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Where do Smart Cities grow? The spatial and socio-economic configurations of smart city development

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ABSTRACT

In the last decade, a number of smart city initiatives have flourished around the world. While the literature is ripe with descriptions of those projects and pioneering cities, there is far less systematic research on why some cities are more advanced than others. As single locating entities, cities are posited to have strong geographic rootedness. Hence, spatial and socio-economic context, considered as the main stimulant of organizational innovation, can be particularly important for cities. We investigate 22 Swiss cities with smart city projects and use fuzzy-set Qualitative Comparative Analysis to determine the configuration of conditions that make some cities more advanced than others in their smart city development. Results indicate that a configuration of high share of service sector, presence of research institutions and high urban density is sufficient for the outcome, whereas population size, new residential development and participation to international networks appear as less important. By providing insights into the spatial and socio-economic underpinnings of smart city development, the study contributes to the understanding of the geographies of smart cities.

1. Introduction

The last decade has seen the flourishing of smart city initiatives and projects around the world (Lee, Hancock & Hu, 2014). Although various definitions are proposed (Yigitcanlar et al., 2018), the concept of smart cities often includes the use of information and communication technologies (ICT) such as sensors, internet of things, deep-learning algorithms and artificial intelligence to improve municipal services and infrastructure for the benefit of environment, resources and well-being of citizens (Ahad, Paiva, Tripathi & Feroz, 2020; Appio, Lima & Paroutis, 2019; Bibri, 2018; Marsal-Llacuna, Colomer-Llinàs & Meléndez-Frigola, 2015; Said & Tolba, 2021). Most of the smart city initiatives entail service and product innovations (Walker, 2013): from street lighting that adapts to the movement of vehicles and pedestrians, to irrigations systems tracking weather and soil moisture for the optimization of water consumption to algorithms enabling predictive policing against break-ins and apps simulating the changes in city landscape. The development of smart cities is portrayed as a new urban development paradigm that can potentially increase the efficiency of services or the quality of living, while minimizing the environmental impacts originating from cities (Bibri, 2019). Given all these potential benefits, it is important to understand what makes cities more or less engaged with smart city projects.

Cities, as dense agglomerations where economic actors, skilled human capital and infrastructure are co-located, are often associated with innovation (Rodriguez-Pose & Wilkie, 2016). In fact, in both developing and developed countries, innovation is mostly concentrated in large, urban areas (Rodriguez-Pose & Wilkie, 2016). This is also largely valid for smart cities which are not evenly dispersed within the urban spaces of a region or a country. Instead some cities stand out as leaders or innovation hubs. While the literature is ripe with descriptions and analysis of those pioneering cities (e.g. Raven et al., 2019; Trencher, 2019; Yigitcanlar, Han, Kamruzzaman, Ioppolo & Sabatini-Marques, 2019) and the associated generic features (Silva, Khan & Han, 2018), there is far less research systematically investigating the underlying fabric and the place-specific characteristics of smart cities (for an exception, see Araral, 2020 and Nicolas, Kim & Chi, 2020). In this article, we thus strive to find out what configurations of spatial and socio-economic conditions are associated with smart city development.

As single locating entities, cities are posited to have strong

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geographic rootedness (Shearmur & Poirier, 2016b). Hence, the spatial and socio-economic context that is often considered as the main stimulants of organizational innovation (Damanpour & Schneider, 2006; Tornatzky & Fleischer, 1990) can be particularly important for cities as well. Therefore, in this study we specifically focus on the relation between spatial and socio-economic attributes of cities and their smart city development. Given the lack of a specific framework directly addressing this relation, we refer to related strands of research in public administration, economic geography and innovation literature to deduce the set of potentially relevant conditions. While economic geography mostly focuses on innovation in the private sector, the innovation literature in public sector is not specific to smart cities. Therefore, we synthesize insights from these fields and empirically assess to what degree the most important conditions derived from these literatures can help us understanding the geographies of smart cities.

In doing so, we conceive of cities as constituted by various combinations of spatial and socio-economic elements (Gilbert & Campbell, 2015). In order to determine the combination of conditions favourable for the development of smart city projects, we rely on the configurational method of fuzzy-set Qualitative Comparative Analysis (fsQCA) (Ragin, 2008). Empirically, we focus on cities in Switzerland. This empirical setting is relevant because although Switzerland is ranked high in the Global Innovation Index, it lags behind in innovation projects in the public sector (Schedler, Guenduez & Frischknecht, 2019). Smart city initiatives have also been progressing slower compared to other cities worldwide (Wiederkehr, Kronawitter & Geissbühler, 2019). One plausible explanation for this is the absence of large metropolitan centres. Compared to some of the pioneering smart cities in Asia and Europe, Swiss cities are smaller in size and population. The distances between the cities are also smaller compared to most of the other countries and there is relatively less urbanization pressure and regulatory push from regional and federal government. These factors make Switzerland a *crucial case* (George & Bennett, 2004) for analysing whether key conditions known to be conducive for the innovativeness of cities in general, such as size, density and proximity, are also important for the development of smart city initiatives in such a distinctive setting where the standard of living is already high and there is relatively low urbanization pressure. Furthermore, focusing on a given jurisdiction allows us to compare cities that are under relatively similar macroeconomic, political and institutional context.

The remainder of the paper is structured as follows. In the next section, we refer to the innovation studies, economic geography and the recent strand of smart city literature to derive the conditions pertinent for the proliferation of smart cities. We then introduce the case of Switzerland in Section 3 and identify the conditions that can be particularly relevant for our empirical setting. The operationalization of the conditions and the analytical method are described in Section 4. We present and then discuss the results in Section 5 and 6, respectively.

2. Drivers of public sector innovation and smart cities

While the smart city concept is relatively new, innovation has been a recurring theme for cities and local governments (Borins, 1998; Light, 1998; Walker, 2013). Cities have considerable resources and leeway for developing and implementing environmental and infrastructure-related projects, and can thus be areas of transformative innovation, as has been shown for issues related to migration, energy or finances (Hersperger, Gennaio Franscini & Kübler, 2014; Kaufmann, 2019; Kaufmann & Sidney, 2020; Kübler, Rochat, Woo & van der Heiden, 2020). Even though public sector organizations such as city administrations may not be primarily driven by profit and market competition, the demand for efficient and higher quality services fulfilling the needs of users (i.e. citizens) make innovation a highly relevant quest (Shearmur & Poirier, 2016b).

Various conditions are associated with the innovative performance of cities, and thus can be relevant for smart city development. First, one of the most widely documented conditions for innovation at the city level is the size of a municipality. Large cities are posited to be more innovative due to several reasons. To begin with, they usually have larger resources including skilled human capital (Rodriguez-Pose & Wilkie, 2016). Large urban areas also tend to feature diverse socio-economic actors and complex environments, which might be conducive to innovation (Damanpour & Schneider, 2006). A high number of inhabitants is also associated with a greater demand for the improvement of services (Arduini, Belotti, Denni, Giungato & Zanfei, 2010; Gonzalez, Llopis & Gasco, 2013; Reginato, Paglietti & Fadda, 2011). Large cities often face the challenge of delivering services efficiently to large number of residents with diverse needs and preferences. Such external pressure in the form of public or political demands can stimulate innovation.

Independent of the absolute size of a city, the increase in population is also explicitly associated with innovation (Walker, 2008). In addition to increased need of efficient services to cope with greater demand, the new residential and infrastructural development induced by population increase provide opportunities for experimentation with new technologies and practices, making new urban spaces as testbeds for innovation.

Socio-economic and professional profile of inhabitants are also deemed as important antecedents of innovation in local governments (Bhatti, Olsen & Pedersen, 2010; Hansen, 2010; Kwon, Berry & Feiock, 2009; Shearmur & Poirier, 2016a). While the former can be a proxy of municipalities' resources, affluent and well-educated population can also mean a greater demand for high quality services which leads municipalities to innovate more (Shearmur & Poirier, 2016b). A recent study on the innovativeness of Canadian municipalities found that richer municipalities with larger work-derived income and high level of economic development are more innovative (Shearmur & Poirier, 2016a). While the income inequality did not correlate with innovativeness, employment rates as well as the share of population with science, business, arts and health related occupations did. On the other hand, primary sector and manufacturing related occupations seemed to have a negative effect on innovation (Shearmur & Poirier, 2016a).

Another common argument for the innovative character of cities is the co-location of economic actors and research institutions that contribute to the generation and flow of knowledge (Rodriguez-Pose & Wilkie, 2016). The creation of innovation through the interactions amongst government, industry and university is conceptualized with the *triple helix model* (Etzkowitz, 2008; Leydesdorff & Deakin, 2011). While public-private partnerships were the dominant form of dyad in the industrial society, with the expansion of the service sector and decline of manufacturing industry, universities' role in innovation become more prominent as shown by numerous case studies from Europe, USA and South America (see Ranga & Etzkowitz, 2013). Universities also play a critical role in the context of smart cities (Ardito, Ferraris, Messeni Petruzzelli, Bresciani & Del Giudice, 2019; Ferraris, Belyaeva & Bresciani, 2018). Apart from being knowledge providers and incubators for start-ups (Ferraris et al., 2018), studies show that universities also serve as knowledge intermediaries and gatekeepers (Ardito et al., 2019). This entails mediating the knowledge management between firms and local government, facilitating the involvement of diverse stakeholders including public and enabling knowledge transfer within the network of entities. As a result, universities are viewed as a key element of knowledge based urban economies that create smart cities.

The geographical proximity of various socio-economic actors are also widely acknowledged as important for innovation (Ferru & Rallet, 2016). Dense urban settings with lower physical distances are argued to be favourable for communication and knowledge spillovers (Audretsch & Feldman, 1996; Feldman, 1994; Storper & Venables, 2004). Although geographic proximity may not be a prerequisite for innovation and learning due to the advancement of information and communication technologies, it is still crucial especially for the transfer of tacit knowledge (Boschma, 2005). Physical proximity also enables networks characterized by high level of trust and strong collaboration through dense and strong ties (Coleman, 1988) that are conducive for the transfer of

Table 1
An overview of key spatial and socio-economic conditions conducive for the innovativeness of cities.

Name	Description	Mechanism of Influence	Some key references
Population (size)	Population, larger urban areas	-Larger resources -Diverse needs and preferences of residents -Greater demand for improvement of services	Arduini et al. (2010); Damanpour (2006) Gonzalez et al., (2011); Reginato et al., (2011); Rodriguez-Pose & Wilkie, 2016)
Population and Residential Growth	Rate of increase in the population and new residential spaces and infrastructure	-Larger pressure on services -Greater opportunities for experimentation as a result of new spaces and infrastructure	Walker (2008)
Occupational profile	Share of third sector (service sector) in the employed population	-Increased ICT use -Larger demand for innovation and digitalization	Shearmur and Poirier (2016b)
Universities	Presence of universities and research centers	-Increased knowledge production including start-ups and spin-offs -Universities as potential mediators between public and private sector -Attracting younger and educated population open to innovation	Ardito et al. (2019); Ferraris et al., (2018) ; Leydesdorff & Etzkowitz (1998); Range & Etzkowitz (2013);
Density and urbanisation	Concentration of urban dwellers, firms and economic activities	-Closer geographical proximity fostering denser networks and knowledge spillovers -Transfer of tacit knowledge -Economies of scale	Audretsch, (1998); Boschma (2005); Ferru and Rallet (2016); McKinsey & Company (2011); The World Bank (2017)
Networks	Membership and embeddedness in international city networks	-Access to knowledge and best practices from distant sources -Normative and mimetic pressure for innovation	Gieske et al., (2016); de Vries et al., (2015); Svara (2013)

complex knowledge (Uzzi, 1997), cooperation, and potentially radical innovation (Mandell & Keast, 2013). Furthermore, dense urban areas (i.e. densification) are also associated with economies of scale for both production and distribution of goods and services (The World Bank, 2017; Wenban-Smith, 2009). For instance, in densely populated centres, it can be 30 to 50% cheaper to provide basic services such as education, housing and water than in sparsely populated areas (McKinsey & Company, 2011).

In addition to close geographical proximity, interaction and embeddedness in distant networks are also conducive for learning and innovation (Gieske, Van Buuren & Bekkers, 2016). In fact, distal, looser ties are known to be advantageous for acquiring novel information (Granovetter, 1973). A review of empirical works on the environmental antecedents of public sector innovation have found the participation to networks and inter-organizational relationships as one of the most frequently observed conditions (De Vries, Bekkers & Tummers, 2016). A study on local government in the United States have also found a strong positive relation between the membership to the organization "Alliance for Innovation" and the commitment of the administration to innovation (Svara, 2013). Inter-city networks and alliances can serve as knowledge hubs and spaces for exchange and collaboration amongst cities that face similar demographic or environmental challenges. Learning from other cities' experiences and best practices can reduce time and resources required for finding and implementing solutions (Canals, 2019). Hence, such networks can contribute to diffusion of innovative ideas as cities tend to look for solutions and mimic the successful examples (i.e. mimetic isomorphism). Likewise, the standards and visions set by the pioneering cities can also influence other members to follow a similar innovative culture (i.e. normative isomorphism).

The aforementioned conditions and their relevance for smart cities are summarized below in Table 1. We hypothesize high population and residential growth, higher share of service sector employment, presence of universities, urbanization and membership to international networks to be conducive for smart city development and use QCA to determine what configurations of these conditions are associated with this outcome.

3. Cases and methods

3.1. The Swiss context

Municipalities comprise the lowest level administrative unit in Switzerland. Compared to many other countries in the world, Swiss cities, municipalities and metropolitan regions are smaller in size, density and population. Of the total 2212 municipalities, only about 1% has population more than 30′000 and 20% have more than 5′000 inhabitants. The 162 municipalities with more than 10′000 inhabitants are denoted as cities, but this is only a statistical classification and does not bear any political or legal effect (Linder 2012). Swiss cities and municipalities are also granted a large degree of autonomy in legislating and planning activities within their jurisdiction (Horber-Papazian, 2007). According to the principle of subsidiarity, unless explicitly assigned to higher political levels, all activities confine within the scope of municipal authorities (Debela, 2020). Hence, in most places, they are also responsible for local infrastructure, land use planning, natural resources management and elementary schools (Fleiner, Misic & Topperwien, 2012). Municipalities also have the right to impose taxes. There is a high degree of fiscal decentralization such that on average municipalities cover 87% of their spending (Bulliard, 2005). Aside from a few pioneering cities, the "Smart City Movement" has been relatively slow to catch on in Switzerland (Wiederkehr et al., 2019). However, there is growing attention as more cities start to develop Smart City visions, plans and projects. There are also emerging platforms such as Smart City Hub[1] or Smart City Alliance[2] that promote knowledge transfer and networking amongst cities, companies and research institutions.

3.2. Methods

3.2.1. Set of cases

The particularities of the Swiss case including the subsidiarity principle and fiscal decentralization as well as the lack of a legal or politically set definition for cities make it difficult to determine a meaningful threshold to delineate our study sample from a total population of more than 2′000 cities and municipalities. For practical reasons, we first included and screened only cities with a population larger than 15′000. Out of these 85 cities, 22 had at least one smart city project[3]. A breakdown of these projects by categories are provided in the appendix (Table A12). Since our aim is to find out why amongst the sample of

[1] www.smartcityhub.ch
[2] https://smartcityalliance.org/
[3] As of December 2019, when data collection for this study was carried out.

cities that had some level of engagement with smart city development some are more advanced than others, we focus our analysis on those 22 cities that have at least one smart city project and explain the varying levels of progress. We use fuzzy-set Qualitative Comparative Analysis (fsQCA) to determine the configurations of conditions conducive for the progress in smart city development. In the rest of this section, we briefly introduce the analytical method, QCA and present our data collection and operationalization of conditions.

3.2.2. Qualitative comparative analysis

Qualitative comparative analysis (QCA) is an analytical technique for determining configurations of conditions that associate with a given outcome (i.e. that are necessary and/or sufficient for the occurrence of an outcome). Although QCA has been used for various purposes such as for comparing the productivity of environmental policy forums (Fischer & Schlaepfer, 2017), for studying stakeholder influence on policy processes (Duygan, Stauffacher & Meylan, 2021) or for identifying the geographical determinants of radical technological paradigms (Gilbert & Campbell, 2015), its use in smart city research is largely underutilized (Ruhlandt, 2018). In recent studies, QCA was used for identifying business models for smart cities (Abbate, Cesaroni, Cinici & Villari, 2019) and investigating cities' use of data and analytics (Ruhlandt, Levitt, Jain & Hall, 2020).

Based on the set-theoretic logic, QCA explains the relations amongst entities in terms of set relations (Ragin, 2008). For example, the statement "X is a necessary condition for the outcome Y", implies X to be the super-set of Y in the sense that whenever Y is present, X is also present. On the other hand, X becomes a sufficient condition for Y, when it is a sub-set of Y such that whenever X is present, Y is also present. Since social entities rarely represent a full membership or non-membership relation with one another, fuzzy-sets (Zadeh, 1965) were introduced to account for relations exhibiting partial memberships. To incorporate fuzzy-set logic in QCA (fsQCA), raw data of the outcome and conditions are calibrated on an interval level scale to designate membership scores of cases to a given set. We describe the calibration procedures we followed for the outcome and conditions in the next-subsection.

The analysis of necessity and sufficiency form the basis of QCA and are carried out by the software fs/QCA 3.0 (Ragin & Davey, 2016). A consistency scores expresses to what degree a postulated subset relation between a given combination of conditions and an outcome is empirically observed. A coverage score shows to what extent the outcome is explained by a condition or a combination of conditions (Schneider & Wagemann, 2012). The sufficiency of a condition is assessed in a truth table that comprises all logically possible configurations of conditions. The ones that fulfil the consistency criteria are then subject to further analysis (i.e. logical minimization) (Schneider & Wagemann, 2012) in which the solution term is reduced by removing the redundant conditions.

3.2.3. Data collection, operationalization and calibration of outcome and conditions

Outcome: Number of smart city projects (SMART). To assess the innovative performance of cities, we take into account their number of smart city projects. The data on projects stems from a search that was carried out between October-December 2019 on the official websites of city administrations. In order to account for projects that may not be disclosed on official websites, we also conducted web search where we combined the name of the municipalities with the terms "smart ville" (French), "smart city", "smart", "digitalisierung/digitalisation", "ville intelligente" (French), "smart Gemeinde" (German). We included a total of 122 implemented, ongoing and planned projects. We excluded feasibility studies and in order to establish a standard, we made sure that the projects included are not just upgrades or retrofits of existing technologies but feature novel technologies and applications. Projects cover a wide range of applications from driverless bus services, remote building management, tracking of residents' mobility to 3D city models and augmented reality. Out of the 22 cities included in the analysis, 11 have only one single project while the rest of the cities have number of projects between 3 and 21. We calibrated cities with only one project as belonging to non-membership set (with a score of 0.0), while the ones with three projects as belonging rather to the outcome set of SMART (0.6). Hence, we assumed a strong difference between the presence of only one project that may be for showcase (Laurent & Pontille, 2018) from the activity of planning and running multiple projects, which in our view indicates a larger accomplishment and sustained level of commitment. For the rest, cities with 7–8 projects are calibrated with score of 0.8, 14–16 with 0.9 and cities at the top with 19 and 21 projects with full membership score of 1.0.

The raw data and fuzzy-set scores for the outcome and conditions are shown in Table A1 and A2 in the Appendix. An overview of data sources and the operationalization procedure for outcome and conditions is given in Table 2.

Condition 1: Population (POP). We consider population of cities as an important indicator of their size and resources. Population (POP) was calibrated with direct calibration method (Ragin, 2008) which requires the researcher to assign three anchors as full-membership (0.95), point

Table 2
Description of the outcome, conditions, data sources and the operationalization procedure.

	Description	Data Sources	Operationalization
SMART	Number of Smart City Projects	Cities (websites)	Manual fuzzy-set membership scores: 0: <3; 0.6: 4: 0.7; 0.8: 7–8; 1: 14–21
POP	Population	Federal Statistical Office*	Direct calibration: Full-membership score (0.95): 100′000; cross-over point (0.5): 50′000; Non-membership score (0.05): 20′000
NEWRDEVP	New Residential Development per 1000 in a given year (2016)	Federal Statistical Office*	Direct calibration: Full-membership score (0.95): 10; cross-over point (0.5): 6; Non-membership score (0.05): 2
SERVSEC	Share of tertiary sector employment	Federal Statistical Office*	Direct calibration: Full-membership score (0.95): 90%; cross-over point (0.5): 78%; Non-membership score (0.05): 70%
UNIRES	Presence and size of universities	Universities (websites)	Manuel fuzzy-set membership scores: 1: > 30′000; 0.9: 15′000–30′000; 0.8: 10′000–15′000; 0.7: 7′500–10′000; 0.6: < 7′5000
URBAN	Urbanization Index	Federal Statistical Office**	Crisp-set: 1: Densely populated area; 0: Medium densely populated area
INTNETW	Membership to International Networks with environment, climate, change sustainability, innovation	Websites of the following international networks: ICLEI, Climate Alliance, Covenant of Mayors for Climate Change and Energy, EuroCities, Energy Cities, Energy Cities Alliance, C40	Manual fuzzy-set membership scores: 0: 0; 0.6: 1; 0.8: 2; 1: 4

*Swiss Federal Statistical Office (2019). "Regionalporträts 2019: Kennzahlen aller Gemeinden" https://www.bfs.admin.ch/bfs/de/home/statistiken/regionalstatistik/regionale-portraets-kennzahlen/gemeinden.assetdetail.7786544.html.
** https://www.atlas.bfs.admin.ch/maps/13/de/12476_15423_15418_227/20585.html.

Table 3
Truth table for the analysis of sufficient conditions.

POP	URBAN	NEWRDEVP	SERVSEC	UNIRES	INTNETW	SMART	nr. of cases	Cons.	Cases
1	1	0	1	1	1	1	5	1	Basel, Bern, Geneva, St.Gallen, Luzern
0	1	0	1	1	0	1	1	1	Pully
1	1	1	1	1	1	1	2	1	Zurich, Wintherthur
0	1	1	1	1	0	1	1	0.95	Carouge
0	0	1	1	0	1	0	1	0.57	Zug
0	1	0	0	0	0	0	1	0.28	Reinach
0	0	0	1	0	0	0	2	0.16	Aarau, Freienbach
0	0	1	1	0	0	0	1	0.14	Baar
0	0	1	0	0	0	0	1	0.11	Wohlen
0	0	0	0	0	1	0	1	0.04	Schaffhausen
0	0	0	0	0	0	0	1	0.03	Illnau-Effretikon
0	0	0	1	0	1	0	2	0.02	Montreux, Vevey
0	0	1	1	1	0	0	2	0	Sion, Chur
0	0	0	1	1	0	0	1	0	Waedenswil

of indifference (0.5) and full non-membership (0.05) and then fit the raw data within the anchors with a logistic function. As a result, the raw data is calibrated into interval level fuzzy-set scores from 0 to 1. Based on the OECD classification of cities and urban areas (OECD, 2012) and our knowledge of the Swiss context, we assigned full membership score to a population of 100′000, full non-membership to 20′000 and point of indifference to 50′000. This means we considered cities larger than 100′000 inhabitants to fully belong to the set of large cities and ones that have 50′000 to 100′000 inhabitants as rather belonging to large cities. Likewise, cities with 20′000 to 50′000 to rather small cities and cities with less than 20′000 inhabitants to be a full member of small cities. As can be noted, these assumptions should be context specific. While 100′000 inhabitants can indicate a large city in Switzerland, this may not be true for other countries.

Condition 2: New residential development (NEWRDEVP). The condition new residential development (NEWRDEVP) indicates the number of new residents per thousand inhabitants. Direct calibration was used to operationalize this condition. Based on our case knowledge concerning Swiss cities including the city of Zug (10.8 new residents per 1000) which is representing a rather fast developing city landscape, we assigned full membership to 10 new residents per thousand and full non-membership to 2 per thousand. The average residential development in Switzerland, 6 per thousand inhabitants was chosen as the point of indifference.

Condition 3: Share of tertiary sector employment (SERVSEC). The condition SERVSEC indicates the share of the population employed in service sector (tertiary sector). The direct calibration method was used to generate interval level fuzzy-set scores. Similar to the calibration of NEWRDEVP, we relied on our case knowledge to assign full-membership score to 90% of service sector employment, and non-membership to 70% of service sector employment, corresponding to a low share of service sector for a large city in Swiss context. The national average of 78% is taken into account in determining the point of indifference.

Condition 4: Presence of universities (UNIRES). This condition accounts for the presence of universities (including the applied sciences universities) and the number of students (including PhDs) and research staff as an indicator of their size, resources and potential impact through start-ups and spin-offs. Cities without universities are calibrated with a fuzzy-set score of 0. To calibrate cities with universities, we considered the number and size of universities in relation to the Swiss context. As a result, cities with less than 7′500 students and research staff were calibrated as 0.6, 7′500–10′000 with 0.7, 10′000–15′000 with 0.8, 15′000–30′000 with 0.9 and 1 for more than 30′000.

Condition 5: Degree of urbanisation (URBAN). As the fifth condition, URBAN denotes the degree of urbanisation that takes into account the geographic contiguity and population density of settlements. This measurement named as *DEGURBA* was developed by Eurostat (Statistical Office of the European Union) and OECD and it is also being used by Swiss Federal Statistical Office to classify the settlements in Switzerland as densely populated areas, intermediate density areas and thinly populated areas (Bundesamt für Statistik, 2011). None of the cities in our sample represents the latter category. Thus, we calibrated urbanisation degree as crisp sets such that densely populated settlements are coded as 1 and the intermediate density areas in our sample as 0.

Condition 6: Membership to international networks (INTNETW). The last condition is on the number of international networks that a city is part of. Since smart city movement has become a global trend that had mostly started with cities abroad, embeddedness in international city networks can enable the transfer of knowledge and experience from some of the pioneering cities. Such networks can also lead to mimetic pressure and stimulate emulation, cooperation or even competition amongst the member cities. Also given that all the cities in our sample are part of the national city networks such as the Association of Swiss Union of Cities and the Association of Swiss Municipalities, we posit the membership to international networks to be the potentially decisive condition.

To operationalize this condition, we first screened major international city networks and select those related to environment, climate change, sustainability and innovation. As a result, we accounted for the membership to following networks: Local Governments for Sustainability (ICLEI), Climate Alliance, Covenant of Mayors for Climate Change and Energy, EuroCities, Energy Cities, Energy Cities Alliance and C40 Cities Climate Leadership Group. The calibration was done by assigning manual fuzzy-set scores. Cities that are not members of any of these networks were given a score of 0. Cities with membership to only 1 were assigned with the score 0.6, 2 with 0.8 and 4 with the score of 1.

4. Results

As standard practice, the QCA results are given in Boolean notation such that "AND" combinations are denoted with the sign *, and "OR" combinations with the sign +. Capital letters indicate the presence of a condition or an outcome while lower case letters indicate their absence. The necessity tests show that the condition SERVSEC, which has a consistency score larger than the threshold set at 0.9, can be considered as a necessary condition for a smart city (see Table A3 in the appendix). This means that for a city to be smart, a high share of service sector employment is required.

The so-called truth table summarizing all consistently sufficient configurations of conditions leading to the outcome SMART is shown in Table 3. With six conditions, we could theoretically observe 64 different configurations. However, the cases in our sample represent 14 different configurations[4] of which 4 have consistency scores higher than the

[4] Considering the issue of limited diversity (the low number of empirically observed configurations relative to the theoretically possible configurations, e.g. 14 out of 64), we re-run the analysis with five conditions to test the robustness of our findings. The results did not change when NEWRDEVP is excluded (see Table A7 for the truth table and the sufficient paths).

Table 4
Sufficient paths for SMART (intermediate solution).

Sufficient path	Raw Coverage	Unique coverage	Consistency
URBAN * SERVSEC * UNIRES	0.78	0.78	0.94
Cases covered: Zurich, Pully, Bern, Geneva, Carouge, Winthherthur, St.Gallen, Luzern, Basel			

threshold we set at 0.9. This corresponds to a conservative threshold (Schneider & Wagemann, 2012), but also represents a clear gap in our observed consistency scores. Since these four rows contain redundant terms, the Quine-McCluskey algorithm in the program fs/QCA 3.0 (Ragin & Davey, 2016) is used for logical minimization.

Below in Table 4, we present the intermediate solution which includes the simplifying assumptions guided by the theoretical knowledge (i.e. to our expectations on whether the presence or absence of a condition is associated with the outcome). The intermediate solution (parsimonious and complex solutions appear in the appendix, Tables A5 and A6) below indicates that for cities to have many smart city projects, it is sufficient to have densely populated areas (URBAN), a high share of service sector (SERVSEC) employment and universities (UNIRES). The high consistency score indicates that the evidence from the empirical data largely supports the postulated relation and the coverage score of 0.78 expresses that the solution term covers 78% of the outcome values. Two of the cases with the outcome but not covered by a consistent configuration are Aarau and Zug.

In order to test the robustness of results, we run a sensitivity analysis by using alternative calibrations for the conditions NEWRDEV and SERVSEC. We chose these conditions since the lack of a clear theoretical anchor that can be used to assign crossover and membership points make their calibration more ambiguous than the other conditions. The procedure is explained in more detail in the Appendix. As can be seen from Table A10 and A11, the results do not show a notable change. The sufficiency test yielded the same solution term with slightly higher coverage and lower consistency scores. For the necessity test, while the consistency score of NEWRDEVP has increased, its relevance of necessity score has decreased suggesting that one should be cautious when interpreting SERVCES as a necessary condition. Overall, the sensitivity analysis indicates that the findings are to a very large extent robust to the calibration procedure.

We also run the analysis for the absence of the outcome in order to check for causal asymmetry (Ragin, 2008). Unlike for "SMART", there are multiple pathways sufficient for to opposite outcome, "smart" (Table 5). Among those, the first solution path consists of low population (pop), low urbanisation (urban) and few memberships to international networks (intnetw). This pathway represents 8 of the 11 cases with membership to the outcome. The second pathway covers 3 additional cases with low degrees of population (pop), urbanisation (urban), new residential development (newrdevp) and absence of universities (unires). None of the cases is covered by the third path only.

5. Discussion

Although the development of smart cities has become a global trend, innovation remains a localized process determined by the enabling and constraining effects of place specific conditions (Gilbert & Campbell, 2015; Martin, 2010). Our analysis also indciate the concentration of innovative activity at certain places as only about a dozen of Swiss cities have several smart city projects. From the six conditions tested, three stand out to be more important. For instance, a high share of service sector employment (SERVSEC) seems to be a necessary condition for smart city initiatives. Since the service sector such as banking, insurance, communication, trade, retailing, healthcare and education are typically associated with white-collar jobs and increased use of ICT, cities with larger service sector are likely to possess the advanced infrastructure and face greater societal demand for innovation and particularly digitalisation which is staple for many smart city projects. However, SERVSEC alone is not sufficient and a high degree of urbanisation (URBAN) and universities (UNIRES) are also required, suggesting that further push and pull factors such as universities and urban density are also crucial for the progress with smart city projects.

In contrast to a single sufficient path for the outcome, we found multiple sufficient paths for its absence. There is also a causal asymmetry between configurations associated with the presence and absence of the outcome. For instance, while a large population and residential growth are not part of the solution term for the proliferation of smart city projects, their absence appear to be related with weaker progress. On the other hand, degree of urbanisation and universities seem to be highly important for both the presence and the absence of the outcome.

Implications for the smart city development

These findings point to some interesting insights concerning the development of smart city initiatives. First of all, they echo studies underlining the importance of universities in smart city context (Ardito et al., 2019; Ferraris et al., 2018) and the triple helix model which conceptualizes innovation systems in terms of the interaction amongst university-industry-government (Kysiak, 1986; Ranga & Etzkowitz, 2013). Our empirical case shows that smart city projects seem to flourish at cities where service sector and universities intersect, hinting at the knowledge economy as the underlying fabric of these urban innovations. Cities harbouring service orientated economic activity and skilled knowledge workers are termed as "knowledge cities" (Ivaldi, Penco, Isola & Musso, 2020; Yigitcanlar, O'Connor & Westerman, 2008). The overlap of this conceptualization with the cities that run a larger number of projects in our sample supports the view that proliferation of smart cities is strongly tied to knowledge economy (Angelidou, 2015). Apart from some major cities such as Zurich, Geneva, Basel or Winterthur, smaller ones in our sample like Pully or Carouge also display such characteristics. However, as indicated by the other condition of the solution term, density, the urban form in which such a knowledge ecosystem is established also matters. While Sion and Chur as the capital cities of their cantons resemble Pully and Carouge in terms of population, high share of service sector employment and presence of

Table 5
Sufficient paths for smart (intermediate solution).

Sufficient paths	Raw Coverage	Unique coverage	Consistency
pop * urban * intnetw	0.63	0.31	0.93
Cases covered: Wohlen, Freienbach, Illnau-Effretikon, Aarau, Baar, Waedenswil, Sion, Chur			
pop * urban * newrdevp * unires	0.43	0.10	0.91
Cases covered: Aarau, Montreux, Vevey, Schaffhausen, Freienbach			
pop * newrdevp * servsec * unires * intnetw	0.25	0.06	1
Cases covered: Illnau-Effretikon, Aarau, Baar			
Solution coverage: 0.80			
Solution consistency: 0.94			

universities, they are not as densely populated as the former two; a notable difference that also associates with the lower number of projects in these cities. In fact, similar to the presence of universities, both the presence and absence of densely populated areas are found to be related to large number of smart city projects and its negation, respectively.

The effect of urban density and compactness to sustainability, public health and liveability of cities have long been a matter of debate in urban studies (Neuman, 2005; Rubiera-Morollón & Garrido-Yserte, 2020; Yo, 2016). Denser urban setting on average are found to be more efficient in use of energy and space and thus tend to associate with lower energy consumption and CO2 emissions from transportation per capita (Larivière & Lafrance, 1999; Lee & Lee, 2014; Makido, Dhakal & Yamagata, 2012; Rubiera-Morollón & Garrido-Yserte, 2020). Due to lower reliance on private vehicles, denser cities also facilitate physical activity and thus can have positive health impact (Frumkin, 2002). However, denser cities can be detrimental for liveability of cities (Neuman, 2005) due to less green spaces (Jim, 2004; Lin & Yang, 2006), obstruction of daylight and airflows (Futcher, Mills, Emmanuel & Korolija, 2017) and also potentially exacerbating the urban heat island intensity (Li, Schubert, Kropp & Rybski, 2020). In addition, several studies have found positive effect of urban density and compactness on innovation when considering measures such as number of patents and innovative firms (Hamidi, Zandiatashbar & Bonakdar, 2019; Roche, 2020). On the other hand, when it comes to adoption of new technologies or practices such as residential photovoltaic systems, the peer effect (also known as neighbour effect) can decrease with increasing housing density (Graziano & Gillingham, 2015). Against the backdrop of these inconclusive findings and potential trade-offs related to urban density, our study underlining its positive effect on the smart city development adds just another layer to this complex phenomenon.

In contrast, the population (or the size of cities) which is widely acknowledged as conducive for innovation turned out to be not a crucial factor at least for the progression with respect to smart city development in Switzerland. This may well be linked to the political and institutional conditions. In Switzerland, even the smaller municipalities have large authority in legislating and planning land use/infrastructure and can impose taxes. This legal and fiscal autonomy may enable local governments to initiate and realize smart city projects at greater capacity. Therefore, the case of Switzerland reveals that the progress towards smart cities is not limited to large, metropolitan areas. In fact, small suburbs with a population around 20′000 (e.g. Pully) can also be hubs for smart city projects owing to their denser settlement, large share of service sector, close proximity to large cities and the universities in the vicinity. Although they are separate administrative entities, these suburbs have strong interactions with the urban centres in terms of flow of people and information, which are likely to have contributed to their progress in smart city development.

Our findings partly coincide with a recent survey of Italian cities in which the city size was found to strongly correlate with knowledge-based economy and innovation levels, whereas only weakly with smart sustainable characteristics; a measure which include sustainability and quality of municipal services (Ivaldi et al., 2020). The insights acquired from our study is also important for the fact that the smart city initiatives in Switzerland are not driven by top-down impetus of regional (i.e. cantonal) or federal government. This is different to most other settings including the European Union, which strongly promotes smart city initiatives with competitive grants and government funding, as well as United States, and China (Pierce, Ricciardi & Zardini, 2017; Yu & Xu, 2018). Therefore, the Swiss case depicts a more authentic display of cities' engagement and innovativeness concerning smart city development that is not influenced by the agenda of higher-tier governments.

Limitations and further research

Overall, the number of projects run by cities provides an indication of cities' progress and commitment with smart city development. However, there are some caveats. First, not all projects are equal in terms of scale, sophistication of design and technologies used, resources required and potential impacts. In this study, we used the total count of projects, which is an aggregated value of various projects, of which some are related to mobility, environment, living spaceor governance. Further analysis can be conducted by breaking down smart city projects to different fields or differentiating them as hard vs. soft infrastructure orientated innovation (Angelidou, 2014). This could enable a more nuanced understanding of whether and how the drivers of innovation may change with respect to different smart city fields (e.g. smart mobility vs. smart governance) and technologies. Furthermore, our analysis is cross-sectional meaning that it provides a snapshot of the status quo which can change in several years. This can most likely involve the increase in the number of cities with at least one project. However, since we set the threshold of membership to the outcome set to several projects and take into account the gradient in the number of projects when assigning the fuzzy-set scores (i.e. calibration), we believe our findings are robust to such changes.

Given that our primary interest is to study the geographies of smart city development and that we are limited with the number of conditions we can analyse from methodological standpoint, we explicitly focused on the spatial and socio-economic factors. Further research can extend this line of enquiry by refining some of the conditions (e.g. examining the role of start-ups and spin-offs explicitly) or by investigating other factors that may be influential at organizational or managerial levels. This may be beneficial especially to uncover alternative explanations for some *deviant* cases (such as Aarau and Zug in our sample) that do not display the sufficient configurations yet belonging to the outcome set. For instance, in the case of Zug, even though it does not host universities or large research institutions, the city and the larger region of Zug (i.e. canton Zug) was ranked third in the number of new start-ups founded between 2013 and 2018 (Stata, 2019). Thus, settings like Zug can be an interesting case for a more detailed analysis on how the flourishing scene of start-ups might be a catalysing factor for smart city development. Concerning the organizational and managerial factors however, one should be careful with potentially endogenous explanations of, e.g., cities with a "smart city office" having more smart city projects. This is also the reason why we did not include more proximate conditions of political organization into our explanatory model, but focused on causally more distant conditions at the levels of spatial and socio-economic conditions. For the same reasons, our analysis takes into account memberships of cities in international networks related to sustainability, environment or energy, but not specifically networks related to smart cities or digitalisation that are only recently emerging. Still, focusing on organizational or managerial conditions can also elucidate why some suburbs are highly progressive while others with similar spatial and socio-economic conditions are not. Running in-depth case studies on some of the surprising cases such as Pully that have unexpectedly high values on the outcome (i.e. *extreme* case) or *typical* cases such as Zurich or Winterthur, which display both the outcome and all the conditions hypothesized to be relevant, can provide complementary insights by unravelling the causal mechanisms and potential interdependencies amongst the explanatory factors.

6. Conclusion

The concept of smart cities has gained increasing attention over the past decade, paving the way to numerous initiatives around the world. While smart cities is becoming a global phenomenon, innovative activities remains to be context-dependant resulting in variations and uneven development even across cities within a given jurisdiction. Although the literature is ample with descriptions of pioneering cities and lighthouse projects, there is less attention directed to spatial factors that can account for the differences in the innovativeness of cities. In this study, we address this gap by examining the spatial and socio-economic configurations characterising the smart city development in Switzerland.

Focusing on cities within a single country allowed us to control for macro-economic and political frame conditions. In addition to its largely unexplored smart city landscape, the Swiss setting is also interesting given the large number of relatively small municipalities with notable fiscal and legal autonomy. The absence of a relatively strong urbanization pressure and involvement of higher-tier government structures also provide a distinct advantage for assessing cities' engagement and innovative capacities. The results show that a configuration of high share of service sector, presence of universities and densely populated urban areas are conducive for smart city development whereas the size of the city, rate of new residential development and membership to international networks are not as crucial. These insights from our study into the spatial and socio-economic underpinnings of smart city development contribute to the understanding the geographies of innovation in the burgeoning field of smart cities. Table 4

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

APPENDIX

Table A1
Raw Data Matrix.

City	SMART	POP	URBAN	NEWRDEVP	SERVSEC	UNIRES	INTNETW
Basel	21	171′513	Densely populated areas	2.1	80	26′323	2
Zurich	19	409′241	Densely populated areas	7.5	94	45′000	4
Winterthur	16	110′912	Densely populated areas	6.9	83	13′485	1
Pully*	14	18′160	Densely populated areas	3.1	94	30′000	0
Bern	8	133′798	Densely populated areas	1.1	92	25′555	2
Geneva	8	200'548	Densely populated areas	0.9	94	16′530	1
St.Gallen	8	75′522	Densely populated areas	1.9	86	8′872	0
Carouge*	7	22′336	Densely populated areas	11.2	85	16′530	0
Zug	4	30'205	Intermediate density areas	10.8	83	0	1
Luzern	3	81′401	Densely populated	1.8	91	10′609	1
Aarau	3	30′205	Intermediate density areas	1.9	91	0	1
Schaffhausen	1	36′332	Intermediate density areas	4.4	76	0	1
Sion	1	34′599	Intermediate density areas	18.0	82	2′300	0
Chur	1	35′038	Intermediate density areas	6.3	88	2′000	0
Montreux	1	26′574	Intermediate density areas	3.0	89	0	1
Baar	1	24′322	Intermediate density areas	10.4	81	0	0
Waedenswil	1	24′536	Intermediate density areas	1.5	79	0	0
Vevey	1	19′827	Intermediate density areas	3.6	93	0	1
Reinach	1	19′144	Densely populated areas	5.8	73	0	0
Illnau-Effretikon	1	16′975	Intermediate density areas	1.4	68	0	0
Wohlen	1	16′078	Intermediate density areas	8.3	76	0	0
Freienbach	1	16′269	Intermediate density areas	5.2	81	0	0

* Pully and Carouge do not host universities in their own jurisdictions but because they are within the 3-5km vicinity of Lausanne and Geneva, respectively they are considered no different than those two cities with respect to presence of universities.

Table A2
Calibrated Data Matrix.

City	SMART	POP	URBAN	NEWRDEVP	SERVSEC	UNIRES	INTNETW
Basel	1	1	1	0.05	0.62	0.9	0.8
Zurich	1	1	1	0.74	0.98	1	1
Winterthur	0.9	0.97	1	0.63	0.78	0.8	0.6
Pully	0.9	0.04	1	0.10	0.98	1	0
Bern	0.8	0.99	1	0.03	0.97	0.9	0.6
Geneva	0.8	1	1	0.02	0.98	0.9	0.8
St.Gallen	0.8	0.82	1	0.04	0.88	0.7	0.6
Carouge	0.8	0.06	1	0.98	0.85	0.9	0
Zug	0.7	0.12	0	0.97	0.78	0	0.6
Luzern	0.6	0.87	1	0.04	0.96	0.7	0.6
Aarau	0.6	0.05	0	0.04	0.96	0	0
Schaffhausen	0	0.2	0	0.22	0.32	0	0.6
Sion	0	0.18	0	1.00	0.73	0.6	0
Chur	0	0.18	0	0.52	0.92	0.6	0
Montreux	0	0.09	0	0.09	0.94	0	0.6
Baar	0	0.07	0	0.96	0.68	0	0
Waedenswil	0	0.07	0	0.03	0.56	0.6	0
Vevey	0	0.05	0	0.14	0.98	0	0.6
Reinach	0	0.04	1	0.43	0.13	0	0
Illnau-Effretikon	0	0.04	0	0.03	0.02	0	0
Wohlen	0	0.03	0	0.84	0.32	0	0
Freienbach	0	0.03	0	0.33	0.68	0	0

Table A3
Test of Necessity for SMART.

	Consistency	Coverage	Relevance of Necessity
POP	0.69	0.78	0.89
URBAN	0.85	0.76	0.73
NEWRDEVP	0.36	0.38	0.83
SERVSEC	**0.94**	0.52	0.44
UNIRES	0.82	0.76	0.84
INTNETW	0.63	0.76	0.89

Table A4
Test of Necessity for smart.

	Consistency	Coverage	Relevance of Necessity
pop	0.87	0.81	0.74
urban	0.82	0.89	0.69
newrdevp	0.62	0.58	0.88
servsec	0.42	0.91	0.74
unires	0.82	0.87	0.72
intnetw	0.86	0.77	0.60

Table A5
Sufficient paths for SMART (complex solution).

Sufficient paths	Raw Coverage	Unique coverage	Consistency
1) pop * URBAN * SERVSEC * UNIRES * intnetw	0.23	0.19	0.94
Cases covered: Pully, Carouge			
2) POP * URBAN * SERVSEC * UNIRES * INTNETW	0.54	0.5	1
Cases covered: Zurich, Geneva, Basel, Wintherthur, Bern, St.Gallen, Luzern			
Solution coverage: 0.73			
Solution consistency: 0.98			

Table A6
Sufficient paths for SMART (parsimonious solution).

Sufficient paths	Raw Coverage	Unique coverage	Consistency
1) URBAN * SERVSEC	0.80	0.011	0.87
Cases covered: Zurich, Pully, Geneva, Bern, Luzern, St.Gallen, Carouge, Wintherthur, Basel			
2) URBAN * UNIRES	0.82	0.04	0.94
Cases covered: Zurich, Pully, Basel, Bern, Geneva, Carouge, Wintherthur, St.Gallen, Luzern			
Solution coverage: 0.83			
Solution consistency: 0.87			

Table A7
Truth Table and sufficient paths for SMART with 5 conditions excluding NEWRDEVP.

POP	URBAN	SERVSEC	UNIRES	INTNETW	SMART	raw consist.	cases
1	1	1	1	1	1	1.00	Basel, Zurich, Wintherthur, Bern, Geneva, St.Gallen, Luzern
0	0	1	0	0	0	0.19	Aarau, Baar, Freienbach
0	0	1	1	0	0	0.00	Sion, Chur, Wädenswil
0	0	1	0	1	0	0.28	Zug, Montreux, Vevey
0	0	0	0	0	0	0.07	Illnau-Effretikon, Wohlen
0	1	1	1	0	1	0.95	Pully, Carouge
0	1	0	0	0	0	0.26	Reinach
0	0	0	0	1	0	0.24	Schaffhausen

Sufficient paths for SMART (intermediate solution)

Sufficient path	Raw Coverage	Unique coverage	Consistency
URBAN * SERVSEC * UNIRES	0.78	0.78	0.94
Cases covered: Zurich, Pully, Bern, Geneva, Carouge, Wintherthur, St.Gallen, Luzern, Basel			

Table A8
Sufficient paths for smart (complex solution).

Sufficient paths	Raw Coverage	Unique coverage	Consistency
1) pop * urban * SERVSEC * intnetw	0.43	0.07	0.90
Cases covered: Aarau, Chur, Sion, Baar, Freienbach, Waedenswil			
2) pop * urban * newrdevp * unires	0.43	0.10	0.91
Cases covered: Aarau, Montreux, Vevey, Schaffhausen, Freienbach			
3) pop * urban * unires * intnetw	0.53	0.09	0.91
Cases covered: Freienbach, Illnau-Effretikon, Aarau, Baar			
4) pop * mewrdevp * servsec * unires * intnetw	0.25	0.06	1
Cases covered: Illnau-Effretikon, Reinach			
Solution coverage: 0.73			
Solution consistency: 0.98			

Table A9
Sufficient paths for smart (intermediate solution).

Sufficient paths	Raw Coverage	Unique coverage	Consistency
1) pop * urban * intnetw	0.63	0.31	0.93
Cases covered: Wohlen, Freienbach, Illnau-Effretikon, Aarau, Baar, Waedenswil, Sion, Chur			
2) pop * urban * newrdevp * unires	0.43	0.10	0.91
Cases covered: Aarau, Montreux, Vevey, Schaffhausen, Freienbach			
3) pop * newrdevp * servsec * unires * intnetw	0.25	0.06	1
Cases covered: Illnau-Effretikon, Aarau, Baar			
Solution coverage: 0.80			
Solution consistency: 0.94			

Sensitivity Analysis

We run a sensitivity analysis by using different membership scores for the conditions NEWRDEVP and SERVSEC. The reason why we particularly focus on these two conditions is becasuse the theoretical anchors for their calibration are relatively more ambiguous than for other conditions. Furthermore, SERVSEC is a critical condition as it is part of the necessary and sufficient solution terms. We thus test if results are sensitive to alternative but equally plausible membership scores for the calibration of these conditions. For the condition SERVSEC, we adopt a lower and a higher bound for full membership (82.5%) and non-membership (75%) scores respectively and retain the Swiss average value (78%) as the crossover point. For the condition NEWRDEVP, we tested the effect of a lower non-membership score (1.5 per 1000).

The table represents the distribution of smart city projects according to the commonly used categories introduced by Smart City Wheel (Cohen, 2012) at the time of data collection. Since some projects can be classified to more than category while some others can represent none of the six categories above the total numbers in this table do not correspond to the number of projects by cities as shown in Table A1 . As can be

Table A10
Test of Necessity for SMART.

	Consistency	Coverage	Relevance of Necessity
POP	0.69	0.78	0.89
URBAN	0.85	0.76	0.73
NEWRDEVP	0.37	0.39	0.72
SERVSEC	0.97	0.50	0.35
UNIRES	0.82	0.76	0.84
INTNETW	0.63	0.76	0.89

Table A11
Sufficient paths for SMART (intermediate solution) with different membership.

Sufficient path	Raw Coverage	Unique coverage	Consistency
URBAN * SERVSEC * UNIRES	0.81	0.81	0.93

Cases covered: Zurich, Pully, Bern, Geneva, Carouge, Wintherthur, St.Gallen, Luzern, Basel

Table A12
Smart City Projects by Categoriess.

City	Smart Environment	Smart Mobility	Smart Living	Smart Governance	Smart People	Smart Economy
Basel	4	3	4	11	1	0
Zurich	1	6	4	5	3	0
Winterthur	3	3	4	3	3	0
Pully	2	0	1	8	3	3
Bern	0	1	1	5	1	0
Geneva	4	3	0	1	0	0
St.Gallen	1	0	2	3	1	3
Carouge	1	1	0	0	0	1
Zug	0	1	0	2	2	0
Luzern	0	0	2	1	1	0
Aarau	3	1	0	0	0	0
Schaffhausen	0	1	0	0	0	0
Sion	0	1	0	0	0	0
Chur	0	0	0	1	1	0
Montreux	0	0	0	1	0	0
Baar	1	0	0	0	0	0
Waedenswil	1	1	0	0	0	0
Vevey	0	1	0	0	0	0
Reinach	0	0	1	0	0	0
Illnau-Effretikon	1	1	0	0	0	0
Wohlen	0	0	0	1	0	0
Freienbach	1	1	0	0	0	0
TOTAL	**23**	**25**	**19**	**42**	**16**	**7**

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