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Mapping the Smart City Business Model Landscape in Switzerland: A Typology of More Than 250 Smart City Projects

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CONTENT

1. INTRODUCTION

In 2018, more than 55 percent of the world's population lived in urban settlements. This number will rise to 60 percent by 2030, and a third of the population will live in cities with at least half a million inhabitants (Lee & Lee, 2014). Fast-growing cities often suffer from traffic congestion, pollution, and increasing social inequality. The currently pressing social, ecological, and economic questions are inextricably linked to cities and city developments (Yigitcanlar et al., 2019). Hence, urban development has the opportunity to set benchmarks not only on the significant challenges of our time, such as climate change, inequality, poverty, and discrimination but also on tangible city-related fields, such as citizens' participation, neighborhood engagement, modern living, and mobility infrastructure (Mora et al., 2017). Increasingly constrained resources and growing inequality require cities to offer smart services to meet higher environmental and social standards. The Smart City concept is variously defined, but many definitions involve the idea that information and communication technologies (ICT) are applied to enhance citizens' well-being (Ahvenniemi et al., 2017). One hundred and ninety-three countries supported the UN's 2030 agenda to build "sustainable cities and communities" that are more inclusive, safe, resilient, and environmentally friendly (Shetty et al., 2019). While much political involvement and academic work feature smart cities in general, concrete research on how to build and scale smart cities is sparse, and does not match the centrality of smart city development in public administration, management, and policy today.

According to Walrawens (2015), smart cities are prioritizing the incorporation of ICT, data protection, citizens' security, financial independence, and social infrastructure into their urban spaces. Transforming a city into a smart city may be very expensive; for instance, Galati (2018) estimated that cities will spend $41 trillion on building smart infrastructure worldwide. Furthermore, the various interests of heterogeneous stakeholders, ranging from entrepreneurs to families to governmental stakeholders, have to be made compatible. Fishmann and Flynn (2018) have found in their calculations that city councils can finance only 16 percent of the investments required to bolster smart city development. This low share raises the question of the need to find further finance to scale smart city developments from non-public funds. Offering specific services through private actors is possible, while other funds could be provided through public–private partnerships (Lam & Yang, 2020). However, how should this be organized? Which fields of smart city development are best suited to private development, and which to public–private cooperation?

It is clear that, with the ongoing demand to develop innovative SC projects, giving consideration to scaling and financing is a significant task for city administrations and public servants. The business model (BM) concept finds considerable resonance in management research and managerial practice since it provides a comprehensive and easily accessible understanding of an enterprise's value creation,

financing, and functioning (Gassmann et al., 2016; Zott et al., 2011). This paper will offer a business model perspective on smart city projects. Furthermore, different business model archetypes and their potential for innovation and scalability in the smart city landscape will be analyzed. Archetypes in this context mean business models that can be generalized across a set of smart city projects.

This report answers the question: *Which business models characterize the smart city landscape in Switzerland, and what business model archetypes for smart cities can be identified?*

We evaluated 251 smart city projects in 71 Swiss cities. This research offers a unique contribution in applying the well-established BM concept from management studies to innovative smart city solutions. The business model perspective helps assess the strengths, weaknesses, scalability, and regional heterogeneity of different smart city projects concerning their value proposition and their method of (public) value creation.

We find that smart city projects are especially prevalent and display a high degree of uniformity in the field of Smart Government. In the field of Smart Economy and Smart People, only a few projects are in existence, many of which are very diverse and are often still in their pilot stage. Generally, we anticipate that the 44 business model archetypes will provide a helpful overview and an inspiration for public administration executives contemplating smart city developments.

The text is structured as follows: First, a brief literature review on smart cities and business models research will be provided. Subsequently, we will introduce a methodology applying content analysis. Our analysis will first identify 251 BMs in smart cities in Switzerland to create 44 smart city business model archetypes. The paper will end by considering how the field might be developed and by indicating some directions for future smart city policy.

2. LITERATURE REVIEW

2.1 Smart Cities

Urbanization challenges city administrations

The United Nations has urged member states to come to an understanding of the critical urbanization trends in implementing the 2030 Agenda for Sustainable Development. This agenda includes Sustainable Development Goal 11 to make cities and human settlements inclusive, safe, resilient, and sustainable (United Nations, 2018). Urban design increasingly determines a country's geographic and social landscape since cities play an ever more pertinent role in social and economic challenges worldwide and significantly impact our environment (Mori & Christodoulou, 2012). Facing challenges on environmental degradation, housing, and citizens' well-being, cities need to apply the new-urbanism and smart-growth concepts (Wey & Hsu, 2014). New-urbanism and smart-growth concepts are central to the vision of developing a city into a "smart city".

Smart Cities as an ambiguous answer to challenges

Key are high-quality urban services, which are mainly based on modern technologies such as ICT. They will generate positive effects on the economy and turn cities into "smart cities" (Albino et al., 2015). However, the label "smart city" is a concept that has yet to be consistently defined globally due to technological, economical, and governing barriers and differences (Silva et al., 2018). According to the European Parliament (2014), a smart city is "a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefits of its inhabitants and businesses". Harrison et al. (2010) specify a smart city as an "instrumented, interconnected, and intelligent city". Technological devices have to capture and integrate live real-world data. These data have to be integrated into information and communication platforms for several urban services, which then analyze, model, and optimize operational decisions (Harrison et al., 2010). Another approach, which gives the notion of a smart city tangibility, is based on the six major smart city

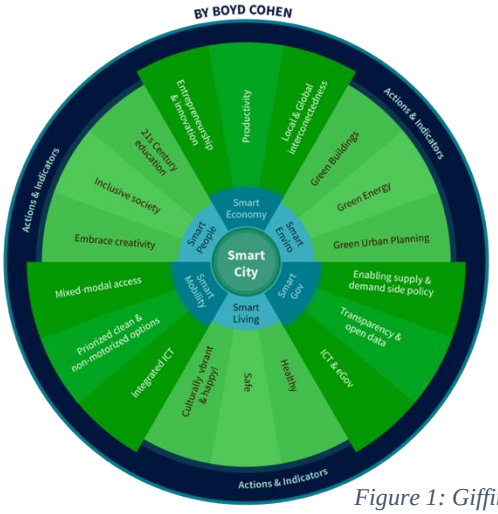


Figure 1: Giffinger's City Wheel reinterpreted by Cohen (2013)

dimensions of Giffinger et al. (2007) presented in Figure 1. These are: Smart Economy (entrepreneurship and innovation, productivity, local and global interconnectedness), Smart Environment (green buildings, green energy, green urban planning), Smart Government (enabling supply and demand-side policy), Smart Living (healthy, safe, culturally vibrant, and happy), Smart Mobility (mixed-modal access, prioritized clean and non-motorized options, integrated ICT) and Smart People (21st-century education, inclusive society, embrace creativity) (Cohen, 2013).

Smart Cities are analyzed from various perspectives

Researchers look at smart cities from various perspectives. For example, Lee and Lee (2014) gathered 228 smart city services into eleven categories covering: administration; environment; public health, medical care, and welfare; transportation; crime and disaster prevention; education; distribution; facility management; culture, tour, and sports; work and employment; and miscellaneous. The same authors identified a service typology of four dimensions covering technology, service authority, the purpose of the service, and the mode of delivery. In-depth research into all four dimensions has been undertaken. Kramers et al. (2014) discuss how Smart Cities incorporate ICTs. Elmaghraby and Losavio (2014) focus on the Internet of Things (IoT) and critical infrastructure to turn a city into a smart, data processing, and efficient urban place. Bulu (2014) and Niaros et al. (2017) are interested in environmental efficiency, security, and sustainability by incorporating technological infrastructure, while Neirotti et al. (2014) discuss improvements in the life of citizens (Kumar et al., 2020). Political representatives, administrators, inhabitants, and entrepreneurs are the primary stakeholders to advance their city's transformation into a smart city (Borsekova et al., 2018). After first being mentioned in the late 1990s (Mahizhnan, 1999; Van Bastelaer, 1998), the Smart City concept changes itself as rapidly as it changes cities worldwide because smartness can be differently understood. Anttiroiko (2015) sees "smartness" from two perspectives: on the one hand, it is about the design of policy, and on the other, it is about implementation. Giffinger et al. (2007) require a smart city to "smartly" combine the endowments and activities of self-decisive, independent, and aware citizens.

2.2 Business Models

A business model (BM) is a popular concept in managerial studies and practice. BMs provide a comprehensive and straightforward description of value creation and capture for a focal organization and heterogeneous stakeholders (Casadesus-Masanell & Ricart, 2010; Martins et al., 2015; Zott & Amit, 2010). BMs help capture an individual organization's specific characteristics or a competitive landscape within an industry (Teece, 2010; Zott & Amit, 2008). Concerning innovation, Gassmann et al. (2014) propose that business model innovation rarely means the organization creates completely new BMs but rather models that are already successful are adapted and necessary details calibrated. Therefore, the analysis of emerging and prevalent BMs in the industry increases understanding of the industry's current status and potential future development (Massa et al., 2017). In science, BMs are

either discussed as enterprise classification methods or used to explain the heterogeneity in firm performance or a firm's innovation level (Gassmann et al., 2016). Our study follows the first approach and sees business models as an opportunity and essential asset for project managers to understand, analyze, and structure their organization within set competitive environments (Casadesus-Masanell & Ricart, 2010; Doz & Kosonen, 2010; Gavetti et al., 2005). We do not apply the business model framework to firms but to public entities, who established and organized the Smart City projects we evaluated.

In our research, we rely on Gassmann et al.'s (2014) business model framework, which we have chosen for its simplicity and conceptual clarity. Such clarity is vital since we are dealing with internally and externally heterogeneous projects. The framework describes a business model along the four dimensions – "Who", "What", "How", and "Why". As Figure 2 depicts, "Who" addresses the customer group, in which defining the target customer is seen as a central dimension of creating a business model. "What" refers to the value proposition (products and services creating value) for the customer. "How" describes the processes and activities performed by the organization to create the promised value. "Why" represents the revenue model, including the cost structure and what makes the enterprise profitable.

Figure 2: Gassmann et al.'s (2014) Business Model Framework

On the challenging question of growth and scaling smart city projects, two dimensions are particularly intriguing. On the one hand, "Who" benefits from the project seems to be highly relevant. On the other hand, "Why" this project is financially interesting and financed in public, private, or public–private settings by for-profit or not-for-profit organizations can easily remain ambiguous. Public financing demands further segmentation because there are various stakeholders, either from the city, the canton, the nation, or the European level. Grants and subsidies are not very transparent. The revenue and income stream may even be more ambiguous or non-existent. SC projects often seem to save costs or perform a public service and generate public, societal, and environmental value without generating economic profits.

A cross-dimensional perspective on Gassmann et al.'s (2014) business model framework allows us to identify archetypes through an aggregation of the business model's specific dimensional components. Archetypes allow for abstraction of and attention to the essential similarities simultaneously, making their application appealing in the practical or academic domains (Foss & Saebi, 2017). BM archetypes increase understanding of SC projects' probability of success and scalability in defining the different dimensions and thinking about improvements and adaptions on the Who-What-How-Why dimensions.

2.3 Smart City Business Models

The literature on the combination of smart city and business models is still very limited. Walravens (2015) built qualitative indicators for smart city business models but confined his analysis to mobility services. Anthopoulos et al. (2019) concentrate on the source of Smart City value and find that a public project's ownership is critical for the decision on which value to create. Bélissent (2010) provides an overview of smart solutions for cities and their applications but is limited to business models and archetype abstraction. Kuk and Janssen (2011) focus their Smart City Business Model research on governments and municipalities' digital services, which is merely one of the five dimensions of Smart Cities. Perätalo and Ahokangas (2018) combine frameworks of Business Models and Smart Cities, emphasizing that network and ecosystem thinking is conducive to building efficient Smart City business models.

3. METHOD

Smart city projects are multi-faceted phenomena and display a wide array of heterogeneity. In order to analyze a neighborhood-help app, a sewage system sensor, or an urban renewable energy policy lab alongside each other, qualitative analyses are most suited. This study applies a qualitative content analysis relying on the business model framework described. For the content analysis of 251 smart city projects, we collected text sources such as newspaper articles, websites, parliamentary discussions, and interviews. The coding, according to Gassmann et al.'s (2014) BM framework and the subsequent generation and analysis of smart city business model archetypes, was carried out by six researchers.

Sampling

For the sampling of the smart city projects, we relied on a bi-yearly city survey conducted by the ZHAW. Swiss public administration offices from 63 cities responded and offered a list of smart city projects they are involved in. Additionally, six researchers searched online for freely available information on further smart city projects in Switzerland for the set of cities covered in the surveys. And they checked for web-research results for cities applying search terms such as "smart city", "city development," and others on Google. Ultimately, 251 projects from 71 cities were evaluated.

Content Analysis

According to Krippendorff (2004), content analysis is "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (p. 25). It rests on "definitions that take content to emerge in the process of a researcher analyzing the text relative to a particular context" (p. 27). Units of analysis in a content analysis are: firstly, the sampling units (which websites, articles, texts, interviews); secondly, recording units (which texts are relevant); and thirdly, the context units, which also set limits on the information considered in the text.

Primary Coding

The first step was to collect the textual content using desk research, relying solely on internet sources. We processed the data with the widely used content analysis software, Atlas.ti. The codebook for the content analysis (Appendix, Table 8.1) was prepared and extensively discussed with the six coders at the beginning and during the data collection, allowing for a solid shared understanding of concepts and codes. The intercoder reliability amounted to a Krippendorff's c-alpha-binary reliability coefficient of 0.853.

Secondary Coding

From the simple coding of our textual data, we derived flashed-output business models for all 251 smart city projects in a second step. For this purpose, we relied on Krippendorff's (2004) concept of hypothesis testing[1]. We derived 251 business models of Swiss Smart Cities with their "What", "Who", "How" and "Why" dimensions, whether they represent public, private, common, or club goods, and whether they are implemented in the pilot phase or planned (also see the codebook in the appendix). Next, we discussed all business models intensively and formed 42 functional clusters to better understand the SCBM landscape. Those functional clusters (see the image wheel) later served as the "abstract what" criterion to build archetypes – an abstract description of the business model "What" dimension.

Identification of archetypes

BM archetypes are abstractions of a set of specific BMs, in which at least two but mostly more of the four BM dimensions converge between several different projects (Gassmann et al., 2016). In order to identify archetypes, the detailed descriptions of all four BM pillars for each SC project were simplified to achieve a certain level of abstraction. For example, in the" Who" dimension, "Building department, Real estate companies and People who want to build something" are abstracted to "housing sector stakeholders". "Citizens who want to get rid of their waste" are abstracted to "inhabitants". "Customers of the St. Galler Stadtwerke" are defined as "interested inhabitants". All four abstracted pillars can be found in Table 2; the archetypes are listed in the analysis.

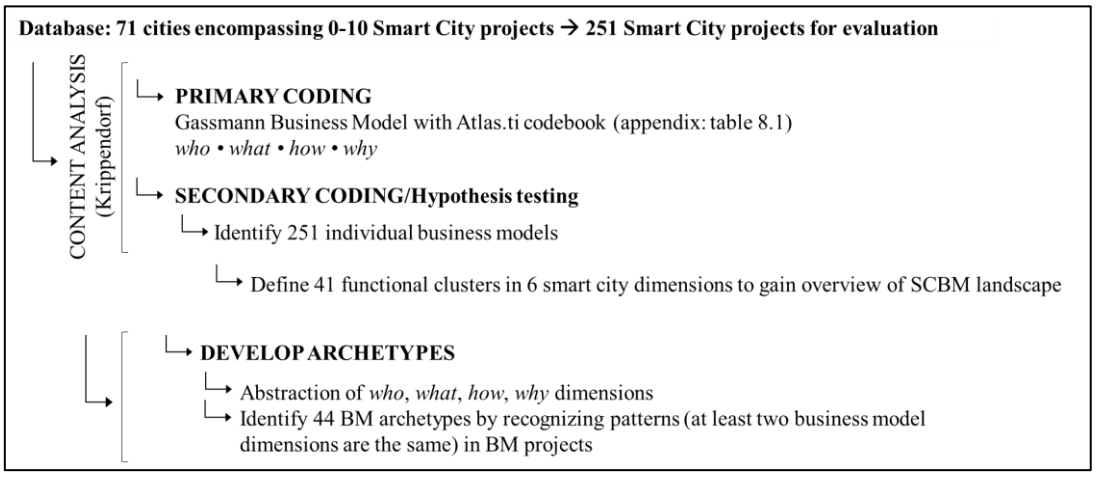


Figure 3: Flowchart of methodology

[1] Hypothesis testing according to Krippendorff "addresses a text's presuppositions, implications, and omissions over and above its explicit meanings and asks coders a more limited question of where a textual unit can be read as supporting or opposing a stated set of alternative propositions."

4. ANALYSIS

In the following sections, we will present the outcomes of our analysis of 251 smart city projects in Switzerland. Firstly, in the descriptive part, we seek to shed light generally on what kind of business models are used in the smart city landscape while, in the second analysis section, we provide insights into smart city business model archetypes.

4.1 Descriptive Data Analysis

Our analysis comprises 251 smart city projects in 71 Swiss cities. Most projects are located in Basel (14 projects), followed by Zurich with 12 projects, St. Gallen with 11 projects, and Bern and Winterthur with 10 projects each. Furthermore, our data set comprises several smart city projects that are scaled across the whole of Switzerland.

Of the 251 Smart City projects evaluated, we were able to identify 68% that had reached implementation, 20% that were in the pilot phase, and the remaining 12% that were impossible to determine.

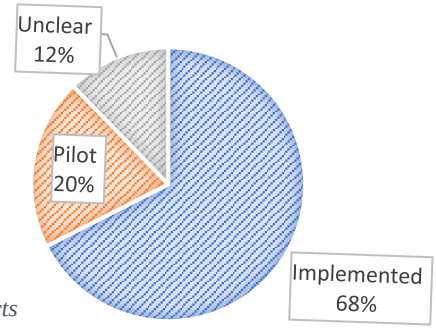


Figure 4: Status of Progress of the Projects

Smart City Business Models

In Table 1, a series of smart city business models is presented. For example, the project "Smart Road" in Bern involves the production of renewable energy (*what*) by combining photovoltaics with a drivable and resistant road surface (*how*) for citizens (*who*) that need to buy less conventional energy (*why*). As shown for biogas in Grenchen, digital participation in Basel, BärnBoost in Bern, and Smart Parking in the city of Baden, BMs for all 251 projects in our data set are assessed.

Furthermore, the SCBMs are sorted according to the Smart City wheel of Giffinger (2007) and Cohen (2013) in the categories of Economy, Environment, Government, Living, Mobility, and People (see Figure 5). This provides an overview of the distribution of projects between the different dimensions of a smart city. In our sample, most projects (69 projects, approximately 27 percent) are Smart Government related, followed by Mobility projects, then models for a Smart Environment and Smart People. Smart Living has only 18 projects, and Smart Economy has the smallest share with 14 projects.

City	Project Name	Cluster Smart City Dimensions	Business Model
Bern	Smart Road	Smart Environment	Citizens (who) profit from the production of renewable energy (what) and, hence, have a reduced need to buy conventional energy (why) by means of a smart roads technology that combines photovoltaics with a drivable and resistant surface (how).
Grenchen	Biogasanlage in der ARA (Biogas Plant)	Smart Environment	The municipality/the public water and energy provider (SWG) built a biogas plant from which all inhabitants (who) with access to the SWG biogas grid/network could benefit. The biogas is made from wastewater (how) and produces 5 GWH per year (what). Biomethane energy is produced from the sludge from wastewater treatment, which is fed into the natural gas network.
Basel	Digitale Mitbestimmung	Smart People	Basel uses online questionnaires (how) to prepare its voters and citizens (who) for the digitization of political participation (what). The online questionnaires are used for population surveys, conducting interviews with opinion leaders and experts from politics, administration, science, and business. The evaluations are widely communicated and provide the guidelines for the introduction of instruments for political co-determination.
Bern	BärnBoost	Smart People	BärnBoost is an idea platform where people from and around Bern (who) can support each other in new projects and events (what). Interested parties can enter their ideas by means of a platform, find suitable partners to help with the implementation and use the city's support on an administrative level (how).
City of Baden	Smart Parking	Smart Mobility	Car drivers (who) can use an app for a digital parking guidance system (what) that controls access to available parking spaces and their reservation (how) and payment (why).

Table 1: 5 project examples and their business models

Functional Clusters

To better understand the enormous diversity of projects, we clustered each SC project in one Smart City dimension into more finely grained categories called "functional clusters". For example, "Digital Construction" in Smart Economy, "Smart Lighting" in Smart Environment, "City App" in Smart Government, "Smart Health" in Smart Living, "Parking" in Smart Mobility, and "Green Tech Education" in Smart People (see Figure 5). Our examples from above can be located in the following function clusters: "Alternative Energy" (Smart Road, biogas), City-Citizen Dialog (digital participation, BärnBoost), and Parking (smart parking).

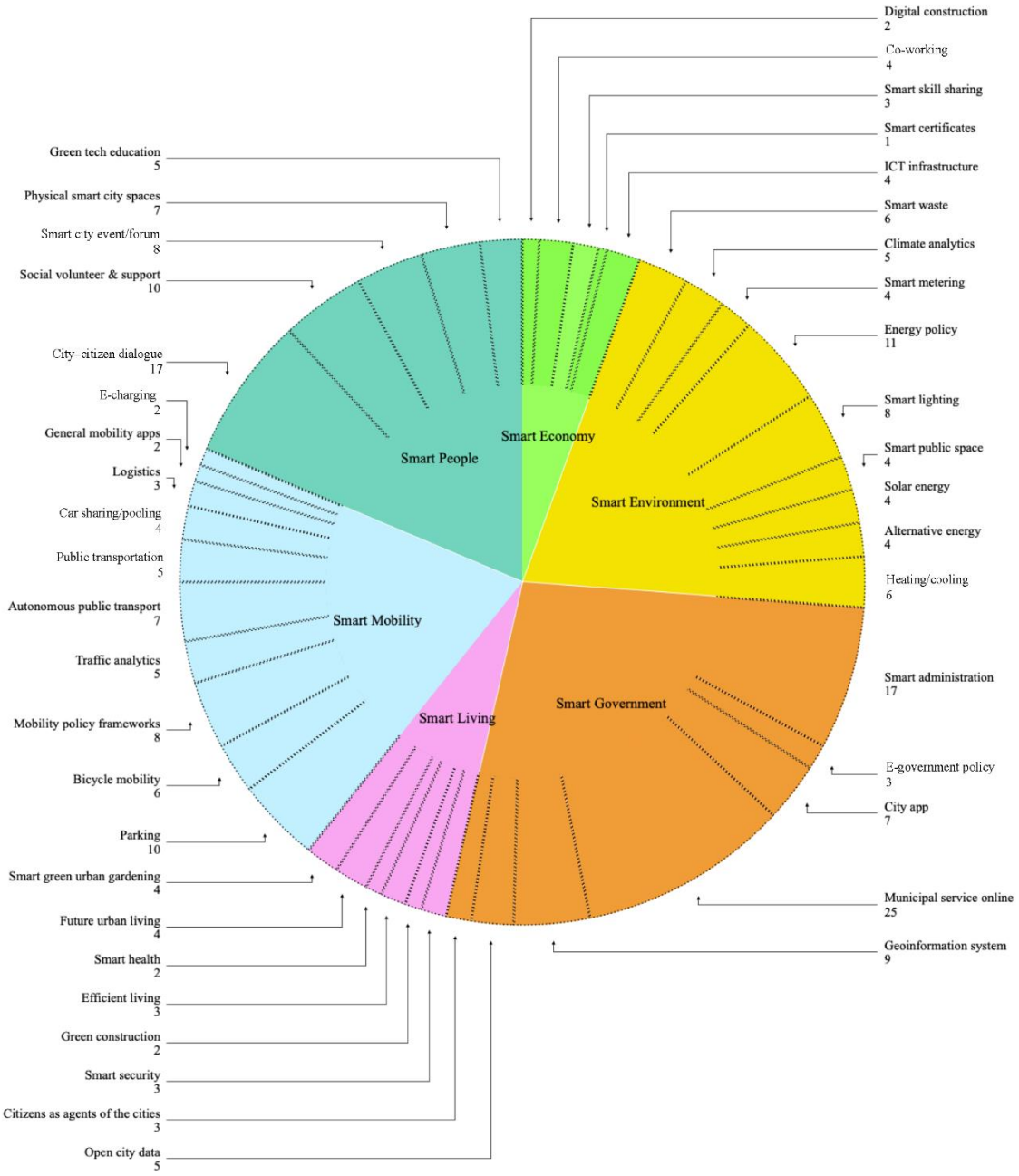


Figure 5: Smart City wheel with Functional Clusters

As displayed in Figure 5, it is very evident that Smart Government projects are relatively homogeneous, with one big functional cluster in "Municipal Service Online", comprising 25 projects and the functional cluster "Smart Administration" with 17 projects, while the other Smart City dimensions are much more fragmented. In the dimensions, we identified: Smart Mobility with 10 functional clusters, Smart Environment with 9, and Smart People 5, respectively. Smart Living (6 clusters for 18 projects) and Smart Economy (5 clusters for 14 projects) seem to be very fragmented. The greater the fragmentation, the greater the diversity of the "What" (value proposition) pillar in the business models.

Municipal Service Online, Smart Administration, and City–Citizen Dialogue are implemented in many cities. This observation could indicate that this business model is at the peak of ripeness. Furthermore, smart solutions for parking and social volunteering and support in communities is widely prevalent in Switzerland. A high number of cities also provide smart energy policies to become cleaner and more environmentally friendly. We see potential in learning from other cities and identifying the best practices of clusters with a high number of projects. Even projects with the same value proposition are often slightly different and might provide ideas to save capacities and increase efficiency.

In our dataset on Switzerland, smart solutions of digital construction, smart security, and smart health are infrequently used. Here, we see the potential for scaling existing projects because they do not depend on specific geographics but rather on technologies and often merely apps. Until now, Smart Economy and Smart Living BMs take a small share of the Smart City Wheel. Nevertheless, they have the potential to grow because they provide many different business models from a "What" (value proposition) perspective, which can all be scaled and extended to more Swiss cities.

Good character of the projects

Additionally, we evaluated the projects according to the seminal classification of goods and services by Elinor Ostrom (Ostrom et al., 1994) into private, public, common, and club goods. Public good theory posits that goods can be distinguished along with the characteristics of whether people can be "excluded" and whether the goods diminish with consumption ("subtractability", alternatively called "rivalry in consumption"). In the case of private goods, people can be excluded from consumption, and the goods diminish with consumption (e.g., food, clothes). In the case of common goods, people cannot be excluded, but the goods still diminish as people consume them (e.g., fish stocks, public parking with limited spaces). Public goods are characterized by non-excludability and are non-subtractable (e.g., air, national defense, or streetlights). Club goods are characterized by excludability and non-rivalry in consumption (e.g., cinemas). One implication of this theory is that public goods should be provided collectively because, otherwise, non-payers would free ride. The smart city projects in our data set show that 57 percent are public goods, nearly a quarter are private goods, 11 percent are club goods, and the remaining 9 percent are common goods. This might point to difficulties for cities in financing these projects since 57 percent are public goods and 9 percent are common goods. If the city does not provide these goods, there is little incentive for private firms to do so because of the possibility of customer free riding. However, the fact that 23 percent of the projects in our data set are private goods and 11 percent are club goods suggests the potential for these projects to be provided by non-public actors, saving money for the public, and increasing efficiency.

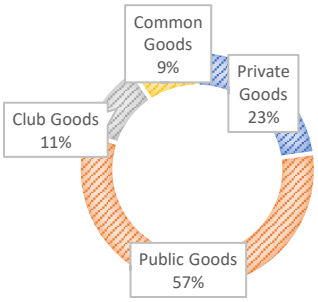


Figure 6: Good Characters of Projects

4.2 Identification and Analysis of 44 Smart City Business Model Archetypes

In this section, 44 business model (BM) archetypes (ATs) for smart cities (SCs) will be presented, and analyzed step by step. Firstly, the creation of the BM archetypes is sketched, and the most prominent of the four BM pillars in the archetypes is shown. Secondly, we relate the ATs to the SC dimensions and discuss their frequency and potential implications. Finally, we point to specific BM archetypes in each SC dimension and scrutinize some opportunities and challenges for SC development.

Smart City Wheel	Archetype	WHAT	WHO	HOW	WHY	Status	#	BM-Combination
Smart Economy	Co-working	Co-working	independents, employees	physical space	rent	established	4	ABCD
Smart Economy	Efficient city planning	Digital construction	housing sector stakeholders	data analytics	not known	pilot	2	ABCD
Smart Economy	High Quality Standard Self Obligation	Smart certificates	organizations local public and private	knowledge, interests, exchange	not known	pilot	1	ABCD
Smart Economy	LoRoWa/Glasfasernetz	ICT infrastructure	everybody local	technology hardware, maintenance	-*	established	4	ABC
Smart Economy	Time Exchange Membership Organization	Smart skill sharing	everybody interested local	website, maintenance	membership fees	pilot	1	ABCD
Smart Environment	Community-based renewables production	Solar energy	interested inhabitants	from the sun to electricity, sharing economy	rent	established	3	ABCD
Smart Environment	Data collection for research	Climate analytics	researchers and inhabitants	technology, knowledge, interests, research exchange	public financing	pilot	3	ABCD
Smart Environment	Energiewende	-	inhabitants	-	electricity payment	established	5	BD
Smart Environment	Energy-efficient street lightening	Smart lightening	everybody local	(on-demand) LED lightening	public financing, relative cost-efficiency	established	8	ABCD
Smart Environment	Environmental Well-being	-	inhabitants and public administration	cleaner physical spaces	-	pilot	10	BC
Smart Environment	Policy Frameworks	-	public administration	interests, research, knowledge, communication, implementation	public financing, relative cost-efficiency	established	12	BCD
Smart Environment	Research Collaboration	-	researchers	knowledge, interests, research exchange	-	established	3	BC
Smart Environment	Smart Metering	Smart metering	inhabitants and public administration	data collection and analysis, maintenance, communication	public-private financing, relative cost-efficiency	established	5	ABCD
Smart Environment	Sustainable Heating and Cooling	Heating/ cooling	inhabitants	energy supply technology	public financing, relative cost-efficiency	pilot	7	ABCD
Smart Government	Barrier-free city	-	disabled inhabitants	-	free service, public financing	pilot	2	CD
Smart Government	Citizens-City-Maintenance App	Citizens as agents of the city	active citizens, public administration	website/app, data analytics, digital skills, software maintenance	public financing, relative cost-efficiency	established	3	ABCD
Smart Government	City-Life-Information App	City app	inhabitants	the app, digital skills, maintenance	free to use, public	established	10	ABCD

					financing, relative cost-efficiency			
Smart Government	Data Business	Geoinformation system	everybody (open source)	data collection and analysis, software, maintenance	pay for data	established	3	ABCD
Smart Government	Digitalization of the Public Administration	Smart administration	employees of public administration	software, data collection, digital skills, security	public financing, relative cost-efficiency	pilot	14	ABCD
Smart Government	Empower Public Servants	Smart administration	employees of public administration	mobilization and empowerment	relative cost-efficiency	pilot	3	ABCD
Smart Government	Lean Bureaucracy through Digitalization	-	inhabitants	website, data analytics, digital skills, software maintenance	pay per service, relative cost-efficiency	established	24	BCD
Smart Government	Open Source City	-	everybody (open source)	data collection and analysis, software, maintenance	free to use, public financing	established	10	BCD
Smart Government	Smart City Standards Lobbying	E-government policy	membership organization public and private	knowledge, interests, research exchange.	membership fees	pilot	1	ABCD
Smart Living	Efficient Housing Data Analytics	Efficient living	-	housing technology/data collection	-	pilot	2	AC
Smart Living	Energy Choice Support	-/	interested inhabitants	interests, research, knowledge, communication, implementation	-	established	3	BC
Smart Living	Health Care Robotics	Smart health	elderly, health sector	data analytics, maintenance	private financing, relative cost-efficiency	pilot	1	ABCD
Smart Living	Safe City Data Analytics	Smart security	-	data collection and analysis	public financing, relative cost-efficiency	pilot	3	ACD
Smart Living	Transformational Knowledge Sharing	Smart green urban gardening	everybody interested local	website, maintenance	-	pilot	2	ABC
Smart Mobility	AI in Public Transport	Autonomous public transport	people traveling around the city	public transportation, autonomous	-	pilot	7	ABC
Smart Mobility	App-based Bicycle Services	Bicycle mobility	people traveling around the city, sporty, Y14-55	app, mode of transport, data analytics, maintenance	-	established	6	ABC
Smart Mobility	App-based Car-Services	Car sharing/ pooling	people traveling around the city (car drivers)	app, mode of transport, data analytics, maintenance	pay per service, private financing	established	2	ABCD
Smart Mobility	Carpooling Wherever You Are	Car sharing/ pooling	people traveling around the city	physical space, communication platform, sharing economy	pay per service, public–private financing	pilot	2	ABCD
Smart Mobility	Charging e-Cars	E-charging	people traveling around the city, car drivers	-	-	established	2	AB
Smart Mobility	Cleaner Public Transportation	Public transportation	people traveling	cleaner public transport	public transport tickets	established	5	ABCD

			around the city					
Smart Mobility	Intercity Logistics	Logistics	organizations	knowledge, technology, hardware	-	pilot	2	ABC
Smart Mobility	Smart Mobility Coordination	Traffic analytics	people traveling around the city	data collection and analysis	-/	pilot	9	ABD
Smart Mobility	Smart Pay & Park	Smart parking	people traveling around the city, car drivers	data collection and analysis, app, (paying service), (sensors and technology)	pay per service	established	7	ABCD
Smart People	Citizen Engagement Labs	-	interested inhabitants	mobilization and empowerment	-	pilot	10	BC
Smart People	Citizen-Innovation-Incubators	City–Citizen dialogue	everybody interested local	online mobilization and empowerment	free to use, public financing	pilot	4	ABCD
Smart People	Digital Participation and Mobilization	City–Citizen dialogue	everybody interested local	online mobilization and empowerment	free to use, public financing	pilot	14	ABCD
Smart People	For Profit Mass Event	Smart city event	everybody interested	event	tickets	established	1	ABCD
Smart People	Kids' Education for Future	-	Children	knowledge as common HOW	-	pilot	5	BC
Smart People	Local Voluntary Economies	-	everybody interested local	-	donation	established	8	BD
Smart People	Spreading Smart City Solutions	-	everybody interested	event, knowledge, interests, technology, hardware/construction	-	established	6	BC

Table 2: 44 Business Model Archetypes for Smart Cities in Switzerland with A-WHAT, B-WHO, C-HOW, D-WHY

The Creation of 44 Smart City Business Model Archetypes

Table 2 shows 44 archetypes, which were formed by abstracting the four BM pillars "Who", "What", "How", and "Why", and comparing them throughout our dataset of 251 SC projects. We set the condition that at least two BM pillars must converge to create an archetype (AT), while mostly three or four dimensions matched. As shown in Table 3, half of the SCBMATs (23) are consistent by converging on four pillars. In these 23 ATs, the SC projects share the same abstracted A-WHAT, B-WHO, C-HOW, D-WHY

BM-Combination	#
ABCD[2]	23
BC	6
ABC	5
BCD	3
BD	2
CD	1
AB	1
AC	1
ACD	1
ABD	1

Table 3: Business model pillar combinations

[2] A-WHAT, B-WHO, C-HOW, D-WHY

dimensions[3]. Additionally, we recognize that the customer (B-WHO) is a BM pillar that, for the most part, is similar in all SC projects and its corresponding ATs. This might be due to the high share of public goods in our BMs with the same target group, mostly city inhabitants.

The most noticeable differences can be found in the WHAT (value proposition) and WHY (financing mechanism) dimensions whereas the other dimensions are similar. On the one hand, one could conclude that funding and financing of public Smart City projects are still unclear and that the cities have not found profitable or efficiently funded projects so far. On the other hand, there is a diversity of potential approaches to finance specific smart city projects, which can be seen as opportunities to adapt SC policies differently. We dig deeper into the topic of financing of Smart City projects in the following paragraph.

The Archetypes in the Smart City Wheel

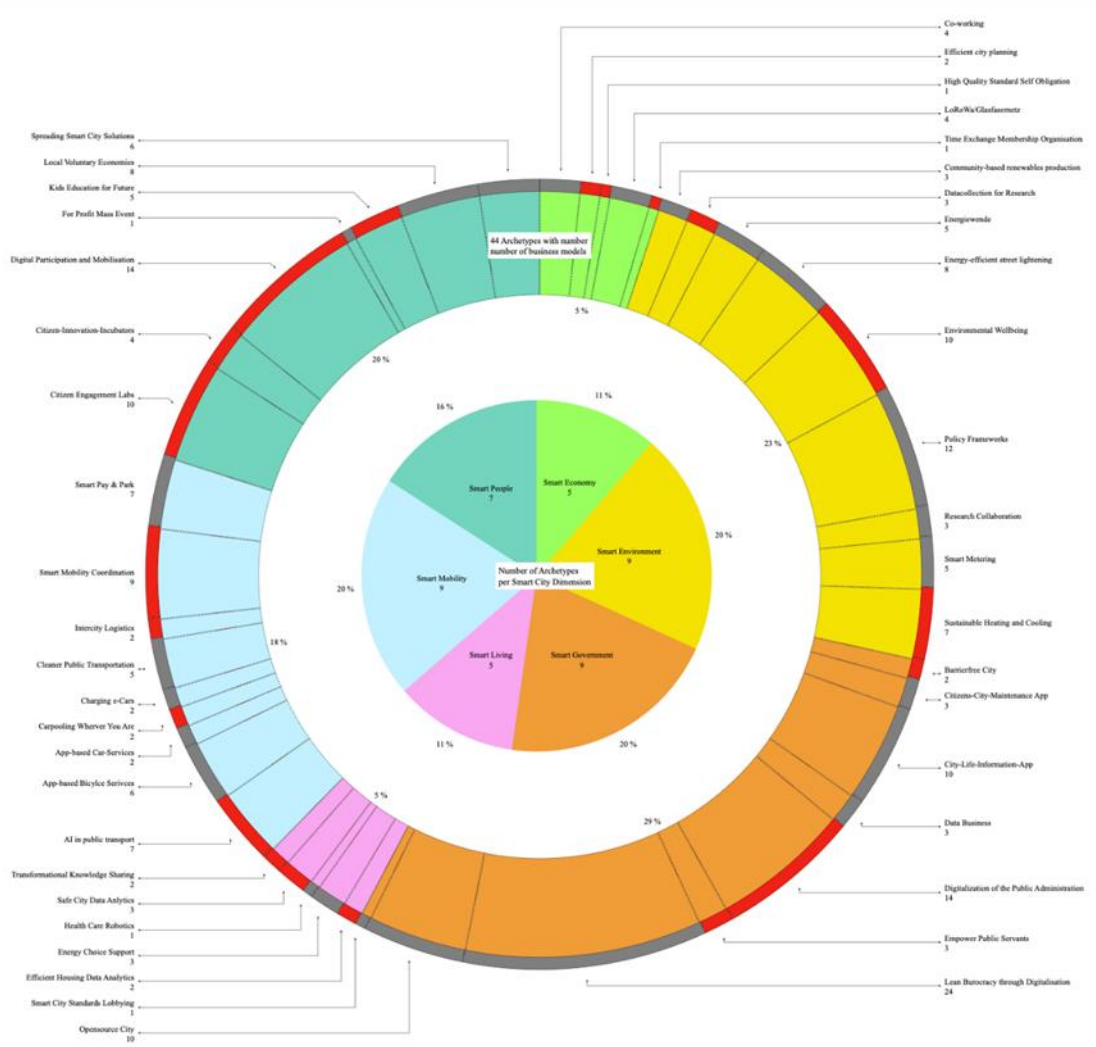
For further analysis, the SCBMATs have been sorted according to the smart city wheel (see Figure 7). We can see that Smart Government has a smaller number of different ATs compared to the number of business models it incorporates, which we discussed previously. Twenty percent of our archetypes concern Smart Government, while approximately thirty percent of all projects are Government business models. This observation allows for two interpretations: First, some Smart Government business model archetypes are already well developed; this model has been consolidated. Second, they might generally be easier for the project owners to implement and to scale and, therefore, are homogenously spread around the whole country. This idea can be emphasized by the fact that two-thirds of Smart Government archetypes have already been implemented and only the "Digitalization of the Public Administration", "Empower Public Servants", and "Barrier-free City" are in their pilot phase.

We can see a similar pattern – a smaller number of different ATs compared to the number of business models it incorporates – for the Smart People dimension. Projects in the archetypes "Digital Participation and Mobilization" and "Citizen Engagement Labs" are also easily multiplied across cities. However, unlike the Smart Government dimension, two-thirds of Smart People archetypes (6 out of 9) are pilot projects, indicating development and growth potential.

The share of Smart Environment and Smart Mobility archetypes and their corresponding individual number of projects is quite similar. The Smart Economy and the Smart Living Dimension are different. Each has five different archetypes, representing 11 percent of our identified archetypes. However, their share of the total number of projects is far smaller, with approximately 5 percent each. The share shows

[3] Find indications on the abstraction in the methodology section and relate to table X where all ATs are displayed.

Figure 5: Smart City Business Model Archetypes (SCBMATs) according to Smart City Wheel and # of Projects



Key: Smart City wheel representing inside the numbers of share of archetypes in each SC wheel dimension and outside the 44 archetypes with the number of projects in each dimension. Grey marked archetypes are established, red archetypes are pilot.

that the Smart Economy and Smart Living dimensions are still very fragmented, and only a few projects make up an individual archetype. In addition, 60 percent of the archetypes of both dimensions are still in their pilot phase. This result might indicate future growth and research potential in the fields of, for example, efficient city planning, high-quality standard self-obligation, transformational knowledge sharing, and efficient housing data analytics (see detailed descriptions in the appendix).

Looking at SCBM Archetypes in detail

This section presents several promising archetypes in greater detail. One archetype in the Smart Environment dimension is the "Community-based renewables production". Three Swiss projects constitute this archetype: The St. Gallen Solar Community, a photovoltaics citizens' group in Wil, and the participatory solar energy plant project in Yverdon-les-Bains. The "What" pillar is the solar energy

that is mixed into the energy source to increase the share of renewables in households' energy consumption. This service can be used by inhabitants of the three cities who become active participants in the solar energy community and register officially ("Who"). The special feature of community-based renewables production is that solar-energy users do not have to own a self-contained house but can also live in flats in the cities. This also serves to address the "How" of the business model. The solar or PV panels are housed in a single location in the city, and the customers can rent/buy one or more panels from this solar park. In this panel park, solar energy is transformed into electricity. The financing mechanism ("Why") is through the rental of the panels to inhabitants of the city. The inhabitants benefit from the solar energy produced by reducing their electricity bill; the amount of solar energy produced is subtracted from the total energy amount used. Six further very comprehensive archetype examples from very different fields are described in Table 4; these include "Time Exchange Membership Organizations", "Co-working, "Smart Metering", "Data Business", "Digitalization of the Public Administration", "Safe City Data Analytics", "Transformational Knowledge Sharing", "AI in Public Transport", "App-based Car Services", "Citizen Innovation Incubators" and "Kids' Education for the Future".

Smart City Wheel	Archetype Name	Business Model Archetype
Smart Economy	Co-working	Co-working offices or buildings for independents and employees offer a physical space with a working and networking atmosphere and the potential to organize events earning money from monthly rents by individuals or companies.
Smart Economy	Time Exchange Membership Organization	Smart Skill Sharing is a service platform for handcrafts where everybody interested locally can participate, offer, or use a service coordinated on a website, which has to be maintained and financed by membership fees.
Smart Environment	Community-based renewables production	Solar Energy supports the energy source used by interested inhabitants who are part of a renewables community in which solar energy is transformed into electricity by a solar or photovoltaic park used by those consuming the energy.
Smart Environment	Smart Metering	Smart Meters help make energy usage more efficient and decrease electricity costs for inhabitants and the public administration with the help of data collection and analysis, maintenance of the hardware, and communicating usage patterns financed publicly–privately to increase the relative cost efficiency.
Smart Government	Data Business	A Geoinformation System provides geo data to everybody globally by collecting and analyzing data and putting it into software to be maintained and financed by users paying for data.
Smart Government	Digitalization of the Public Administration	In smart administrations, employees of public administration learn how to use special software and handle data collection – therefore, increasing their digital skills and data security to decrease administrative costs in the long term. The process is publicly financed.
Smart Living	Safe City Data Analytics	Smart Security is provided to citizens by public servants through data collection and analysis such as the number of people at an event or the evaluation of crime and prediction of future crime by public financing not only to increase security but also to increase the relative cost efficiency of the processes.
Smart Living	Transformational Knowledge Sharing	Smart Green Urban Gardening is promoted through knowledge sharing by locals interested in greening the city. They research information themselves and contribute content to a website that collects and presents all the knowledge. The website is maintained by the project owner.
Smart Mobility	AI in Public Transport	Autonomous Public Transport supplements the service provided for people traveling around the city in public transport, which may lead to a more frequent or more extensive network of buses once the pilot phase is completed. A driver still has to control the movement of the vehicles.
Smart Mobility	App-based Car Services	A car can be rented temporarily by people with a driving license traveling around the city with an app that offers location and cost information about the chosen car and payment functions. They can then use the car for as long as they want in a particular geographical space. They can be sure that the car is well maintained because they pay per service.
Smart People	Citizen-Innovation-Incubators	Cities promote innovation driven by all locals who want to implement or realize their ideas. Cities motivate and empower citizens with financial support and organizing meetups and inspiration platform that are free to use and publicly financed.
Smart People	Kids' Education for Future	Children are the main target group for providing education in the field of data or environmental sciences.

Table 4: Examples of promising Business Mode Archetypes

5. CONCLUSION

This paper sets out to map the landscape of smart city business models in Switzerland in order to better understand which types of initiative are currently working, which areas are well established and thriving, and where potential for development is to be found. The paper analyzed 251 smart city projects throughout Switzerland and analyzed them using an established business model framework. Furthermore, they were mapped according to the smart city wheel dimensions. The research found: 69 projects (27%) related to *Smart Government*; 52 projects (21%) *in Smart Environment* and *Smart Mobility*, respectively; 47 projects (19%) in *Smart People;* and, bringing up the rear, 18 projects (7%) in *Smart Living* and 14 projects (5%) in *Smart Economy*.

As a second analytical step, all 251 were condensed into 44 broader and more abstract Smart City Business Model Archetypes (SCBMATs). Examples in this field are “Time Exchange Membership Organizations”, “Digitalization of the Public Administration”, “Safe City Data Analytics”, and “Citizen Innovation Incubators”. The analyzed list of 44 BMATs can help cities and public administration officials to orient themselves easily toward SC development.

Generally, we observed that the field of smart government offers the most widely represented and ripest field from a business model perspective. In particular, the fields of Smart Economy and Smart Living are small, showing a high degree of fragmentation in BMs and BMATs with projects often remaining in the pilot phase. In consequence, this area offers enormous potential for further development in and mutual learning about smart city development.

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7. APPENDIX

Table 8.1: Codebook for content analysis

Code Group	Code Name	Definition of Code
0. Smart City Dimensions based on Oliver Gassmann et al. 2018	Smart Economy	Establishment of an innovative, resource-conserving, and open economic system that relies on networking, cooperation, circular economy, and flexible working models
	Smart Environment	Resource and environmentally friendly development of the urban environment (buildings, public spaces, infrastructure systems), promotion of renewable energies, and use of synergy potentials
	Smart Government	Intelligent, needs oriented, and transparent control of urban administrative processes and infrastructure as well as the interaction between residents and the administration
	Smart Living	Ensuring a barrier-free, communal, safe, and healthy life based on equal opportunities
	Smart Mobility	Creating clean mobility and logistics, promoting efficient means of transport, intermodality, and sharing concepts
	Smart People	Using and promoting residents' resources and ensuring 'lifelong learning', participation, social integration, and openness to creativity
0.0 Good Characteristics	Club Good/Low congestion Good – Good Characteristics	Excludable and non-rival -> television broadcasting Netflix
	Common Good – Good Characteristics	Non-excludable but rival -> fish in the open sea
	Private Good – Good Characteristics	Excludable and rival car, house, food
	Public Good-Good Characteristics	Non-excludable and non-rival-> air to breathe, sunset, flowers in the garden of a house facing the street, street lighting, parks, ...
1. WHAT is the value proposition? – BM The second dimension describes what is offered to the target customer or, put differently, what the customer values. This notion is commonly referred to as the customer value proposition (Johnson, Christensen, and Kagermann, 2008), or, more simply, the value proposition (Chesbrough and Rosenbloom, 2002; Chesbrough, 2010; Morris, Schindehutte, and Allen, 2005; Teece, 2010). According to Osterwalder (2004, p. 43), it can be defined as an "overall view of a company's bundle of products and services that are of value to the customer." (Gassmann et al., 2014)	Value proposition – BM – WHAT	What customer problem are we attempting to solve? What customer needs do we try to satisfy? What segment-specific products and services do we offer our customers? What value do we generate for our customers? How does our value proposition differ from that of the competition?
2. WHO are the target customers? – BM Every business model serves a certain customer group (Afuah and Tucci, 2001; Chesbrough and Rosenbloom, 2002; Hamel, 2000; Teece, 2010).	Customer segments – BM – WHO	Have we segmented our customer base? What is the business relationship to be sought in respect of each customer segment?

Thus, it should answer the question "Who is the customer?" (Magretta, 2002, p. 87). Drawing on the argument from Morris, Schindehutte, and Allen (2005, p. 730) that the "failure to adequately define the market is a key factor associated with venture failure", we identify the definition of the target customer as one central dimension in designing a new business model. (Gassmann et al., 2014)	Customers – BM – WHO	Who are our target customers?
	Distribution channels – BM – WHO	Through which channels do we reach our customers? Are these channels integrated with our other business activities? Do the channels correspond to our customers' needs?
	Stakeholder groups – BM – WHO	For whom do we generate (added) value?
3. HOW is value created? – BM To build and distribute the value proposition, a firm has to master several processes and activities. Those processes and activities, along with the involved resources (Chesbrough and Rosenbloom, 2002; Hedman and Kalling, 2003; Johnson, Christensen, and Kagermann, 2008; Osterwalder, 2004) and capabilities (Morris, Schindehutte, and Allen, 2005), plus their orchestration in the focal firm's internal value chain, form the third dimensions in the design of a new business model. (Gassmann et al., 2014)	Activities and competencies – BM – HOW	What activities are essential to ensure that we deliver on our value proposition? What activities are we equipped to carry out with our existing competencies? What new activities and what competencies do we need in addition?
	Internal resources – BM – HOW	What resources are essential to ensure that we deliver on our value proposition? How can we allocate the resources efficiently?
	Partners – BM – HOW	Who are our most important partners? Who are our main suppliers? What activities can our main partners undertake, or what essential competencies do they have? What do our main partners get out of working with us, and how can we bind them to us?
4. WHY is revenue created? – BM The fourth dimension explains why the business model is financially viable, thus it relates to the revenue model. Its inclusion in our business model conceptualization is supported by the work of various authors such as Chesbrough and Rosenbloom (2002), Johnson, Kagermann, and Christensen (2008), Mahadevan (2000), Magretta (2002), Morris, Schindehutte, and Allen (2005), and Teece (2010). In essence, it unifies aspects such as the cost structure and the applied revenue mechanisms and points to the elementary question of any firm – namely, how to make money in the business. (Gassmann et al., 2014)	Cost drivers – BM – WHY	What are the principal costs in our business model? What are the financial risks? How do we address them?
	Initial financing – BM – WHY	How is the infrastructure financed? How is the initial financing organized?
	Revenue streams – BM – WHY	What are our sources of revenue? What is the customer willing to pay for? How do customers pay at present? How should they pay in the future? How much does each revenue stream contribute to the overall turnover?
9. Other	Challenges	Challenges or Problems for the project
	Maturity of the project	Pilot, age
	Policies, politics, legislations	What are the most important laws/legislations/etc. that the project builds/depends on?
	Purpose	Not a value proposition-> the overall goal of the project. When the project has been created, what did they postulate? The difference between is and ought -> purpose is the ought, value = is. Outlook and vision
	Success/Failure	Success and failure

Table 8.2: Abstract business model pillars with multiple uses

Abstract Income Generation Why	
cost savings compared to previous mode	55
public financing	39
free service, financed by the city	31
private and public financing	21
free service, financed by cantons, cities, and municipalities	15
pay per service	11
not known	11
public transport tickets	10
pay per special service and save costs	9
sponsorships and donations	7
pay per service and save costs	5
electricity payment	5
monthly rent	4
voluntary work, donations	3
pay per product	3
pay for data	3
membership fees	3
free service, financed by EU and cities	2

Abstract Customer (WHO)	#
inhabitants	40
interested inhabitants	26
everybody interested locally	25
people traveling around the city	22
people traveling around the city, car drivers	16
everybody locally	16
everybody (open source)	14
employees of public administration	11
public administration	10
house owners	8
people traveling around the city, sporty, Y14-55	7
inhabitants and public administration	7
active citizens, public administration	4
inhabitants, children	4
everybody interested	4
researchers and inhabitants	4
companies	3
independents, employees	3
employees traveling around the city	3
employees	2
researchers	2
children, schooling sector	2
politicians	2
housing sector stakeholders	2

Abstract HOW	
website, data analytics (DA), digital skills, software maintenance	20
online mobilization and empowerment	17
data collection and DA, software, maintenance	15
interests, research, knowledge, communication, implementation	14
mobilization and empowerment	11
software, data collection, digital skills, security	11
data collection and DA, app, knowledge	10
app, mode of transport, data analytics, maintenance	8
app, digital skills, maintenance	7
knowledge, interests, and research exchange	6
tech, knowledge, interests, and research exchange	6
energy supply technology	5
public transportation, autonomous, more stops	5
cleaner public transport	5
data collection and analysis, app, paying service	4
knowledge, technology, hardware	4
hardware, maintenance, tech, sensors, data analytics	4
measuring, DA, maintenance, communication	4
technology hardware, maintenance	4
physical space, knowledge	3
data collection and analysis, knowledge	3
website, maintenance	3
on-demand LED lightening	3
sensors and devices, data analytics, maintenance	3
knowledge, interest, tech, hardware/construction	3
physical space	3
data analytics and technology devices	3
from the sun to electricity, sharing economy	3
training, workshops	2
construction	2
sensors/devices, data analytics, maintenance, support	2
all-in-one mobility proposal with all modes of transportation and payment option	2
website, DA, digital skills, maintenance, blockchain	2
physical space, communication platform, sharing eco	2
information and communication	2
software, data collection, security	2
customized LED lightening	2
information and communication, workshops, events	2
sensors and devices, data analytics, app	2
website, data analytics, AI, software maintenance	2
smart and on-demand LED lightening	2
public transportation, autonomous	2
data analytics, website, maintenance	2