smartness each time a new smart city solution is added into the previous status and its business model can each time be supported by already established activities.

3.9. Key Actors

In the BMC, key actors refer to key partnerships and reflects the network of suppliers and partners that are essential for the Business Model and reduce risk or acquire resources. In the SC-BMC, key actors refer to the key actors in the network and the form of cooperation among them in the smart city ecosystem for maximizing the effect of the co-creation of value. Either formal or nonformal cooperation among one or more actors in a smart city partnership can refine the allocation of resources and activities or share infrastructures, at least between the city and the solution provider, thus reducing risk, especially in cases that require a large investment in infrastructure and incentivizing more actors to participate and be actively engaged in a collaborative process.

3.10. Key Actors Offerings (*)

In the Nenonen and Storbacka [41] business model framework, offerings refer to what each actor has available to offer in the co-creation, i.e., technology, R&D, and IP rights. In the SC-BMC, key actors' offerings similarly describe the type of offering each actor is bringing to the realization of the value proposition. These offerings can be smart city technology, services, development of novel products, processes and services, citizen engagement, etc.

3.11. Key Actors Co-Creation Operations (*)

In the Nenonen and Storbacka [41] business model framework, operations refer to the firm's infrastructure, suppliers, and partners, as well as the ICT infrastructure and geographical coverage. In the SC-BMC, the key actors' co-creation operations refer to the type of operation each network actor can potentially deliver in terms of, i.e., sourcing materials, infrastructure, operation of systems and monitoring impact of the solutions, and creating links with other stakeholders, contributing to the co-creation of delivering a smart city solution and maximizing its impact. For instance, operations allow cities to systematically evaluate the opportunities and weaknesses or gaps that need to be addressed for the successful implementation of the smart city integrated solution. In the Smart City Business Model Canvas, each actor can canvas the type of operations they can incorporate in a systematic way to facilitate the orchestration of those operations. The smart city solution provider can then optimize those operations and utilize them accordingly in collaboration with those actors.

3.12. Budget Cost

In the BMC, budget cost component refers to cost structure, covering the costs likely to be incurred for implementing the business model key activities and acquiring the necessary resources. In the SC-BMC, budget cost refers to the combination of a cost and value offered by the different key actors. This combination of cost and value is achieved by capitalizing the assets of the different actors in the network and during co-creation, minimizing operational and infrastructural costs while increasing the generated value. The budget cost is also related to the key resources and the key activities that are necessary to deploy the smart city solutions such as fixed costs, i.e., salaries, rents, process of IoT sensors installations and services, network/grid infrastructure, technology installations, land, or costs that vary according to the incentives or rewards provided to end users in order to start using smart city solutions. The SC-BMC helps in the identification of public funding and private financing blended together, facilitating the multi-actor collaboration. Economies of scale may also provide a cost advantage in the case of large-scale rolling out of solutions, causing the average cost of investment to fall as output rises. For instance, the installation of sensors recognizing free parking spaces at the city level allow the supplier of the service offering free parking space guidance to reach economies of scale. Economies of scope provide also advantages in the smart city network of actors. In utility enterprises, for example, marketing activities of smart solutions would reach a high number of end users through the existing customers network.

3.13. Environmental Impact: Cost and Benefits

In the triple-layered business model canvas [13], environmental impact addresses the ecological cost referring to the energy consumption, water use, and emissions based on Life Cycle Analysis research, as well as the benefits 'beyond purely the financial or economic value', i.e., a positive ecological value, which may be a reduction in CO_2 emissions or improved air quality. In the SC-BMC, the environmental impact similarly addresses the potentially negative inherent environmental cost, i.e., greenhouse gas emissions, land use, and energy and water used for the installation and operation or disposal of smart city solutions, i.e., need for raw materials required for building stock retrofitting [14]. Issues such as the embodied energy of the applied solutions should also be considered if we are looking towards a holistic sustainability assessment. For instance, the installation of large-scale PV or

wind parks could negatively impact the available productive land and biodiversity of the area. The SC-BMC seeks to limit or reduce such negative impacts and ensure that the environmental benefits offset relevant (if any) environmental costs. The environmental benefit in SC-BMC addresses the outcome of the implementation of smart city solutions, which can include the reduction of energy consumption as an informed behavioral change of end users who are able to have a clear picture of energy usage through IoT enabled technologies.

3.14. Social Impacts: Costs and Benefits

In the triple-layered business model canvas, social cost refers to the impact of the activities of a company to the wellbeing of the community, and social benefit addresses the issue of 'positive social value' as an outcome of a company's actions. In the SC-BMC, social impact similarly addresses issues, such as social cost in terms of exclusion due to the inability to participate in the advanced smart city services because of digital illiteracy, for example, and social benefit as the positive social value created by smart city solution, i.e., improved quality of life (in terms of air quality, less traffic, etc.) and growth prospects that can derive from creating opportunities for new business activities, which result in job creation and economic prosperity.

This concludes our description of the smart city business model canvass. Individually and together, the cells in the extended canvas cover not only the essential elements in the business model of every firm individually, but also take into consideration the important network characteristics of smart city business models and add categories that systematically assess social and ecological impacts of business models. Finally, we adapted several cells to include highly relevant aspects of smart city solutions that the standard business model canvas would ignore. This makes it imperative that the SC-BMC is not used by single actors in the ecosystem in isolation. Rather, it is advised to canvass smart city solutions with the actors most directly involved and in an iterative process, in which the different partners first map out their network, and then make explicit how they create value for other actors in the network and the end users of the integrated solution.

4. Conclusions

The SC-BMC offers practical guide and a framework to the smart city and its network actors to map and design business models that can address the increased complexity of the urban environment and the transition to smart urbanism. It translates the prevalent smart city trends into a framework that can be implemented initially by a city administration and used in collaboration with the network actors, who design and deliver a smart city solution in any smart city domain. The SC-BMC presents a holistic approach for presenting all network actors' co-creation contributions in the generation of value and can be a complementary framework for facilitating replication of smart city solutions in different contexts. The framework was envisaged to be validated in smart cities that are in the phase of implementing novel smart city solutions. Once validated there, the SC-BMC will also help cities that are planning to become smarter. These cities can use the SC-BMC to understand what aspects are missing in the value generation. Actors in the smart city ecosystem can use the canvas to design viable business models for smart city solutions that can attract investors, and the canvas can increase the replication potential and upscale of smart city solutions. Additionally, the SC-BMC can be used to compare and prioritize solutions that are more cost-effective when comparing resources to be committed with potential revenues. However, an analytical cost-benefit analysis should complement the SC-BMC before making decisions, and further research is needed in this respect.

The Business Model Canvas is one of the most used frameworks for business model design and analysis by entrepreneurs. Modifications of the BMC have been suggested by many researchers to address specific activities or specific contexts. The Smart City Business Model Canvas framework proposed in this paper maintains the principles of simplicity and was built upon a very well-known and widely used tool. The contributions of this paper can be found in the integration of the concepts of co-creation and network-centric value creation, which simultaneously address the social and

environmental dimensions of the solutions deployed. Our approach can incentivize impact-oriented investors and financers to participate in the wide-scale replication and roll-out of the smart solutions, increasing quality of life for citizens.

Cities pose different characteristics and pursue different goals that are suited to the available resources and context conditions. The adaptation of the SC-BMC to the strategic vision of the city promotes strategic smartification planning and allows all actors in the city's ecosystem to use it with the support of the city and other related actors. Smart cities that are already designing their future projects can use it for developing smarter and more sustainable business cases. Cities that wish to follow and are planning to adopt smart cities' strategies toward becoming smarter can use the SC-BMC to map their ecosystem and identify the values that various players can introduce to design successful business cases that will cater to the needs of investors, even if the ecosystem is not so mature. Smart city solution providers can use our framework in collaboration with the city and the actors involved to devise business models that build on the value created from all the different actors. Recognizing the role that each actor, including the end users, can play in the deployment of smart city solutions from the starting phase of their design might potentially enhance the sense of co-ownership in smart city projects, engaging and empowering citizens to take greater roles in the ongoing development of their living and working spaces.

The limitations of this study include that the proposed SC-BMC has not yet been rigorously tested in practice. Testing the SC-MBC in practice is a priority on our research agenda. As it is, the current framework provided only a first attempt to capture the characteristics of the smart city value that can be created through the application of smart city solutions. However, the SC-BMC needs to be validated though various different cases of smart city projects. Validation cases will commence within the "IRIS" Project Lighthouse Cities and its fellow cities. The "IRIS" is funded by Horizon 2020 and aims to improve urban life through integrated solutions in the energy, transport, and ICT with a citizen-centric approach.

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