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A VIABLE SYSTEMS PERSPECTIVE FOR MANAGING URBAN COMPLEXITY:

COLLECTIVE PERCEPTION BASED ON FUZZY AND SEMANTIC APPROACHES IN THE DECISION-MAKING PROCESS

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To my family, safe haven
To my friends, anchor of my soul
To my love, the route and the meaning

Can collective intelligence save the planet?

It's the only hope we have.

— Patrick Joseph McGovern

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"If I have seen further it is by standing on the shoulders of Giants."

— Isaac Newton (1675)

In this beautiful journey, so many people welcomed me, shared knowledge, offered different points of view, and helped me to become the person who I am today.

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ABSTRACT

Purpose. The growing complexity of urban landscapes and the faster technology evolution make central a rethink of urban governance, in order to understand how the application of smart technologies and automatized research techniques to big data management reframe and boost decision-making processes. The adoption of a systems perspective permits to focus on the definition of new model of decision-making for urban context, based on a participatory logic, which can increase actors' engagement, which populate the same context and harmonize their objectives with community's overall goal. In this regard, adopting the interpretative lens of the Viable Systems Approach (VSA), this work aims to propose a decision-making support model for the urban governing body to frame the urban collective perception of the actors (e.g. citizens and tourists) regarding the city and its assets. Thus, the adhesion to VSA can enhance the awareness of the interventions that could be aimed at solving urban problems.

Methodology. The proposed model follows a robust and innovative methodological framework based on a big data-oriented approach. Firstly, following the Lynch's theory, the most relevant urban elements that contribute to create the common perception of a city are defined. After, starting from crawling texts from online sources, the methodology foresees to apply an Aspect Based Sentiment Analysis (ABSA), an advanced sentiment analysis, to evaluate the sentiment expressed in the reviews by online users regarding the urban elements. Finally, scenario analysis is performed by using Fuzzy Cognitive Map (FCM) to analyse the impact of users' opinion about city issues.

Findings. A large-scale text analytics study has been conducted on two selected Italian cities. The results lead to an exposition of shared evaluations on the levels of "sentiment" as perceived by the community in relation to urban points of interest through summary sheets. Furthermore, carrying out a What-If simulation, it is determined how the current collective perception affects other important urban issues and how, changing the collective perception through targeted interventions, the urban context will react. In this way, the information variety endowment of the decision makers is increased and a series of interventions, aimed at establishing the conditions for a context consonance, by obtaining an overall view composed by the different perceptions of the community, can be implemented.

Research limits. Beyond the advantages offered by big data analysis (primarily the possibility of analyzing a huge amount of data in real time), the automated collection of people's reviews is characterized by a certain superficiality, since it does not allow going deep into the understanding of the people's opinions. In fact, although the sample was particularly large (a huge amount of reviews extracted in a period span of 12 months), could be interesting a deeper analysis of users' complete through in-depth interviews.

Practical implications. The model can support urban decision-makers by offering some insights on the level of sentiment and some relevant results deriving from scenario analysis to understand how the collective perception of the city can influence important urban questions and how the governing body should intervene for aligning to an ideal city. In this way, it is possible to reduce the delay which characterizes the urban systems in relation to a critical situation perceived by the community and the interventions by the institutions. Another important aspect regards the capacity to depict graphically the results obtained: processing information through the visual system can significantly increase managerial capability to address complexity. Furthermore, the proposed model promotes a common language between urban decision makers and stakeholders by guaranteeing a greater awareness of the interventions to carry out.

Originality. The originality of the paper lies in combining, in a single model, the VSA, interpretative lens of reality, with an innovative methodology followed a big data-oriented approach. In particular, the work has utilized knowledge from three different fields, i.e. urban management, computing science and statistics, which have been synergistically integrate for customizing, implementing, and using IT tools capable of automatically identifying, selecting, categorizing and analyzing the collective perception of a city and urban assets in it through people's reviews.

Keywords

Urban governance; Decision-making; Viable Systems Approach; Collective perception; Aspect Based Sentiment Analysis (ABSA); Fuzzy Cognitive Map (FCM).

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CHAPTER I

INTRODUCTION

SUMMARY: 1.1. Problem statement – 1.2. Purpose of the study – 1.3. Context and significance of the study – 1.4. Preliminary considerations on the methodology – 1.6. Definition of terms

> "*Una città non è disegnata, semplicemente si fa da sola. Basta ascoltarla, perché la città è il riflesso di tante storie*"
> — Renzo Piano

1.1 PROBLEM STATEMENT

The technological revolution, globalization, economic, political and social transformations, have more and more deeply affected the physical morphology (cityscape) and the social tissue (mindscape) of contemporary cities (Amendola, 2006). The urban landscape has become extensive, dynamic and varied by making more and more difficult to define it both from cultural and institutional standpoint (Castells et al., 2003). Nowadays, the cities play a leading role in the development of policies, both with respect to the central government and as international actors aimed at searching for alliances and synergies to increase their competitiveness (Véron and Vicari Haddock, 2004). Whilst new technological tools and smart city models[1] have been developed, on the other side the major challenges regarding environmental, energy, and demographic issues require a change in urban governance aimed at creating value and achieving a long-term sustainable advantage (Keams and Paddison, 2000).

This increasing turbulence pushes towards a rethinking of the ***urban governance***:

[1] Dameri qualifies the smart city as "a well defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, *cooperate to create benefits for citizens in terms of well being, inclusion and participation, environmental quality, intelligent development; it is governed by a well defined pool of subjects, able to state the rules and policy for the city government and development*", highlighting the strong relation between the environment, citizens, technology, and governance (2013).

fragmented and uncertain environments make central the coordination process in which different actors, institutions and social groups attempt to achieve their objectives (Le Galès, 2006). Therefore, from the importance of the collaborative view to the developing of new smart technologies, new paradigms of urban governance have been increasing investigated by scholars with the aim to improve well-being in different areas in urban context. Specifically, there is the need to understand how technologies are managed and harmonized by governance, how decision-making processes are reframed and boosted by the application of smart technologies and automatized research techniques to big data management (Tocci, 2007; Da Cruz et al., 2019). Despite the relevant role of technology in the enhancement of urban management, the use of technologies does not imply the attainment of competitiveness. Hence, there is the need to understand how the big flow of data can be optimized in order to exploit the potentials of the current ICTs (information and communication technologies) by avoiding to turn these advantages into threats (Gandomi and Haider, 2015). Therefore, the main governance dimensions, mechanisms and processes to be implemented to address social demand should be explored (Tocci, 2006).

These considerations encouraged the shift from a traditional urban model, based on the high involvement of state in policies implementation and on the predominance of local government in the search for consensus, to a new way of intending the governance, which underlines the necessity to adopt a systems perspective. Holistic approaches, in fact, can take into account the overall system, the several phenomena that occur, and the variety of categories of stakeholders, ranging from users to governing bodies, who participate in the development of the city. In the light of these considerations, the work adopts the perspective of the ***Viable Systems Approach (VSA)*** (Golinelli, 2002, 2005, 2011; Barile, 2009; Barile et al., 2015), which allows to embrace the complexity of the urban governance problem in which the governing body is responsible for seeking consonance between the varieties of actors interested in the outcome of decision-making process.

Based on these considerations, the challenge is focused more and more on the definition of new ***models of decision-making***, based on a participatory logic, which can encourage the alignment between different information varieties: the goal is to increase engagement with the actors which populate the same context and harmonize their objectives with community's overall goal.

In this direction, new opportunities for improving the decision-making process through a diffused governing body regard the possibilities to monitor the public opinion in order to find and understand the opinions and points of view that users express. Nowadays an interesting phenomenon regards the possibility for users to share messages, posts, tweets and tags always faster and with greater intensity on the social network by making possible to derive powerful information in order to understand how the citizens live in their city, how they use public spaces and facilities, how they spend their free time.

Clearly, such information can be extremely useful for urban governance, which should be able to gather the **perceptions of the city by social actors** (e.g. citizens and tourists) in a non-intrusive way, in order to obtain information that is as truthful and accurate as possible. Thus, gathering and interpreting citizens and tourists' perception, by analysing their activities related to the city on the social media, is a powerful and useful way to improve urban ecosystem. This kind of data analysis can allow at uncovering hidden phenomena that might otherwise be difficult to identify; these phenomena can represent, then, the starting point for the planning and implementation of strategies to improve urban decision-making processes. Therefore, with the advent of the Semantic Web[2] and the explosion of social networks, a deluge of information has flooded the Web and can be exploited by decision-making as well for a variety of purposes and applications, thus potentially strengthening their success and pervasiveness. Unfortunately, generally the decision-making models used within such a context typically tend to rely on the data derived from the range of sensors and logs that capture the "state" of a city from a quantitative perspective.

However, as stated earlier, nowadays it is crucial to be able to capitalize the whole amount of subjective, qualitative but nonetheless useful information that can be found across social interactions among people on the web and similar media.

[2] The Semantic Web can bring structure and a significance to the meaningful content (data) of Web pages by identifying an relating them. The goal is to relate all the information that is present on the web, thus forming a "data web" with enormous potential (Berners-Lee et al., 2001).

Actually, some methods of sentiment analysis exist but, in many cases, can measure users' feelings rather than their perception. In fact, the process that realizes the sensation is defined, in the psychological field, "sensory transduction", intended as the transformation of the sensory information perceived and sent to the brain in the form of an electrical stimulus. It is substantially different from the perceptual process which instead is the psychic process that allows to attribute meaning to the sensory data input. Unfortunately, the distinction between sensation and perception is not so immediate and some consider it as a single psychic function: sense-perception. This problem, still not sufficiently dealed in the field of big data analytics, represents an obstacle to the validity of many of the techniques currently used to analyse the effective perception of the city (Bertrand et al., 2013; Ali et al., 2017).

1.2 PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

Once framed the role of technology in urban governance and decision-making, the general goal of the study is to define an urban governance model from viable systems perspective able to support the urban decision-making process.

As discussed above, a twofold gap emerges from extant literature by emphasizing the need to: 1) understand how contemporary urban governance can be reframed according to systems perspective and boosted by the application of smart technologies; 2) how actors' perception on the city, rather than their feelings, can be explored through natural language processing to support decision-makers.

For this reason, the work aims at addressing the following research questions:

Research Question 1 (RQ_1):

How can decision-making processes in urban viable systems be reframed and boosted by the application of smart technologies and automatized research techniques for big data management?

Research Question 2 (RQ_2):

Is it possible to formalize a decision-making model able to support urban governing body in the exploration of actors' (e.g. citizens and tourists) collective perception regarding the city?

Therefore, firstly, urban governance is redefined through the interpretative lens of the Viable Systems Approach (VSA). Secondly, a decision-making support model for the urban governing body to frame the urban collective perception of the actors

(e.g. citizens and tourists) is proposed. Thus, the adhesion to VSA can enhance the awareness of the interventions that could be aimed at solving urban problems.

Specifically, to address the second research question, an empirical research based on natural language processing is performed to compare citizens' perception on two Italian cities: Salerno and Siena.

An innovative methodology, Aspect Based Sentiment Analysis (ABSA), is applied to provide information on the various components of users' sentiment toward the cities, by allowing a more precise and accurate analysis. In this way, the results of the empirical research can be interpreted as relevant insights supporting the assessment of cities collective perception and, thus, enhancing decisions effectiveness in viable urban systems.

1.3 CONTEXT AND SIGNIFICANCE OF THE STUDY

This work tries to fill simultaneous gaps present both in urban management field and in Viable System Approach (VSA).

Regarding the urban management, this work tries to investigate the literature in order to highlight the most relevant challenges connected to urban governance connected with new smart technologies. From this, the work aims to offer to the community of urban governance scholars a new methodology able to present the collective perception regarding a city and the asset in it. In particular, this work tries to define a new model able to support the urban decision-maker by highlighting the impact of the collective perception on specific urban questions (e.g. quality of transportation, level of safety, etc.) and by addressing his interventions.

On the other hand, focusing on the systems studies, an innovative aspect consists in the consideration of the city as viable system, adapting to the urban context the principles and postulates of VSA. Also, this work aims to reinforce the systems perspective, offering a first empirical application of the VSA concepts in the field urban management.

In synthesis, the above topics are relevant for the contexts mentioned before. They are original, because some theoretical aspects are emergent and the empirical research of this kind is relatively new (in terms of execution, context, and contribution). The concepts are organized systematically and coherently. There is an appropriate methodology consisting in an innovative technique. Finally, this dissertation respects all the criteria that generally a research should have: it investigates the theory and offer an application of the methodology; it is also open to evolutions and improvements;

and has a managerial impact.

1.4 PRELIMINARY CONSIDERATIONS ON THE METHODOLOGY

Nowadays, new data from the internet, or rather the traces of information that billions of people leave on Google, social media, and so on, have the potential to reveal important aspects regarding several fields (Stephens-Davidowitz and Pabon, 2017). By analysing this “digital goldmine” thanks to new opportunities given by big data-oriented approaches, it is possible to understand what people really think regarding problems belonging to different fields.

Thanks also to sentiment analysis and opinion mining is possible to analyse people's opinions, sentiments, evaluations, attitudes, and emotions from written language and the organizations definitely can beneficiate of this phenomenon for conducting more aware decision-making process (Liu, 2012).

Starting from this innovative perspective, also in the field of urban management these revelations can reveal interesting insights, showing for the first time the real consciousness of the people about the city and the relevant assets inside. In a digital era in which smart tools allow to deeply understand thoughts and attitudes of the users, the decision maker could benefit of this vast amount of information and try to realize urban initiatives based on the collaboration with the actors.

However, the current approaches to assessing the collective perception of a city generally used by decision-makers and consulting company generally make use of classic surveys methodology or sentiment analysis techniques, which cannot be considered as the effective perception of the city. Therefore, we propose an innovative decision support-model for urban context. Firstly, in order to assess the concept of collective perception of a city and the most relevant urban assets which contribute to it, the work follows the Lynch’s theory (Lynch, 1960).

From this, we proceed to apply an advanced sentiment analysis, the aspect based sentiment analysis (ABSA) (Liu, 2012), basing on a big data-oriented approach, in order to analyse, in the reviews of an online community, the users’ opinion regarding a city and the assets present in it. In particular, this technique generally used in marketing was adapted to the territorial field.

After this, the collective perception determined will be evaluated by a Fuzzy Collective Map (FCM), able to highlight the impact of the collective perception on specific urban questions (e.g. quality of transportation, level of safety, etc.) (D’Aniello et al., 2018). This last step can support the decision-making process of the urban

governing body by addressing his interventions.

1.5 DEFINITION OF TERMS

In line with the need to reread traditional urban governance through the lens of VSA and to propose a model that can encourage decision-makers to explore users' perception through smart technologies and automatized research techniques, the fundamental concepts adopted in the work are the following:

- **Urban governance**: a coordination process by which different actors, institutions, and social groups attempt to achieve their objectives discussed and collectively defined in fragmented and uncertain environments.
- **Viable System**: a system that pursues constantly the goal of survival in a complex context by interacting with other super-systems and sub-systems. For instance, it can be an individual, a group, an organization, a city, etc.
- **Information Variety**: the knowledge exchanged in viable systems is composed of three layers, categorical values, interpretation schemes (general and synthesis) and information units.
- **Consonance**: an indicator that expresses the major or minor potential that two or more information varieties have in aligning their values, schemes, and information. It indicates the relationship distance or cohesiveness degree between systems (e.g. urban decision maker towards citizens or tourists).
- **Resonance**: an indicator of systems' interactions, which can be qualified as accelerative or declarative, representing consonance's variations when new information units are perceived or exchanged by the interacting information varieties.
- **Collective perception**: the mental picture that a large stratum of the population carries towards the city and the assets in it.
- **Sentiment Analysis**: analysis of people's opinions, sentiments, evaluations, attitudes and emotions from written language. It is one of the most active research areas in natural language processing and is widely studied in data mining, Web mining, and text mining.
- **Aspect Based Sentiment Analysis**: an evolution of Sentiment Analysis, able to provide information no longer on the whole sentiment level, but on the various components of this sentiment, by allowing a more precise and accurate analysis. It is used commonly in marketing analysis.
- **Fuzzy Cognitive map**: graphs finalized to represent a variety of relationships

among concepts like *events*, *processes* or *states*, by allowing qualitative reasoning on the states of complex systems.

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CHAPTER II

MULTILEVEL URBAN GOVERNANCE: REDEFINING DECISION-MAKING IN DIGITAL ERA

SUMMARY: 2.1. From governance to urban governance 2.2 Urban governance: definitions, perspectives, challenges – 2.2.1 Hierarchical urban governance models – 2.2.2. Horizontal urban governance models– 2.3. Urban governance in Digital Era – 2.3.1 Key dimensions – 2.4 The role of technology in urban governance and decision-making– 2.4.1 ICTs and engagement platforms – 2.4.2 Analytics and research techniques for Big Data Analysis 2.5. Toward Multi-Level Urban Governance and Decision-making

"Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody."
— Jane Jacobs, The Death and Life of Great American Cities

2.1 FROM GOVERNANCE TO URBAN GOVERNANCE

From ancient times to the contemporary era, the actions of economic and social groups need to be guided toward the attainment of common purposes. For this reason, the term *governance* is introduced to define the set of rules and institutions to orient organizations.

Governance is defined traditionally as a set of regulation processes, of coordination and control mechanisms pursued by private and public institutions in policies formulation and implementation (Rhodes, 1997; Pierre, 1999).

Over the course of time, the advent of the social, economic and cultural transformation and the subsequent evolution of markets lead to the softening of (private, public, non-profit) organization's boundaries. These phenomena make the

analysis of governance more and more complex. Then, in current postmodern and fragmented society (Haveri, 2006), which translates into a fragmented market, the interpretation of this notion should be redefined.

For this reason, in extant literature, a shift from an "old" bureaucratic conception to a networked vision of governance has occurred. This new mind-set takes into account the need to adopt a wider and multi-stakeholder view (Sacconi, 2005) in order to manage changing prosumers to increase service performance and effectiveness.

In parallel with the establishment of this broadened perspective, a *governance*-based view (Kooiman, 2003) has replaced the traditional conception of *government*. This transformation involves a series of implications on the nature of power distribution, relationship modalities in networked organizations and a series of constraints on local authorities and private firms. Governance refers to an all-encompassing process designed to harmonize different public- private, socio-economic or political interests, whereas government introduces a particular kind of regulatory mechanism or governance style to pursue collective goals.

This evolution reframes the conceptualization of governance, in general, and of public governance, in which different evolutionary stages can be identified (Osborne, 2006) to define the transition from a top-down hierarchical view (*Public administration*, PA) to horizontal and collaborative-network models (*Public Governance*, PG). In particular, if government concerns the public institution that has the authority to govern (Bobbio, 2002), governance is linked to the interactions and to the orientations which overcome a purely institutional perspective (Mayntz, 1999). In fact, government does not include the plurality of social actors and different interests present in a collective framework (Rhodes, 1996).

In short, governance represents a new model characterized by a less hierarchical control and a greater degree of cooperation between the actors. It appears, therefore, that the process of governance focuses on the relevance of social capital and mutual trust between private and public actors and civil society. The aim is to pursue collective aims despite the potential conflicts between private and public interests (Devas, 2005).

The controversial nature of public services, mainly related to the absence of economic goals, is widely debated in literature. The difficulty in studying and in concretely managing public governance mechanisms is attributed in particular to (Polese et al., 2018): 1) the aim of social utility (and not simple profits); 2) the

vagueness and multiplicity of goals; 3) the different and conflicting stakeholder interests (Rainey and Bozeman 2000; Jung and Ritz 2014; Dezi et al. 2005). It follows that the study of governance in public sector does not succeed in gaining autonomy (Cepiku, 2005; Schneider, 2002).

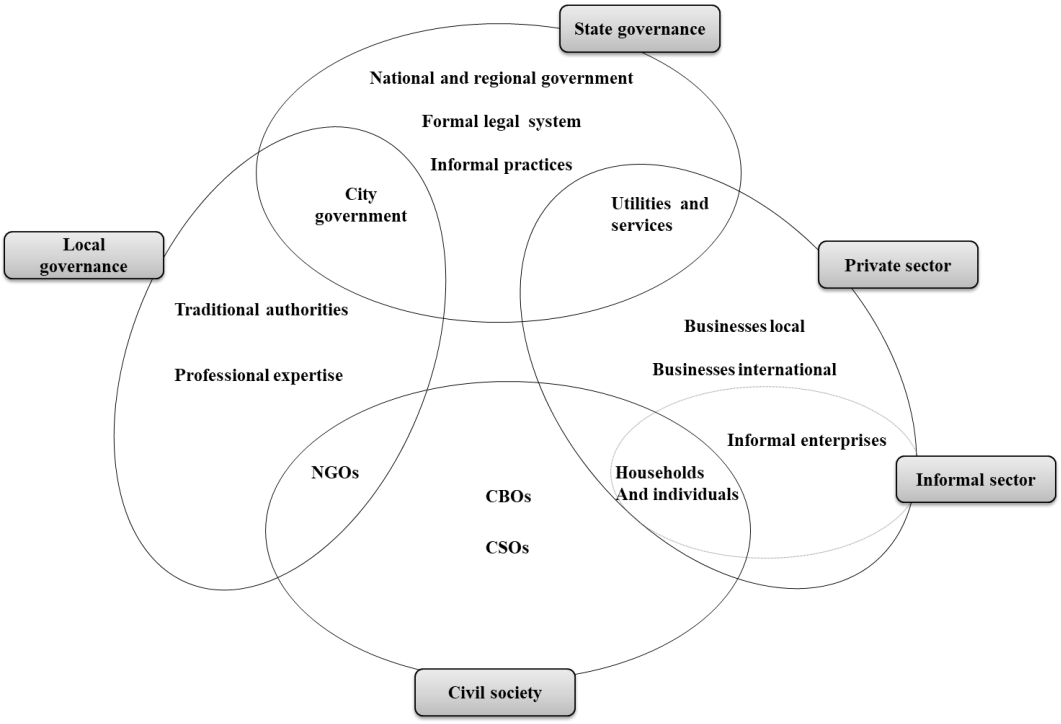
Thus, governance has a multifaceted nature and can be intended as: 1) a conceptual framework (Le Galès, 2003); 2) a theory; 2) a practical object of study that can be observed according to a normative dimension (Pierre, 2005) aimed at exploring the norms and institutions for the most effective and efficient actions (Crespo and Cabral, 2010)

Mixing private and public sector with urban general management, the topic of *urban governance* is even more complex than the "general" notion of governance.

More specifically, urban governance can be defined as the result of a coordination process in which different actors, institutions and social groups attempt to achieve their objectives, discussed and defined collectively in fragmented and uncertain environments (Le Galès, 2001). This kind of governance derives from the building of a social and political order, in which decision-making processes do not derive from a single actor with full responsibility, but rather from the effect of the strategic interaction between multiple actors, that own different resources and rationality (Rosso, 2004).

Therefore, urban governance involves a range of actors and institutions and the relationships between them determine what happens in the city. In managing urban change, government has a strategic role and should establish and maintain partnerships with and between *key stakeholders* (Healey, 1998). Urban governance, by referring to how government (local, regional, and national) together with the stakeholders decide how to plan, finance, and manage urban areas, involves a continuous process of negotiation and contestation regarding the allocation of social and material resources and political power (Devas et al., 2004; Brown, 2015). The main actors of urban governance, as shown in Figure 2.1 and described in Table 2.1, are: 1) state; 2) local governance; 3) private sector; 4) informal sector, or civil society.

Figure 2.1. Actors and institutions of urban governance



Source: Author's elaboration from Devas et al. (2004) and Brown (2015)

Table 2.1. Actors, parties, and interests involved in urban governance

Governmental	**Businesses**
· central government · municipal government · development corporations or authorities · central government agencies locally (e.g. district commissioners, police) · traditional authorities (e.g. chiefs) · state-owned public	· formal sector: international/national · formal sector: local · informal sector
NGOs/CBOs/CSOs[3]	**Households/individuals**
internationally connected NGOs · formal civil society organizations (e.g. trade unions, churches and other religious organizations, political parties) · local, community-based organizations	Governance is about collective action. Since households/individuals are objects and participators (consumers, voters) they are still included into the framework.

Source: Devas et al., 2004

[3] The Non-Governmental Organizations (NGOs) can be defined as "*any international organization which is not established by inter-governmental agreement*" (Ahmed and Potter, 2006). The Community Based Organzations (CBOs) refer to public or private nonprofit organization that is representative of a community or a significant segment of a community and works to meet community needs. The Civil Society Organizations (CSOs) are voluntary organizations with governance and direction coming from citizens or constituency members, without significant government-controlled participation or representation (NGOs AND CSOs: A NOTE ON TERMINOLOGY).

However, the coexistence of different actors with multiple objectives and interests increases the risk of organizational insufficiency and lack of coordination (Warren et al., 1992). It follows that a deeper understanding of the shades of meaning of urban governance is required to understand how flexible managerial and decision-making models can be adopted. For this reason, the different definitions and perspectives introduced to analyse urban governance are debated in the following paragraph.

2.2 URBAN GOVERNANCE: DEFINITION, PERSPECTIVES, CHALLENGES

As discussed above, urban governance can be intended as a process, rather than a static phenomenon, and can be conceptualized as a model, in which a series of top-down (local government-citizens) and bottom-up (citizens-local government) relationships aim at pursuing collective aims.

The definition of governance as an integrated system based on embedded activities and relationships, in which local authorities and private organizations with different needs strive to pursue collective goals, highlights the controversial nature of a multifaceted phenomenon shaped by the coexistence political, economic and social values.

Urban sector has always been characterized by a governance "gap" (Pierce, 1993; Pierre, 1999) to be filled, due to the different needs of the multiple stakeholders groups (private companies, public organizations, institutions, local administrations, non-profit associations, citizens) encapsulated in complex cities, considered as multilevel networks or systems. The cohabitation of different individual objectives implies the potential conflict among different beliefs and values to be matched with overarching system's finality.

Therefore, starting from the last decade of the 20th century, the investigation of the most proper coordination mechanisms pursued and implemented by governance emerges as a hot topic in literature and as an urgent need to be addressed by practitioners.

The shift occurred in the "classical" theories on governance and public governance (see paragraph 2.1) translated into the transformation of the conceptualization of urban governance, that has been broadened to take into account the issue of private-public

interactions as a key driver to manage the conflicting interests involve in urban territories. Over time, the set of stakeholders included in urban decision-making processes and policy implementation has been widened to engage all the social actors lying in a territory.

Despite the different approaches proposed to actualize the transition from a restricted to a collaborative view, a common definition of the coordination mechanisms of urban governance has not been proposed (Crespo and Cabral, 2010). Moreover, the functioning of the institutional dimensions of urban governance seems to be still unclear (Dezi et al., 2005).

The evolution of urban governance can be interpreted in parallel with the general passage in governance theories from: 1) government to governance; 2) managerial to entrepreneurial viewpoint (Stone, 1987; Stoker, 1998). Thus, urban governance models based on a restricted distribution of economic power (ruled only top-down by state and government) is broadened to involve social participation and a proactive leadership vision aimed at pursuing social goals (thanks to the collaboration of varied stakeholders).

Starting from a reelaboration of literature (Osborne, 2006; Pierre, 1999), a classification of the different urban governance models can be obtained considering two main variables that take into account the shift from government to governance and from managerialism to entrepreneurialism:

1) power structure: based on the dichotomy hierarchical urban governance based on top-down mechanisms vs horizontal urban governance based on bottom-up processes;
2) relational modalities: based on the opposition between a competitive logic, grounded on the closeness of organizational boundaries, and a cooperative logic, which introduces public-private partnerships and citizens' engagement.

The two macro-categories are not opposite but can be considered as the poles on a continuum (Pierre and Peters, 2000; Crespo and Cabral, 2010); actually, cities can combine "naturally" the different models or move from one to another by adopting integrated solution to survive in the context.

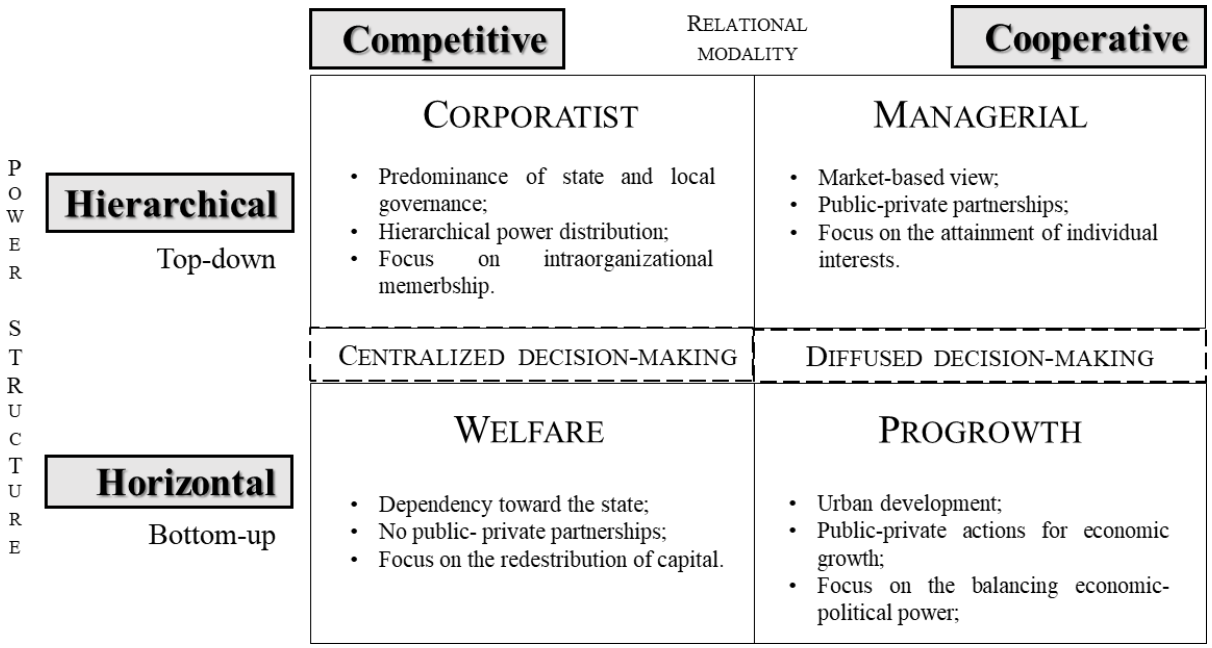
Starting from the combination of the two different sub-categories (top-down and bottom-up and competitive and cooperative) of power structure and relational modalities, a typology that classifies four urban governance models can be obtained

(Pierre, 1999): 1) *corporatist urban governance models*; 2) *managerial urban governance models*; 3) *welfare urban governance models*; 4) *progrowth urban governance models.*

The models, depicted in Figure 2.2, are described in the following sub-paragraphs to emphasize the different views on governance that imply different conceptualizations of organizational layout, of decision-making process and of organizational boundaries. For this reason, each model is described according to the following main features:

- organizational layout and power distribution;
- relational openness to external stakeholders (exclusive- inclusive models);
- decision-making processes based on different degrees of involvement of direct and indirect stakeholders in policies design and implementation;
- final goal, ranging from costs-benefits balancing to economic and/or social development.

Figure 2.2. Typology of urban governance models



Source: Author's elaboration

2.2.1. Hierarchical urban governance models

The combination of hierarchical power distribution with competitive approach gives birth to *corporatist urban governance model* (see the 1nd quarter of Figure 2.2).

Deriving from statist tradition (Pierre, 1999), corporatist model is based on the high involvement of state in policies implementation and on the predominance of local government in the search for consensus. Power distribution is characterized by a hierarchical approach that includes, however, the different stakeholders' interests only at the intra-organizational level (internal organizations' membership).

Thus, leadership is exerted through top-down processes through centralized and internalized decision-making processes that shape "closed" organizations that do not involve social groups in the proposition of regulatory actions.

This perspective can be connected to perfect (or global) rationality model[4] of decision-making (Simon, 1955). According to this deterministic perspective, decisions are based only on the pursuit of maximum profit (one best way) and are undertaken by a single actor. It follows that the governance layout is hierarchical and bureaucratic and that corporate culture is established and spread only at the top-level of organizations.

The final aim of this competitive-based governance model is to increase the effectiveness of urban politics and public service delivery to increase revenues and balance private profits with public spending.

Managerial urban governance model stems from a market-centered view based on the application of public management standards for public services providers, whose main concern is the attainment of individual interests (Dalton, 1996).

Regarding relationships with other (private or public) companies, this view aims at governing public organizations through private management standards; thus, public service providers are considered as managers that should pursue customer's satisfaction and service efficiency. Consequently, public-private strategies are introduced to soften the distinction between firms and local government.

The asset of power is hierarchical, since the decision-making processes are centralized and do not involve social actors in the design of policies. Decision-making is driven by absolute rationality since it is hypothesized that the uncritical application of private management standards to public companies can guarantee the same levels of efficiency. However, this model can be considered suitable for stable markets in which technology or consumer behaviour do not change rapidly and frequently.

The final goal is the balancing of the trade-off between costs and revenues.

[4] At the basis of Simon's concept of limited rationality (1957): "*except for particularly simple problems, it is not reasonable, in most cases, to attribute to decision-makers both the technical knowledge and the calculating capacity necessary to determine the solution paths provided by the theory*".

Therefore, this model is situated in the 2nd quarter of the typology.

2.2.2 Horizontal urban governance models

The transition from a restricted view of governance- or even government- to a broadened-horizontal perspective implies some changes in the coordination mechanisms, in the assets of power and in the objectives of governance. In detail, two alternative models for urban governance- based on bottom-up decision processes- can be identified: 1) *progrowth model*, a competitive framework; 2) *welfare model*, a cooperative framework.

According to *progrowth model*, the main goal of urban governance should be the economic development of cities and the balance of economic and political power.

Therefore, this model is characterized by the presence of concerted public-private actions to ensure economic growth. However, the power distribution is grounded on elitist view, since there is a unitary interest to be pursued: the enhancement of profits. It follows that this perspective is characterized by restrictive assumptions that neglects any kind of participation of social actors and civil society in urban planning and decision-making.

Since it is not possible to predict environmental changes, the perfect pursuit of maximum profit is unrealistic to achieve and, therefore, the business macro-purpose becomes the most satisfactory solution (one-best fit) in terms of profit. Given that decision-makers should take many risks, their attitude is guided by more instinctive and less rational mechanisms (Vicari, 1998; Baccarani, 2004). Moreover, in order to foresee (or at least react to) the external changes, decision-making processes do not start anymore from the structural choices but from the evaluation of business relationships that are intended as strategic lever of success.

In order to involve external stakeholders and to increase their commitment, decision-makers should select a varied set of relevant stakeholders (Barile, 2009).

Lastly, *Welfare* cities are grounded ideologically on a “dependency toward the state” (Pierre, 1999, p. 386). The final goal is to ensure not only economic outcomes but involves the accomplishment of social development and growth. Even if the partnerships between private and public sectors are avoided, the model is based on a cooperative approach between local government and state and on an inclusive orientation that stresses the need to redistribute capital toward the different direct and indirect urban stakeholders. Thus, it is considered as the integration of bottom-up

processes according to a cooperative approach.

2.3 URBAN GOVERNANCE IN DIGITAL ERA

Over the course of time, social, economic (the mounting globalization) and technological evolution encourage cities to adopt new social and institutional policies, consequently new kind of mixed and hybrid governance, defined less rigidly than the models analysed in paragraph 2.2. Nowadays, cities are embedded in global systems; thus, there is the need to ensure competitiveness, to maximize not only economic resources but also human, social and political capitals through new governance models (Tocci, 2007). Urban territories become complex ecosystems in which people, goods, services, information are encapsulated to create and co-create the development of the entire community.

Thus, contemporary urban governance can be interpreted according to two different dimensions (Tocci, 2006): 1) internal integration; 2) external integration.

According to the *internal integration dimension*, governance concerns the ability of a city to integrate groups of actors, organizations and to harmonize the different interests that interact in it. Thus, cities should optimize public and private interests, local and central state, by working to develop common policies and strategies.

The *external integration dimension* defines the ability of a city to represent itself outside its internal sphere. In other words, it refers to the ability to share strategy, collective projects with other local communities and, above all, other cities.

To sum up, the key roles of urban governance (Slack and Côté, 2014) involve the following activities:

I. the constant reframing of the physical and social assets of urban area, in line with social and economic changes;

II. the enhancement of local services efficiency;

III. the strengthening of the effectiveness in costs reduction and resources distribution among different actors;

IV. the improvement of residents' ability to access local government and engage in decision-making, affecting local government accountability and responsiveness to citizen demands.

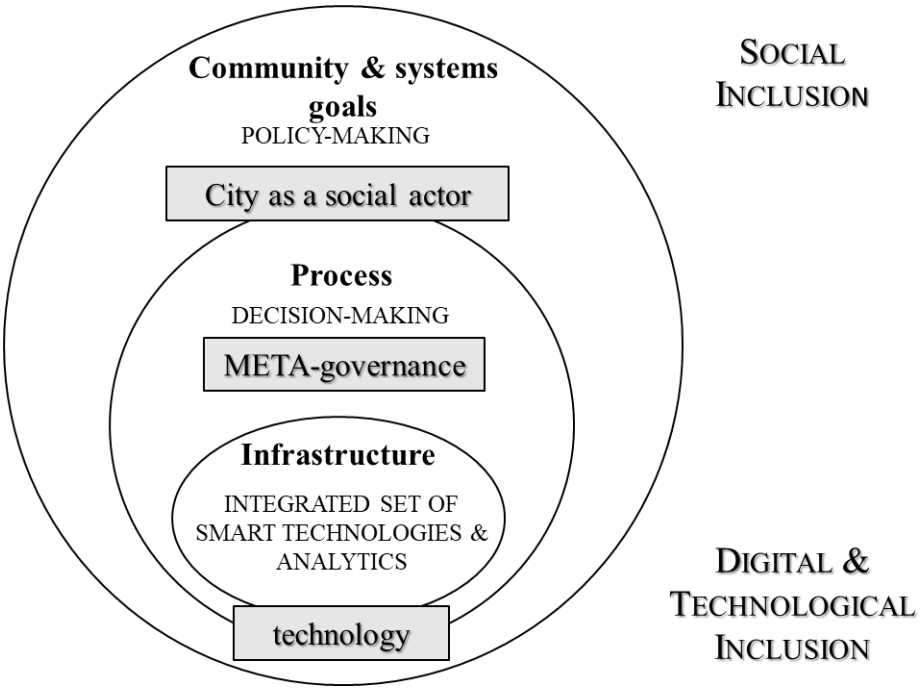
Therefore, in digital era, urban territories should implement a systems governance that aims at pursuing: 1) economic, cultural and eco-sustainable development; 2)

social inclusion and equity; 3) enhancement of territorial competitiveness; 4) improvement of overall quality of life.

Contemporary cities need to be reframed as social actors, whose interaction are mediated by technology that requires meta-governance, a hybrid form of governance. Thus, the three dimensions here identified to redefine urban governance in digital era –depicted in Figure 2.3 – are:

1) social inclusion and reinterpretation of city as a *social actor*;
2) realization of an integrated set of *technologies* to enhance governance regulation mechanisms; Digital inclusion in the access to ICTs and social inclusion in the co-development of policies.
3) *meta-governance* process, mixing horizontal and vertical power structures and grounded on flexible decision-making.

Figure 2.3. The key dimensions for a reinterpretation of urban governance model in digital era



Source: Author's elaboration

Over the course of time, the state has lost its centrality; thus, cities can be intended as a set of social systems and sub-cultures that can become autonomous social and political actors (Bagnasco and Le Galès, 2001) searching for alliances and synergies to increase their competitiveness (Véron and Vicari Haddock, 2004).

Cities should act as collective communities (Tocci, 2007), by overcoming individual interests, establishing shared new values and institutions to shape the beliefs and way of life of all the stakeholders engaged in the system. Thus, cities are territories, which share, shape, redefine and co-create new values deriving from information and knowledge sharing between its members.

According to Pichierri (2005), a collective actor is identified through the presence of five elements: collective decision-making; common interests; integration mechanisms; internal and external representation of the collective actor; innovation capacity (Le Galès, 2006). Thus, urban governance in cities as social actors should mediate between multiple requests and needs and should interpret the city itself as collective and unitary actor (Tocci, 2007).

Contemporary cities are a set of institutions and actors that are connected with each other thanks to technology-mediated interactions. Thus, *technology* is a strategic driver that can improve cities sustainability and quality of life by enhancing social capital, citizens' knowledge and innovation (Nam and Pardo 2011; Stratigea et al. 2012).

The increasing diffusion of ICTs, Big Data and automatized techniques such as machine learning lead to the development of *smart cities* (Nam and Pardo, 2011; Kitchin, 2016), in which decision process are enhanced by smart technologies that foster connections between and among citizens, public and private organizations and enhance relationship by increasing transparency and involvement and reducing informational asymmetry.

In contemporary digitalized world, cities are embedded in information society[5] (Castells, 2002) in which organizations have a higher scope that requires constant production levels and the increasing acquisition of new information, skills and knowledge. Thus, also due to the increasing information fluxes (big data) surrounding organizations' life, cities should collect, analyse and interpret data to translate them into information to be used in corporate strategies to enhance business process.

Whilst new technological tools have been developed, on the other side the major challenges regarding environmental, energy, and demographic issues require a change

[5] The rise of new digital industrial technology, known as *Industry 4.0*, is a transformation that makes it possible to gather and analyse data across machines, enabling faster, more flexible, and more efficient processes to produce higher-quality goods at reduced costs. This revolution can increase productivity, shift economics, foster industrial growth, modify the profile of the workforce and change the competitiveness of companies and regions. Some contributing digital technologies are: mobile devices; Internet of Things (IoT) platforms; 3D printing; smart sensors; big data analytics and advanced algorithms; augmented reality.

in urban governance models aimed at creating value and achieving a long-term sustainable advantage (Keams and Paddison, 2000).

Governance mediated by ICTs can foster cities development potentially (Da Cruz et al., 2019): however, the application of technology does not involve the automatic attainment of competitive and sustainable advantage.

The use of technology in urban governance should be harmonized by urban entrepreneurship (Meijer and Thaanes, 2018) that exploits the possibilities of innovation offered by technology through the adoption of a proactive mind-set.

Therefore, there is the need to understand how technologies are managed and harmonized by governance, how decision-making processes are reframed and boosted by the application of smart technologies and automatized research techniques to big data management.

Meta-governance can be defined starting from the integration –rather than the opposition- of top-down and bottom-up view, as a systems and hybrid model of governance (Da Cruz et al., 2019). This model can take into account the embedded nature of urban networks-systems and the blurring of boundaries between public-private product-services.

A systems governance implies the coexistence of nonlinear policy-making processes among different actors with multiple needs (Da Cruz et al., 2019) across the delivery of varied kind of public and private services (Harvey, 2005). The redefinition of urban governance model is based on the harmonization of top-down and bottom-up, cooperation and competition coexist to give birth to meta-governance (defined vertically and spread horizontally) and collaborative governance (a synthesis of competition and cooperation) to improve the general well-being of a community (Da Cruz et al., 2019).

Governance in digital era should harmonize technological advancements by including them in daily life to improve decision-making, firstly, and policy-making, secondly. The evolution in governance models require transformation in decisions process and policies formulation.

An effective meta-governance strategy should harmonize all stakeholders' needs to renew and regenerate cities thanks to active involvement of private and public companies, citizens and civil society in the development of co-created decision-making, firstly, and integrated policies, secondly. The main features of this new urban governance model can be: 1) new power distribution (at the policy and institutional

level, the first circle in figure 2.3); 2) decentralized and diffused decision-making (the second circle in figure 2.3) that enables empowered knowledge exchange thanks to technology-mediated relationships (see the third circle in figure 2.3); new technology-mediated interactions and new possibilities for firms to collect data from users automatically and rapidly.

2.4 THE ROLE OF TECHNOLOGY IN URBAN GOVERNANCE AND DECISION-MAKING

The huge amount of data available in contemporary markets, in increasingly rapid and previously unimaginable times, changes the configuration of urban territories and increase the possibility to improve public services. The opportunities offered by multiple and interconnected technological channels (Rangaswamy and Van Bruggen, 2005; Neslin et al., 2006) enhance the opportunities for companies to interact with customers and partners, making communication and the exchange of data and information potentially continuous.

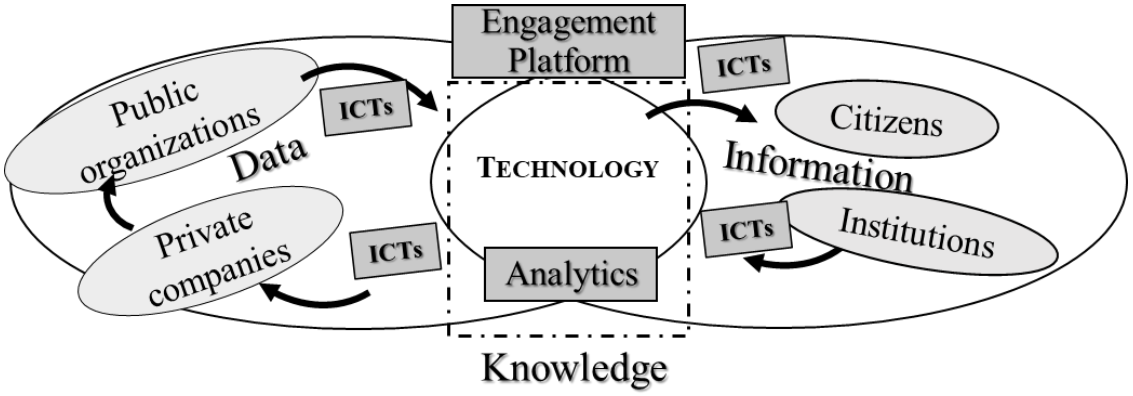
However, even if the existence of multiple *touchpoints* with customers-citizens offers great advantages, there is the need to understand how the big flow of data can be optimized in order to exploit the potentials of the current ICTs (*information and communication technologies*) by avoiding to turn these advantages into threats (Gandomi and Haider, 2015).

The varied set of new technologies that contemporary organizations can adopt to increase engagement with actors, improve services and analyse data to catch insights for innovation can be subdivided into two main categories of tools, synthesized in Figure 2.4 and described in the following subparagraphs:

1) *ICTs* such as websites, communities, mobile applications, social networks to keep in touch with customers and with a varied set of stakeholders and *engagement platforms* (Breidbach et al., 2014) to allow the sharing of ideas, values and proposition with users;
2) *Research analytics tools*, that allow data collection and analysis through automatized instruments thanks to the application of methods and techniques such as *decision-support system* (DSS), *cognitive computing* and *fuzzy logic*. Data computing is realized thanks to an integrated set of analytics that can support companies' decision-making thanks to the

extraction of users' buying behaviour, choices, attitude and opinion service. Thanks to the interpretation of this information, the insights collected can be turned into knowledge.

Figure 2.4. The different kind of tools and analytics deriving from smart technologies



Source: Author's elaboration

2.4.1 ICTs and engagement platforms

Digitalized organizations should select and combine harmonically the most appropriate big data technologies and techniques to create a technology-driven ecosystem (Saggi and Jain, 2018), where the data extracted can be turned into information and, then, knowledge to improve decision-making.

To realize this complex transformation and manage properly information fluxes, companies should build an integrated technological infrastructure that can be defined thanks to the key notion of *Internet of things* (Atzori et al., 2010). IoT is a combination of connected physical and mobile devices for the development and deployment of information systems that integrate data collection, integration and information dissemination (Brous et al., 2019; Jonoski et al., 2010) between and among different ecosystems (from smart cities to smart healthcare, etc.).

Thus, interconnected urban territories should realize an ecosystem of technological tools (synthesized in Table 2.2) to develop a business model based on open and collaborative e-government based on:

1) ICTs and data collection tools, to interact with users and monitor and collect feedback;
2) E-citizenship tools (*engagement platforms*) to engage citizens in the delivery

and improvement of public services.

Table 2.2. ICTs and engagement platforms in urban territories

	Smart technologies tools
ICTs Users' data collection tools	Blockchain-based framework Networking technologies (distributed sensor systems, wireless, mobile platforms) Smart mobility application Gamification, CPD, QAE Storage systems Cloud computing eService Monitoring component
Digital Citizen Tools	Kit digital citizen (TrentoSmartCityWeek) On-line Living Labs On-line information desk
E-democracy platform	E-petition (Change.org) App for service recovery, improvement and proposal of new services Co-creation Platforms for social challenges
Objectives	Collection of users' feedback Constant renewal of the key values of smart culture Involvement of citizens in policy-making

Source: Author's elaboration

Users' data collections tools are an integrated set of smart technologies to collect and analyse data are employed, such as blockchain based framework, networking technologies (distributed sensor systems, wireless, mobile platforms), gamification-based technologies and eService Monitoring component. Regarding ICTs, social networks are used to share news about the events and initiatives realized but also to extract relevant data through API, web scraping, content management systems and clustering.

Thanks to blockchain framework, the provision of smart services for mobility, environment, e-government can be enabled. Blockchain models can catalyse offer and

demand to draft and seal smart contracts, monitor their fulfilment and grant rewards.

Networking technologies can be based on a series of sensors to collect from citizens data related to safety, energy, mobility, waste disposal and offer some useful services, such as car sharing. The aim is to introduce and boost digital services to promote waste reduction and to provide some "smart points" for the provision of smart mobility.

Then, there are some ad hoc technologies to enhance users' engagement thanks to gamification, in which citizens and public administrators can cooperate to improve the e-services and solve problems, and *gamification engine*, mechanisms to increase the participation and to offer personalized services.

Smart technologies allow also to implement an integrated *storage systems* based on technologies such as cloud computing, and relational or non relational databases (SQL or NoSQL) that permit to store useful information (users' data, purchase orders, reviews) to extract relevant knowledge for the improvement of quality and relationships with users (Storey and Song, 2017 Lamba e Singh, 2018);

Digital citizen tools concern a varied set of *e-tools*, which promotes co-innovation and co-creation of public services and the enhancement of the relationship citizens-government.

Thanks to smart technologies, community can be involved in the delivery of services and can increase their technological capabilities by simplifying the access to public services. *E-government* is based on the democratization of the access to e-services by offering an open system of platforms that can help them when interacting with the e-service.

Thanks to Digital Citizen tools, new forms of sociality (technology-based), new ways of communicating through ICTs (more transparently) and on the development of new forms of participatory (e-)decision-making can be introduced. The creation of a cohesive digital and smart culture can be pursued to help urban community overcoming innovation and technological barriers (community).

E-democracy can provide citizens with updated information on services. On the other hand, users can inform the other citizens on malfunctions, can share their insights with citizens and can propose new mobile applications based on their experience. In this way, citizens can be leading actor of community improvement

This new e-government and open innovation model can be enhanced thanks to the

digitalization of public service delivery and to the constant search for an active dialogue with citizens. In this way, users can live their experience with services differently and the general quality of public services can be improved.

Open and collaborative solution of e-government can be based on digital open platform to dialogue with citizens that can: 1) propose new services (Living Lab); 2) address challenges in service and service delivery; 3) propose new ideas.

Thus, the inclusion of citizenship acts as a key lever to: 1) raise service delivery effectiveness and simplifying the relationship citizens- local government; 3) harmonize relationships and knowledge exchange among different stakeholders; 2) enable the proposition of innovative insights from the community and for the community.

Therefore, a synergistic set of smart technologies can create an e-government environment with a collaborative space where citizens and civil servants share and exploit accessible knowledge about public procedures, and more specifically, citizens can solve their problems and actively take part in the enhancement of e-services.

2.4.2 Analytics and research techniques for big data analysis

The new technologies described in the previous paragraph can provide companies with numerous advantages, since they guarantee greater rapidity in decision-making processes that helps challenging the difficulties faced by decision makers due to the growing variability and indeterminacy of the context. Furthermore, smart technologies and ICTs increase the opportunity for companies to manage environmental complexity by monitoring users and stakeholders' attitude and their opinion on services and preventing changes and turbulences in markets.

As synthesized in Table 2.3, the main research techniques that allow the application of automatized extraction tools to analyse Big Data are: 1) text mining and techniques for users profiling; 2) fuzzy logic; 3) decision-support systems; 4) consensus-based model; 5) artificial intelligence and cognitive computing.

Table 2.3. Research analytics in smart organizations

Analytics *Data analysis tools*	Text mining, datawarehouse and recommendation systems for users' profiling

	Fuzzy logic, Decision Support Systems, Consensus based model Artificial intelligence & cognitive computing
Objectives	Production of added value services through digital technologies Enabling of service and process innovation Improvement of transparency in communication

Source: Author's elaboration

Text mining techniques data are devoted to the extraction and analysis of data, carried out by considering online sources, such as websites, active groups on social networks, blogs, forums and much more (Daud et al. 2017; Lytras and Papadopoulou 2017). They aim at profiling users to understand their behaviour and to apply differentiated strategies to engage them.

Machine learning techniques are defined as predictive analytics, that require statistical learning and network science to convert data resources into actionable knowledge (Suthaharan, 2014; Archetti et al., 2015);

In the information society, therefore, dominated by social networks, the changes (both in consumer tastes and in macroeconomic variables) follow each other quickly, which makes it much more difficult to govern and predict both social and consequent phenomena economic type. For this reason, in terms of decision-making, the tools offered by ICT can allow to manage complexity, allowing companies to acquire competitive capacity in a dynamic and hyper-competitive scenario. As new technologies affect businesses globally, their application to corporate contexts has led to the emergence of real corporate information systems, aimed at managing information within companies, increasing effectiveness (reducing the cost of production activities) and efficiency (improvement of product differentiation and personalization capacity). These systems can support both strategic management activities (*Management Support Systems*, MSS) and operational ones (*Operations Support Systems*). Within the MSS, which produce information relevant to the management decision-making process, the *decision support systems* (DSS, Perez et al., 2010; Vercellis, 2009) are born, which help to facilitate managerial choices, through the formulation and reformulation of queries without predetermining the answers and supporting the decision-making process in an interactive way.

These tools are particularly useful to enhance management choices, in conditions of environmental complexity. DSSs are information systems based on the conversion of data from internal and external sources into information to be provided in the most appropriate way to managers at every level and in each company function in order to allow them to make quick and effective decisions (Fenza et al., 2016)

These techniques and tools offer support to the decision-making process and to the strategic direction of the company and to the evaluation of information and data useful for making a choice between several alternatives.

Decision-support approach can be based also on techniques that use logic to improve decision-making, such as *fuzzy logic* and *linguistic consensus model* (Herrera et al., 2014; Cabrerizo et al., 2014) enabling to reach consensus about the final decision considering decision-makers' opinions conveniently expressed through linguistic values and their heterogeneous influence. The framework integrates a reinforcement-learning algorithm to update and consequently assign appropriate weight (i.e., level of influence) to each decision-maker. The weights are assigned taking into account the context and the time elapsed from the last involvement of each decision-maker. Ontologies and description logic are adopted to model and reason about contexts and to support weight assignment to each decision-maker. For instance, this methodology can be employed to evaluate the weights of the different participants in the fuzzy decision-making paradigm to support more effectively the undertaking and the implementation of decisions.

Cognitive computing systems are machine learning systems that enable decision-making thanks to circular learning mechanisms and allow machines to communicate with operators in natural language. These techniques can support human decision-making and guide problem solving by detecting alternative courses of action starting from data (Chen et al., 2016).

Based on learning cycle principles, cognitive computing solutions (Chen et al., 2016; Hurwitz et al., 2015) are systems that start from a fixed vocabulary to deduce and learn the meaning of new words based on contextual clues. After the understanding of a minimum amount of meanings, content from fragmented information is transformed into holistic pictures by using visualizations techniques. The association between meanings and data can help managers to identify connections among variables more rapidly and to highlight unexplored connections (Chen et al., 2016). In line with the main features of data-driven approach, cognitive computing is

grounded on two main elements: 1) the role of contextual insights (inputs) that through the identification of patterns (information associated to data) leads to development of hypotheses; 2) the circularity of learning acquired and a continuous learning attitude (Hurwitz et al., 2015) that contributes to pinpoint the most suitable courses of action. This technique seems to fit with the accomplishment of businesses conduct (learning by doing, learning by experiencing) that aims at reducing complexity over time by acquiring increasing knowledge that help to manage the instability of markets and the emergence of unpredictable phenomena.

2.5 TOWARD MULTI-LEVEL URBAN GOVERNANCE AND DECISION-MAKING

Despite the relevant role of technology in the enhancement of urban management, as discussed in paragraph 2.3, the use of technologies does not imply the attainment of competitiveness. There is the need to explore the governance dimensions, mechanisms and processes to be implemented to address social demand (Tocci, 2006). In particular, the way in which the technologies tools described before can be used strategically to improve decisions, despite technological developments, cities should be understood in order to shed light on how digital tools can be employed to include citizens in these enabling environments.

Thus, Smart urban communities cannot exist without smart people that use properly smart technologies to enhance: governance, relationships and dialogue with citizens and decision-making (Visvizi et al., 2018).

Smart growth and innovation in cities do not stem from smart technology per se but from management's abilities to collect and interpret relevant information exchanged through ICTs-mediated relationships that are optimized by governance thanks to flexible and participatory decision-making.

The identification of human component (governance's mediating abilities, entrepreneurial attitude, citizens' digital competencies and willingness to use technology) as a key enabler of sustainable development is in line with a rising research stream in literature that considers technology as a means for sustainability and innovation and not anymore as the end of the process (Visvizi et al. 2018). A key role is played by proactive and innovative entrepreneurial orientation (Kourtit et al. 2012; Appio et al. 2018)

The dimensions for multilevel urban governance, depicted in Figure 2,5 are:

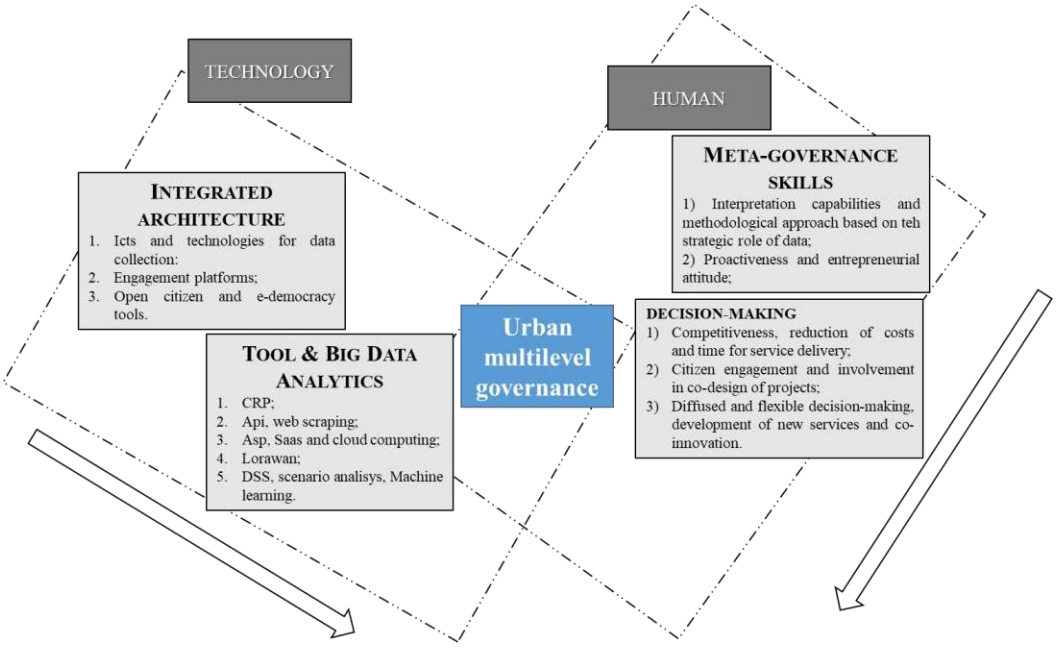
1) integrated set of analytics & technological infrastructure;
2) meta-governance and entrepreneurial attitude based on the strategic role of data
3) flexible decision-making, thanks to the proper management of data and information fluxes.

Urban multilevel governance can be defined as the application of a set of norms, rules and values (Deakin 2011) that can improve well-being in different urban areas, from economy to environment and social inclusion, in cities intended as collaborative technology-mediated networks.

The first dimension of smart communities is the technological architecture, which can be defined as the integrated network of smart technologies that forms the digital infrastructure of community (digital- network infrastructure – technology – ICTs). The second dimension is the human ability to manage decisions at a process level: at this level, decision-making can be realized thanks to potential involvement of all the stakeholders. Lastly, the alignment between the process-based objectives pursued through decision-making with the attainment of overall community goals requires the transformation of decision into policies.

Overall, the process data are exchanged to be turned into information relevant to introduce decisions and, then policies.

Figure 2.5. The 4 layers of urban multi-level governance



Source: Author's elaboration

As discussed above, smart growth and innovation do not stem from smart technology per se but from management's abilities to collect and interpret relevant information exchanged through ICTs-mediated relationships, that are optimized by governance. In smart communities, governance should harmonize the actor's objectives and align them with community's overall goal to foster the creation of a cohesive sustainable-innovative culture.

Based on the dimensions identified above (decision-making, technology, knowledge), multi-level urban governance should be based on the integration of social, human and technological sphere.

The *human and cognitive variable* is related to the development of innovative decision-making and management skills and on the enhancement of users' competencies and knowledge, enabled through their engagement; related to management capabilities and citizen's skills (Da Cruz et al., 2019).

Then, *management abilities* translate into the ability of governance to address innovation thanks to diffused decision-making and participatory policy-making.

Thus, as discussed above governance is an overarching complex process that embeds and involves decision-making, which can be viewed as one of the driver of governance. If efficient governance can give birth to efficient decision-making, the kind of governance model (especially in terms of distribution power) influences decision-making styles: for instance, hierarchical governance implies centralized and "closed" decision-making (see Figure 2.1).

Decision-making skills concern the ability to grasp new insights and innovation capabilities arising from actor's (users, providers, government bodies, institutions, research centres) relationships and, on the other hand, to entrepreneurial attitude for the development of the creative smart capital (Komninos 2013).

Thus, innovation can be co-developed jointly with users, thanks to management's skills to turn information into knowledge and to citizens' empowerment. Paroutis et al. (2014) identify a strategic view on innovation that is redefined as a "users-driven" process generated bottom-up by actors with an adequate digital knowledge promoted through social inclusion through the establishment of open innovation business models (Marsal-Lacuna et al. 2015).

Hence, the smart use of technological tools depends on human's ability to

exchange information through these instruments and on smart entrepreneurship (Stratigea 2012; Vanolo 2016) that maximizes innovative and creative potential and smart governance that harmonizes the process (Lombardi et al., 2012)

Decision-making in new urban communities should aim at regenerating the context by: 1) acquiring new skills to foster innovation and the development of new services; 2) increase know-how and recruit new talents; 3) improve city image for businesses, tourists and residents of a community.

Therefore, multilevel governance in urban communities can be reframed as the overarching entity that can harmonize the different relationships among actors (people and management), technologies and information flows to pursue innovation in the long run.

If technology is not sufficient for the emergence of innovation, it is only through entrepreneurial and strategic efforts to speed-up bureaucratic processes that communities can create new solutions to improve sustainability and manage complexity (Toppeta, 2010).

For this reason, democratic and multilevel governance seems to be the most adequate governance model to take into account the complexity and multidimensionality of smart community and to enhance decision-making.

Multilevel governance stems from the studies on networked governance (Stoker 2006; Kooiman et al., 2008) and on systems view (Barile et al., 2013; Piciocchi et al., 2012). This governance model is based on diffused decision-making and systems governance grounded on collaborative and participatory assets of power and entrepreneurs' strategies for the exploitation of innovation opportunities through the diffusion of value propositions and shared purpose for resource integration generating multiple innovations.

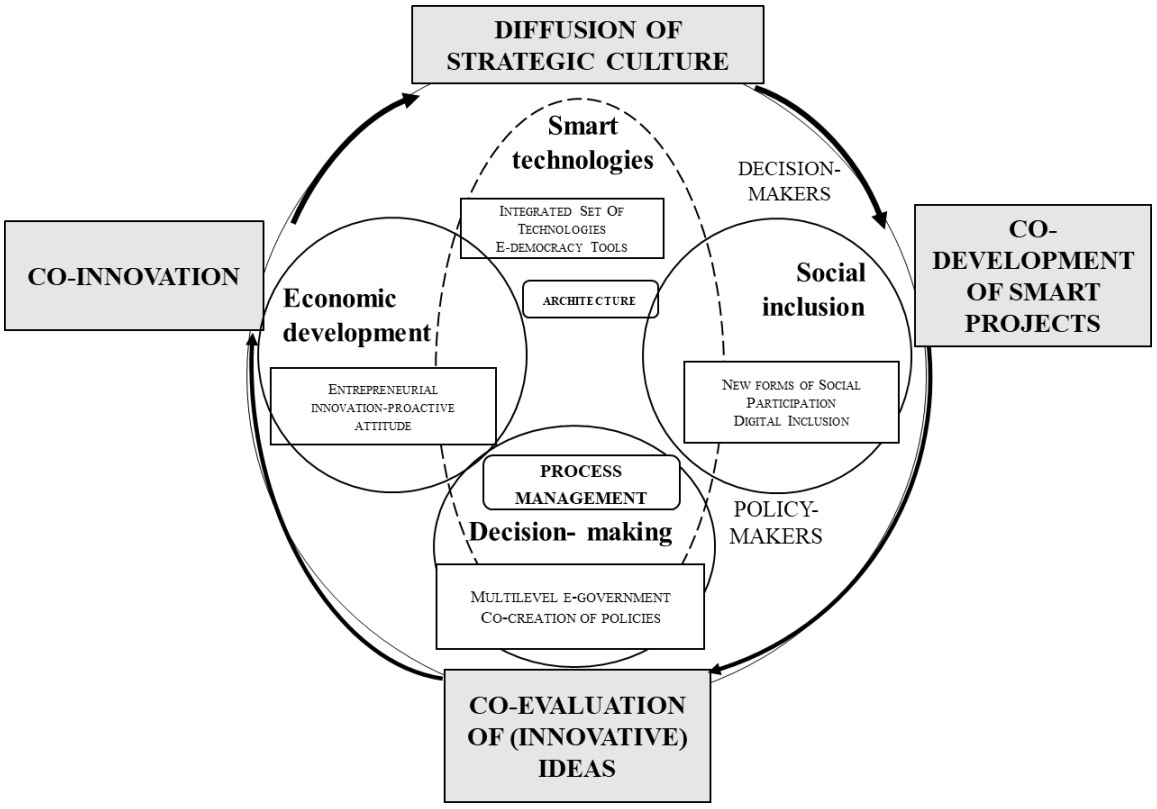
The system view reframes the governance as a multi-level system in which shared power and collaborative decision-making arise; the main challenge is to harmonize the stakeholders' heterogeneous expectations and objectives. Successful governance lies in the capability to mediate between conflicting interests and harmonize the stakeholders' objectives with overall system goals. In particular, the governance should spread the diffusion of the common interpretative schemes, information units, and shared knowledge (Piciocchi et al., 2012) that can enhance trust among users to promote the community as a whole. Multi-level governance at a meta-level can foster co-innovation thanks to the active

participation of each stakeholder group in resource exchange to increase development and competitiveness both at a micro (single system), meso- and macro-level (partners and overall economic and social markets).

In line with a process-based view (Ferretti and Schiavone, 2016), the main steps for multilevel governance can start from the diffusion and co-development of a cohesive culture to develop and implement policies according to a participatory (bottom-up and top-down) approach. Each phase of policy creation and realization, from design to implementation and evaluation, is co-created with users.

This process (depicted in Figure 2.6) can be conceived as a cycle that could start with a planning phase and can follow incremental steps towards innovative results such as product development. Once designed, a process is implemented and managed during its execution phase in order to compare its performance with some indicators and evaluate the results.

Figure 2.6. Decision-making cycle in urban multi-level governance



Source: Author's elaboration

Governance man steps can be included in a decision-making cycle composed

of the following stages (Troisi et al., 2019): 1) strategy, design and co-creation of common values (ethical, social and economically sustainable); 2) development and sharing of policies; 3) alignment between objectives and community goal; 4) evaluation of projects and feedback; 5) potential continuous improvement.

Firstly, a strategic effort is needed to promote the acquisition of new competencies, economic development and job opportunities, develop tourism and enhance urban and community well-being. To renew territory and regenerate economic, social and territorial life thanks to cohesive culture to be established (top-down processes) and diffused in the entire community (bottom-up processes).

Then, companies should enhance the engagement of citizens in the joint development of concerted decisions and proposal of common solutions.

Thus, each user can become policy maker by turning shared decisions into common policy. Lastly, the co-development of policies and of innovative solutions can address opportunities innovation and strengthen the culture of community. Thanks to democratic governance, new open models based on innovation and e-governance can be established and new cultural and social institutions can be created.

Lastly the process of co-innovation as a cycle can be renewed over time (the arrow in the figure). The participatory and multi-level governance regenerate the smart culture produced through the constant renewal of values and knowledge. The entrepreneurial attitude to innovation and the continuous development of educational, learning and engagement activities can allow at revitalizing the sustainable culture over time and at reinforcing the cohesive culture shared by actors. In this way, community members can reproduce the smart culture over time by adapting it to environmental changes and co-designing gradually the foundations for a smart future.

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CHAPTER III

REINTERPRETING URBAN GOVERNANCE THROUGH VIABLE SYSTEMS APPROACH: INSIGHTS FOR URBAN COMPLEXITY MANAGEMENT

"The whole is greater than the sum of its parts."
— Aristotle

3.1 REDEFINING URBAN GOVERNANCE MODEL: A SYSTEMS PERSPECTIVE

As discussed in the previous chapter, the mounting hyper-competitiveness of contemporary markets determines some evolutions in the governance models conceptualized in extant research and in the dynamics of decision-making and policy-making of urban territories.

According to the review performed on urban governance models (see paragraph

2.2), it can be noticed that the general shift toward a “broadened” (and multi-stakeholder) perspective on governance translates into the proposition of a new mind-set that: 1) rereads governance mechanisms through a meta- approach mediating between top-down and bottom-up power distributions; 2) interprets decision-making as a diffused and participatory process.

The adoption of a systems approach can be considered as a trend that redefines, over the last forty years, the interpretative schemes of extant scientific research, ranging from biology to physics to economics and management. The growing awareness on the complexity of biological, physical and social systems (Fabrizi, 1963) encourages scholars to imagine new paradigms in which the focus is on not only on the components of the object observed, but also on the relations between them, as well as, in the case of a social organization, also on the behaviours of the different actors and the context in which their action takes place. If governance studies start to conceptualize a multi-level and systems approach, simultaneously the general studies on management introduce a systems viewpoint to redefine the conceptualization of business models and phenomena. Thus, the focus is expanded on the observed entity as a whole, on the relationships and interactions that dynamically and in an emerging way are developed between the elements that compose it and between these and other external entities. The application of systems lenses and, at the same time, its cross-disciplinarily nature contribute to the realization of considerable progress in the observation and analysis of phenomena, by providing useful elements for the investigation of old and new scientific problems in the field of natural sciences, neuro-sciences, and social sciences. These premises are the clear manifestation of the disruptive scope of systems thinking.

Furthermore, as discussed in paragraph 2.3, in the modern information environment reshaped through *4.0 technologies* changes radically the approach to decision-making, by shifting the attention from *perfect or absolute rationality* to *limited rationality* and from deduction to induction and abduction. In fact, the decision-making process can be supported by the modern representations of even very large amounts of data and information, the Big Data, and by the increasing possibility of their elaboration and the computational capacity, offered by Big Data analytics (see par. 2.4, Intezari and Gressel, 2017).

In this direction, as highlighted in the analysis of the evolution of urban governance model, the complexity of government and decisions processes in territories requires the espousal of a systems approach that takes into account the different needs of multiple stakeholders, ranging from users to government bodies,

who participate in the development of the territory. Thus, cities can be reinterpreted as systems in which different stakeholders communicate and exchange resources through technology- mediated interactions harmonized through process management (application of managerial and technical skills) to enhance social actors' involvement in decision-making and to increase policies effectiveness.

In the light of the need to reframe cities as systems, *Viable Systems Approach* (VSA) (Golinelli, 2002, 2005, 2011; Barile, 2009; Barile et al., 2015) can be considered as the most proper theory that can provide governance studies with the right multi-level and all-encompassing standpoint to reconfigure the traditional urban governance models described in chapter 2.

VSA stands out from among extant systems theories thanks to the introduction of a broadened focus studying organizations' behaviour through the analysis of their context and relationships established with sub- and super-systems in order to survive and to co-evolve. Thanks to a meta-perspective mediating between holism and reduction, VSA provides researchers and managers with new interpretative schemes to renew business and organizational models (Barile, 2008).

The approach applied successfully in various areas of economic and social field (Polese et al, 2017; Toledo et al., 2017; Walker, 2017), stems from *General Systems Theory* (GST, Von Bertanlaffy, 1962) and *Open System Theory* (OST, Katz and Kahn, 1978). Specifically, it embraces a comprehensive viewpoint halfway between reductionism and holism deriving from the consideration of organizations as systems, as a complex set of interacting components (in line with GST) and from the willingness to explore the ways in which they survive in changing environmental conditions (in line with OST). Hence, VSA describes the environment in which organizations lie and focuses on the analysis of relationships among socio-economic entities, in search for viability (Beer, 1972; Golinelli et al., 2001).

VSA seeks to identify the most proper strategies to manage contextual changing, leading decision-makers to adopt new and personal interpretive tools to achieve a better understanding of the observed complexity and achieve viability (Barile and Polese, 2010). Through a reinterpretation of information and knowledge management in viable systems, the governing body, based on the principle of *relevance*, acts to guarantee the survival of the system (Barile et al., 2014). The modern information

environment appears capable of accelerating the processes of alignment of information varieties, acting, in particular, on information units, (Barile et al., 2015), interpretative schemes and on the value categories (see paragraph 3.4).

In this way, the theory introduces a set of concepts that can allow at analysing the complexity of urban governance, in which the governing body is responsible for seeking consonance between the varieties of information of all systems involved in its decision-making process. In this context, the availability of big data and tools for the elaboration of information and for the extraction of knowledge (see par. 2.4) can represent a key driver to enhance the possibility to ensure system's survival and, thus, viability.

Thanks to the key notion of *information variety*, that conceptualizes how decision makers can manage Big Data and the different input information sources to decrease complexity and acquire knowledge to challenge viability. VSA can provide studies on urban governance model with the proper conceptual and logical categories to understand how: 1) to reduce data variability deriving from complexity to turn it into an increasing of information variety; 2) to enhance systems' viability through the acquisition and renewal of knowledge according to circular learning mechanisms. The circularity involved in information and knowledge exchange and renewal is in line with the principle of continuous improvement, introduced as a key driver for the multi-level urban governance introduced in paragraph 2.5.

For this reason, in the remaining sections of the chapter, an integration of VSA's main assumptions with the main dimensions of meta-urban governance model is proposed. Firstly, the general concepts of VSA are described (par. 3.2) in order to highlight how the notion of information variety (par. 3.3) can be intended as the key common thread for a combination with urban governance model to explore, lastly, how (3.4) this integration can be realized to reframe decision-making process.

3.2 THE VIABLE SYSTEMS APPROACH (VSA)

3.2.1. Origins of VSA

The paradigm of the Viable Systems Approach (VSA) is based on multidisciplinary studies mainly focused on systems thinking, systems theory, management cybernetics, and organization theory, from which are defined principles and concepts to be applied synergistically in organizations.

The first epistemological reflections aimed at investigating phenomenal reality and the distinction between *potentiality* and *act*, and therefore *structure* and *system*, can be found in Greek philosophy. Already Aristotle and the first Pythagoreans identify the concepts of *form* and *substance* of things which are fundamental for understanding the concepts of structure and system and the relations between them. For Aristotle, change is characterized by the action of an efficient cause which, by acting on matter (the *structure*), gives it form and makes it appropriate to needs (the *system*). The dichotomy substance-form, subsequently reinterpreted in components/structure (*substance*) and relations/system (*form*), constitutes the *core* of the reflections of various scholars who, in the early years of the twentieth century, lay the foundations for the subsequent formalization of systems thinking (Emery & Trist, 1974).

A significant work, which anticipates some relevant aspects of the body of knowledge related to cybernetics, is the *Tectology*, a three-volume work dating back to the 1920s by Aleksandr Bogdanov. It illustrates the attempt to formalize a science based on the formulation of organization principles, which explain the possible modes of internal connections between the different components that originate in a structure (Bogdanov, 1913). Starting from these conceptualizations, the intent of the scholar was to enucleate the organizational-behavioural principles of every possible system, living or non-living, in order to arrive at a proposal of science universal, capable of unifying natural and social sciences. In the same period another Russian scientist, V. I. Vernadskij (1926), initiates a reflection on living systems and their relationship with the physical world, arriving at hypotheses in agreement with those of Bogdanov. In particular Vernadskij proposes that the biosphere should not be understood as an isolated phenomenon by specific causes but such as a living system, characterized by strong interconnections between all living organisms (subsystems) that populate it and that, through exchange processes, feed their lives (2012). It is Norbert Wiener who introduces the definition of the science of control and communication as *cybernetics*. In their brief epochal essay, Wiener, Rosenblueth and Bigelow (1943) illustrate that the complex behaviour of automatic machines, as well as electronic computers, but also, and more generally, the nervous systems of living organisms, can be traced back to the foundations of the science of information/communication. These advances underline the importance of organization in the future general theory of systems, anticipating L. von Bertalanffy who, analysing the concepts of opening and closing systems, homeostasis, self-regulation and equifinality, tries to explain the behaviour of

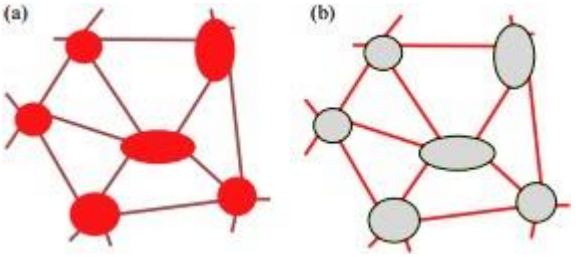
living systems (von Bertallanfy, 1938, 1949, 1962, 1966, 1967, 1968, 1969; von Bertallanfy et al., 1951). Starting from the studies carried out by L. von Bertallanfy a widespread interest in the systems approach has given rise to a rich strand of studies. The contribution of Herbert A. Simon is fundamental, by focusing on environmental analysis and, in an attempt to define a mechanism of choice that is able to direct the behaviour of an organism facing multiple objectives, comes to the identification of some structural characteristics typical of the organism "psychology". The scholar is convinced that an organism, placed in an environment with certain characteristics, identifies/activates very simple perceptive and choice mechanisms, which allow it to follow a useful path to obtain the satisfaction of specific needs, thus ensuring a high probability of survival. The delimitation of the decision-making horizon within which the organism will select the possible choices, using the tools at its disposal, is to be traced back to the existence of those factors that characterize the so-called "limited rationality" of the decision-maker and the environment perceived by him. This approach appears to be closely linked to the psychological theories of perception and cognition (Simon and Kaplan, 1989). Also, Heinz von Foerster must be mentioned. A scholar who, in the 1980s, was one of those who believed that reality could not be considered as something objective, independent of the observer, because it was the subject himself who created, builds, invents what he believes exists. Reality cannot be considered independent of the one who observes it, since it is precisely the observer who gives it meaning, actively participating in its determination. These considerations introduce the aspects proper to constructivism, which qualifies the orientation, shared by different disciplines, to a subjective view of reality which is built by the subject who experiences it (von Glasersfeld, 1989).

Starting from these studies in cybernetics (Wiener, 1948; Ashby, 1947) and social cybernetics (or second order cybernetics, or cybernetics of cybernetics, or the cybernetics of observing systems) (Foerster, 2003), the concepts mentioned were widely applied by Stafford Beer to business and other type of organizations. In this way, Beer founded management cybernetics, a field of cybernetics concerned with management and organizations (Beer 1959, 1972, 1985). From these conceptualizations, several Italian have carried out studies on systems approaches to management, by creating the so-called Viable System Approach (VSA). These efforts were culminated in the first book in Italian edition entitled: "L'approccio Sistemico al Governo dell'Impresa: L'impresa sistema vitale" (Golinelli, 2000). Subsequently, the

collaboration between Italian school and international scholars is increased. For instance, the VSA has been connected with the fields of Network Theory (e.g. many-to- many marketing of Evert Gummesson), Service-Dominant Logic (Vargo and Lusch), and Service Science-Management-Engineering (SSME) of the International Business Machines Corporation (IBM).

Therefore, the VSA, unlike a theory, does not constitute a structured and formalized discipline; rather, it is proposed as a *pervasive* and *interdisciplinary* thought, as a common approach to various disciplines, able to give life to a *meta-model* useful to reread any phenomenon, biological, physical or socio-economic. In the various theoretical contributions that have contributed to the spread of systems thinking and the related new way of interpreting reality and its phenomena, the systems thinking is considered closer to the holistic view than the analytical-reductionist vision (Capra, 1997). Indeed, the most widespread interpretation of systems thinking refuses to favour a reductionist vision of reality, in order to identify, even if not in an absolute alternative, an overall perspective of the phenomena (defined holistic) which aims to highlight the links between the elements of the same phenomenon, the links between different phenomena, as well as the links between the elements that are related to different phenomena. However, the systems approach does not coincides only with the holistic approach and does not conflict with the analytical-reductionist approach (Tagliagambe and Usai, 1999). Rather, it is represented by a continuum that has reductionism and holism in its extremes and is able to reconcile, justifying them, both. The paradigmatic revolution produced by systems thinking resides, therefore, in the shifting of attention from the parts to the whole, implying a vision of reality as a unitary and interacting unicum. In such representation, the individual properties of the actors, constituting the phenomenon itself, become indistinct, while the relationships between the actors themselves and the generated events are relevant. This leads to a significant change in the perspective of the investigation: from the components to their relations, as shown in Figure 3.1. Part (a) of the representation qualifies a perspective that essentially considers the individual components. In part (b), on the other hand, the focus is on the relations and not on the components. The focus on the relationships between the components does not, however, cancel the identity of the parties, does not ignore the role of the individual elements in the whole and does not ignore the role of the individual elements in the whole.

Figure 3.1. The shift of the focus from elements to the relations



Source: Capra (1997)

The result is a methodology for approaching the study of phenomenal reality which, while taking into account the individual elements, and the relative properties, of which a given phenomenon is composed, also expressly examines the system in its emerging properties, deriving from the synergies developed by the interaction between the parties. In synthesis (as shown in Table 3.1), the VSA is a multidisciplinary approach for diagnosing organizations as viable systems, in order to achieve *consonance* and *competitiveness*, and as a consequence, *viability*. VSA considers both statics and dynamics of viable systems. It serves as a bridge between reductionism (focus on parts) and holism (focus on the whole), starting from the structure and arriving to the emergent system.

Table 3.1. Framing the disciplines connected to VSA

VSA Foundations	**Main Focus**
Multidisciplinary interpretative approach *– between holism and reductionism*	Attention shifting from parts to whole.
Open systems *– systems thinking*	Every system is in strong relation with other system entities.
System's boundaries *– systems thinking*	Valorizing exchanges with the environment for system's goal.
Autopoiesis and common finality *– chemical and biological sciences*	Dense pattern of relations with super and sub-systems.
Homeostasis and self-regulation *– natural and ecological sciences*	Living organisms' capacity to preserve own viability and stability in any condition.
Structures, Systems, and Equifinality *– natural and ecological sciences*	Static versus dynamic representation of organism.
Consonance and Resonance *– sociological and psychological sciences*	Potential connectivity and its activation (structural compatibility and related system harmony).

System viability – *systems thinking*	System developing (and surviving) within its context in a consonant and resonant way.
Adaptation and relationships development – *natural and ecological sciences*	Relationships and peripheral components; transformations and organization design; restructuring and organization plan rethinking.
Complexity and decision making – *sociological and psychological sciences*	Qualitative traits of the observed phenomenon correlating a combination of multiplicities and autonomies with the impossibility of any explanation and based on three parameters: "variety", "variability", and "indeterminacy".

Source: Author's elaboration from Barile and Polese, 2010.

3.2.2. Foundations of systems thinking: the structure-system paradigm[6]

Structure and system consist in the static and dynamic representation of the same reality (Barile, 2009; Barile and Saviano, 2011; Golinelli et al., 2011).

There are several logical categories, linked together, which are indispensable for the study of systems thinking. In detail, the system emerges from the selection, made by the governing body, of a specific structure within an extended structure, in compliance with the defined organizational scheme. Therefore, a given logical structure can take the form of a multiplicity of physical structures and the governing body can extract a (finite) number of specific structures. Furthermore, the governing body, considering the relevance of the super-systems with emphasized priorities, identifies the specific structure to be selected. In fact, the viable system is determined by continuous processes of contextualization implemented in a specific environment by the decision-maker (Golinelli, 2000, 2002, 2005, 2011; Barile, 2009), which operates, in this way, a selection of systems considered relevant (Figure.3.2). Once the specific structure is activated, the system emerges. This aim is achieved through the interaction of the components in a succession of relations (processes), in compliance with the rules.

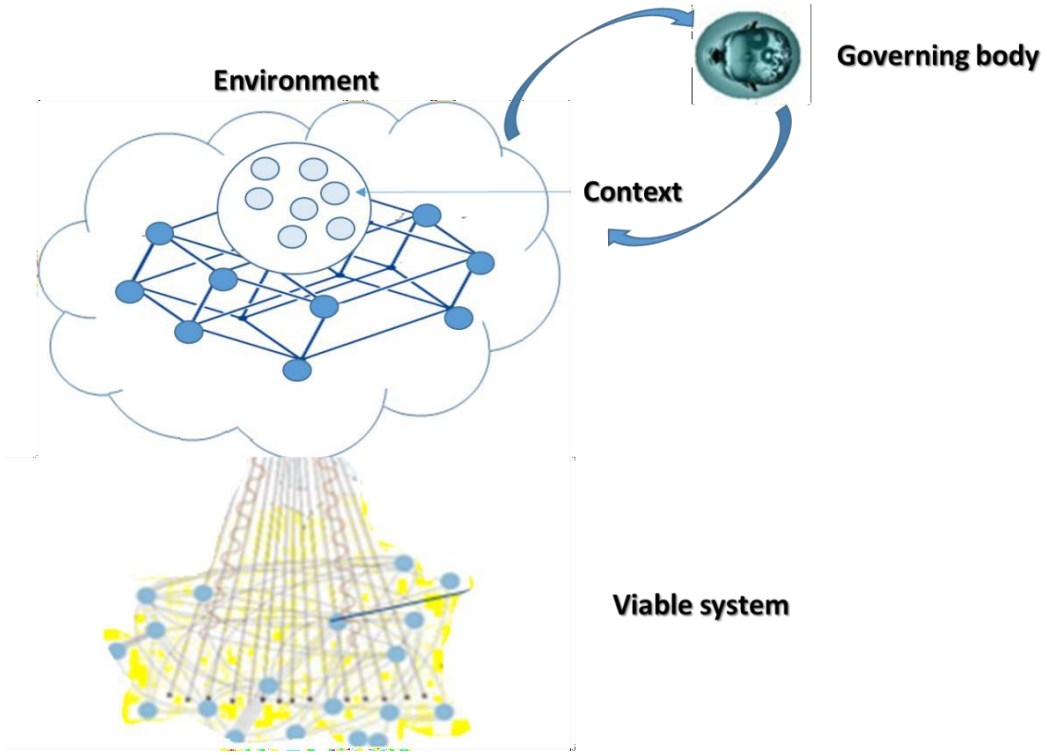
Thus, it is evident that the concepts of structure and system represent a fundamental basis of the systems approach and that they are created by two perspectives, which integrate the descriptive and functional representation of the organizations (structural aspect) and the interpretation of forces which govern the

[6] Golinelli, G. M., Pastore, A., Gatti, M., Massaroni, E., & Vagnani, G. (2011). The firm as a viable system: managing inter-organisational relationships. *Sinergie Italian Journal of Management*, (58), 65-98.Barile, S. (2009). Management sistemico vitale (Vol. 1). Torino: Giappichelli; Barile, S., & Saviano, M. (2011). Foundations of systems thinking: the structure-system paradigm. *Various Authors, Contributions to Theoretical and Practical Advances in Management. A Viable Systems Approach (VSA). ASVSA, Associazione per la Ricerca sui Sistemi Vitali. International Printing*, 1-24.

development of processes, which are subject to continuous evolution in relation to the changing needs of the environment (system aspect).

It must be underlined that the system emerges from the structure in a governed but uncontrolled way. This means that, even in the presence of a regulation of the degree of openness carried out by the decision-maker (governing body) of the system, many of the interactions or related properties will be emerging, i.e. they will be activated regardless of the organization activity (defined organization scheme) carried out by the decision-maker (see Figure 3.2).

Figure 3.2. The contextualization process



Source: Author's elaboration from Barile (2009)

To sum up, the following dimensions, considered as a set of correlated elements, characterize the *structure*:

- Physical boundaries that identify what belongs to the structure and what is extern;
- Components with a specific function assigned;
- A set of stable connections between the components.

These features describe statically the different part of systems and are not useful to understand the behavioural dynamics of the structure, the relations between the components and the interactions that lead to the dynamic emergence of the system.

Instead, the *systems perspective* emphasizes that:

- The concept of borders does not have any meaning because the simple contact with the system determines the involvement and includes the participants inside;

- The system is formed by many components, often different, which should follow the common plan decided by the decision-maker (even composite). This process allows the pursuit of specific objectives converging towards a single goal: the survival of the system itself within the context in which it operates;

- The focus is shifted from the connections, physical links between the components, to the relations, fostering interaction between components. The activation of the relations produces an effect of interaction between the components that leads to the emergence of a potential system from the structure.

According to a process-based view, VSA pinpoints the different stages that can lead potentially from the structure to the system. The different steps, intended as an evolutionary path that transforms organizations into systems, are described in Table 3.2.

Table 3.2. From the structure to the system

Structure	A set in which the elements are reinterpreted as components to which is attributed the ability to participate in the implementation of certain functions (through the performance of specific roles within the potential emerging system). The components can be related in accordance with certain constraints (rules).
Logic structure	A set of logical components described as able to play a certain role in accordance with prefixed rules and with

	well-specified ability to connect with other components.
Physical structure	A set of physical, concrete components, the operation of which is known, equipped with a connector prepared for connection with other components.
Extended structure	As the previous physical structure, additional to a set of external components in order to complete the entire set of resources that can be used by the governing body for the activation of the system.
Organizational scheme	Intended as a design drawing by virtue of which the connections to be established between the components of the extended structure are defined to allow the activation of relations between them.
Defined organizational scheme	The selection of the processes to be activated to allow the emergence of the system is supported by progressive refinements of the organizational framework. Therefore, the basic organisational scheme is perfected and becomes a

	defined organisational scheme.
System	A specific structure geared towards the achievement of a goal.

Source: Author's elaboration from Golinelli (2000) and Barile (2009)

3.2.3. Postulates of VSA[7]

The key concepts of VSA, exposed in the previous paragraph, are summarized through the proposition of five postulates (Barile, 2008), discussed below:

- *Survival:* The viable system, living in a specific context, extrapolated from the general environment by the system's governing body or the observer, has the primary end of survival.
- *Eidos:* The viable system in its ontological qualification can be conceived in a double perspective: that of the structure and that of the system.
- *Isotropy:* The viable system in its behavioural qualification is characterized by the emergence of two logically distinct areas: that of deciding (*decision- making* area) and that of action (decision-performing/*problem- solving*/operations area).
- *Interactionism and Finalization:* The viable system, in its existential dynamics, is projected toward pursuing purposes and attaining objectives by interaction with super-systems and subsystems, with which exchange respectively pressures, expectations, guidelines and rules.
- *Exhaustiveness:* For a viable system, all the external entities that populate the surrounding environment are viable systems too, or components related to a viable system of a higher level. So, a viable system, as an autonomous entity, may be dissolved within the super-system to which it refers during a specific time-frame, because of consonance and resonance conditions.

3.2.4. Fundamental Concepts (FCs) of VSA[8]

The VSA postulates, presented above, enable the introduction of the VSA

[7] For further information see: Barile, S. (2008). L'impresa come sistema: Contributi sull'Approccio Sistemico Vitale, 2nd Ed., pp. 24. Torino: Giappichelli. Golinelli, G.M. (2005). L'approccio Sistemico al Governo dell'Impresa: L'impresa sistema vitale, Vol. 1. 2nd Ed., pp. 106-110. Padova: Cedam.

fundamental concepts (FCs)[9], proposed as interpretative schemes for the discussion of VSA contributions to management and marketing research (Barile et al., 2011). The FCs are as follows:

- *Systems approach*: Individuals, organizations, and social institutions are systems that consist of elements directed towards a specific goal.
- *Systems hierarchy*: Every system (of level L) identifies several super-systems, positioned at a higher level (L+1), and several sub-systems, located at a lower level (L-1). This is called recursive property of viable systems.
- *Reductionism and Holism*: The interpretation of complex phenomena requires interdisciplinary approaches and should synthesize both a reductionist view (analysing elements and their relations) and a holistic view (able of observing the whole).
- *Opens Systems and Systems Boundaries*: Systems are open to connection with other systems for the exchange of resources. A system boundary is a changing concept within which all the activities and resources needed for the system's evolutionary dynamic are included.
- *Autopoiesis, Homeostasis, and Self-regulation*: Viable Systems are autopoietic and self-organizing; that is, they are able of self-generating internal conditions, which through self-regulation, support the reach of equilibrated conditions, thus synthesizing internal possibilities and external constraints.
- *Structures and Systems*: Every organization is constituted by components that have specific roles, activities, and objectives, which are undertaken within constraints, norms, and rules. From structure emerges a system through the transformation of relations into dynamic interactions with sub-systems and super-systems.
- *Relation and Interaction*. The concept of (structural) relation has a static character, it qualifies as objective, not dependent on what may

[9] The Fundamental Concepts (FCs) of VSA have been reported in this dissertation from: Barile, S., Bassano, C., Calabrese, M., Confetto, M., Di Nauta, P., Piciocchi, P., Polese, F., Saviano, M., Siano, A., Siglioccolo, M., & Vollero, A. (2011). Contributions to Theoretical and Practical Advances in Management: A Viable Systems Approach (VSA). Avellino: International Printing Editore, pp. 151-155; Barile, S., Polese, F. (2010). "Smart Service Systems and Viable Service Systems: Applying Systems Theory to Service Science". Service Science, 2 (1/2), pp. 21 – 40; Hysa, X. (2014). Managing group dynamics with the viable systems approach (VSA): a study on consonance, group cohesiveness, and positive conformity.

emerge from the activation of the report itself. The concept of (systemic) interaction has a dynamic character, depends on from the observer and from what he deduces in his prospect of investigation.

- *Consonance and Resonance*: Systems are consonant when there is a potential compatibility among the system's components. Systems are resonant when there is effective harmonic interaction among components.
- *System's Viability*: A system's viability is determined by its capability, over time, to develop harmonic behaviour in sub-systems and super-systems through consonant and resonant relationships.
- *Adaptation and Relationship Developments*: Business dynamic and viability require continuous structural and systemic changes focused to the alignment of internal structural potentialities with external systemic demands.
- *Complexity and Decision-Making*: Viable Systems continuously align internal complexity with external complexity in order to better manage changes affecting its viable behaviour. As described in paragraph 3.3.2, decision-makers within these cognitive processes are influenced by strong beliefs (i.e. categorical values), interpretation schemes and information units.

3.3 DECISION-MAKING IN VSA: INFORMATION VARIETY AS A DRIVER FOR COMPLEXITY REDUCTION

In the light of the considerations previous exposed regarding complexity and decision- making, a viable system is seen always from the perspective of its governing body, which is defined as the *top decision-making entity* (e.g. the leader or the board), composed by one or more individuals (Golinelli 2010, pp. 187-241). It comes out that the destiny (i.e. system's survival) of every viable system depends on the decisions made by the government body.

For viable systems the concept of decision is strictly connected with that of survival (Barile and Canfora, 2008). The viable system during the lifecycle encounters many problems; as Popper (1999) said: "*All life is problem solving*". For solving problems, a viable system must use cognitive abilities such as perceiving, learning,

reasoning, memorizing, reflecting, and so on. Since the decision-making is a cognitive course of action, the maintenance of viability implies a continuous decisional process that can be represented as a knowledge itinerary.

After the analysis of VSA reinterpretation of decision-making in complex context (par. 3.2.1), the key notion of information variety should be introduced necessarily to explore how the theory can provide governance with the strategic drivers for a proper utilization of data to acquire knowledge and survival (par. 3.2.2).

3.3.1. Complexity and decision-making in VSA: the 4Cs

Governing Body should take decisions in very complex environment. From VSA point of view, these decisions can be undertaken through the transition across four problem areas: 1) the area of Chaos; 2) the area of Complexity; 3) the area of Complication; 4) the area of Certainty (the so-called 4 Cs[10], synthetically described in Table.3.3). In this way, the uncertainty that characterizes the context is distinguished in four different problem areas considering the different level of incertitude. Based on this distinction, the problems, depending on the area in which they originate, require different resolving approaches.

During the *chaos* phase, new data enters the system and causes an increasingly confusion for decision-makers. Subsequently, the unstoppable tendency towards states of ever-increasing disorder comes to be arrested by the decision-maker's idea that can order the accumulated and relevant information about the problem. In this way, the problem acquires clearer and better-defined contours.

The emergence of an idea corresponds to the step of *complexity* and to the logical phase of abduction. This marks the transition from the area of chaos to the area of complexity, with the triggering of a process that in many cases leads to the initiation of the resolution hypothesis.

After this point, it is possible to observe that the process of entropic growth is still taking place, the confusion continues to increase, even if at a decreasing rate (it has changed the concavity of the curve). The next notable point is characterized by the transformation of the idea intervened in the previous abduction phase in an experimental hypothesis that should be verified (induction phase), by turning complexity into *complication*. This phase has a great importance in the research and involves the experimentation of the hypothesis produced in the phase of abduction

[10] For further information see: Barile, S. (2009). *Management sistemico vitale* (Vol. 1). Torino: Giappichelli.

and, in case of verification, the transition to the area of complication. If the outcome is favourable, entropy decreases with the entry of further information, the knowledge possessed begins to find an order, and the resolving hypotheses applied, even if still with the existence of methodological, technical and instrumental difficulties.

The third remarkable point (the deduction phase) defines the passage towards the fourth area, the *certainty*. This is the area in which the problem appears to have been overcome definitively: the decision-maker knows the problem and the solution. New information is useful only to better circumscribe the situation around he knowledge acquired and proceed towards the solution.

The four phases, and the different degrees of information variety in each stage, are synthesized in Table 3.3.

Table 3.3. The 4Cs

Chaos	A situation in which the viable system has an unconscious fastidious sensation but is not aware about the origin/cause, the effect, and the solution. So, both problem and resolution scheme are incognita.
Complexity	A problematical area characterized by the viable system's consciousness about the problem. Although the problem is known the viable system is convinced that there is no way how to solve it.
Complication	A context in which the viable system increases the optimistic percentage thinking that the problem has a solution, but the formula (i.e. interpretation scheme) is

	not yet in its hands; it is just a matter of time.
Certainty	It is the last area characterized by the type of problems that seems to be very easy (99% certain) to solve because already exists a method. These are repeated problems, such as organizational routines[11].

Source: Author's elaboration from Barile (2009)

As noticed in the previous description of the 4Cs model, each informational stage can be associated with a different type of reasoning that decision-makers should implement to foster the transition from chaos to certainty. The four logical strategies that should be applied to challenge complexity are: 1) *abduction* (abduction, to move from chaos to complexity); 2) *induction* (to turn complexity into complication); 3) *deduction* (to undertake decisions in certain situation).

The *abduction* strategy bases the decisions only on beliefs, convictions and possessed values in order to orient towards the launch of hypothesis, which is the first step of scientific reasoning.

The *induction* phase occurs when a possible resolved hypothesis arises but it is necessary to verify it. The experimentation of hypothesis goes from particular single cases and arrives to a general composition. Therefore, the decision-maker moves from the general interpretative scheme representing the working hypothesis through a synthetic interpretative scheme that formalizes a model to be verified

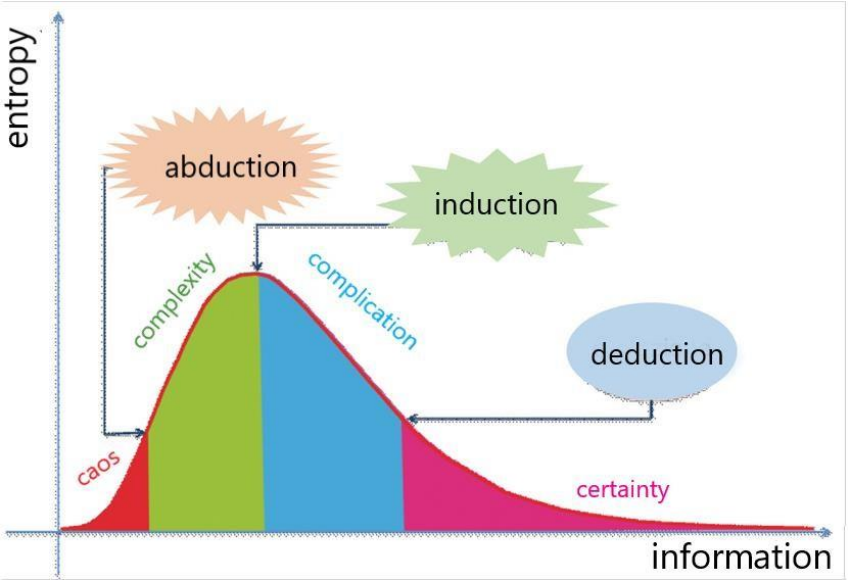
Deduction concerns the verification of the model that should converge towards the solution successfully. A summary interpretative scheme can be codified and used if problems of the same type arise.

Therefore, Figure 3.3 distinguishes between the different logical strategies to be applied in the diverse problem areas. The first (*abduction*) requires creativity for the

[11] The certainty cannot be 100%, as it is demonstrated graphically in the figure 2.1, where the curve runs asymptotically with x-axis. The reason is that every solution (e.g. theory) should be open for improvement. Popper (2005) calls it *falsifiability;* Kuhn (2009) calls it *paradigm shift;* Schumpeter (2003) calls it *creative destruction*.

generation of a hypothesis of solution. The second (*induction*) is based on the verification through experimentation of the hypothesis produced in the first stage. Lastly, the third (*deduction*) is focused on the formalization of the solution criterion identified through a specific interpretative scheme to be used when a problem is similar to the one that generated it.

Figure 3.3. The 4Cs



Source: Author's elaboration from Barile (2009)

3.3.2 The characters of information variety: information units, interpretative schemes, and value categories

A viable system, as defined by the VSA paradigm, has the purpose of surviving in its own context, interacting with other systems that populate it (Golinelli, 2000). In particular, the governing body detects the problematic areas that could primarily compromise the planned objectives and, through a continuous learning process, proceeds with the reorganization and adaptation of its knowledge to be able to identify a possible solution and, therefore, reaches a choice (decision area). The solutions identified from time to time conditions the life of the viable system and determines the path of survival. Having thus confirmed the existence of a close connection between decision and knowledge, it is necessary at this point to better investigate the characteristics of the latter.

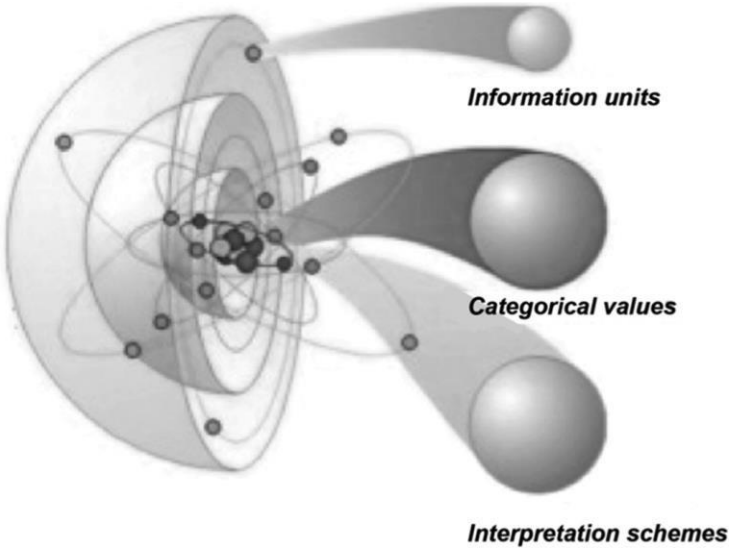
Knowledge is primarily interconnected with other concepts such as learning and reasoning; it can and must be understood as a cyclical process in which perception, action of the intellect, memorization and processing of information (reasoning) create

a virtuous path that leads to an ever-increasing supply of knowledge. Considering knowledge as a process in continuous elaboration, the comparison between two temporally distinct moments t_1 and t_2 shows that knowledge in changed moments is different. Thus, the concept of *knowledge endowment* fixed at a certain instant t is outlined, also called the *information variety* [12]at time t[$Vinf_t$] possessed by a viable system.

In particular, the *information variety* is a representation of knowledge that a viable system possesses in a specific time point and is defined through three dimensions, as depicted in Figure 3.4, that can be expressed in a coherent system of measurement (Barile, 2006):

$$V_{inf}\ (k)=(U_{inf}(k),S_{int}(k),C_{val}(k))$$

Figure 3.4. Representation of information variety



Source: Barile et al., 2014 (available at www.asvsa.org).
Image used with the permission from aSvSa

In particular:

$V_{inf}\ (k)$=***Information variety*** *of the viable system K*;

$U_{inf}(k)$, = ***Information unit*** *of the information variety of the viable system K*;

$S_{int}(k)$ = ***Interpretative schemes*** *of the information variety of the viable system*

[12] The information variety possessed by a viable system refers to the definition of synchronous dimension of the phenomenon variance, understood as "differentiation (potential or actual) of possible cases that may occur at the same time". For further information see Rullani, E. (1984).

K;

$C_{val}(k)$ = ***Categorical value*** *of the information variety of the viable system K.*

The *information units* consist in the amount of single units of data detained by a system (the structural knowledge of the system). Specifically, the information unit is every incoming signal from the external context or/and from the internal brain's memory center, subjectively perceived by the observer in accordance with his/her needs or/and desires. In essence, everything that can be perceived through the five senses or that is determined by successive elaborations.

The *interpretative schemes*, on the other hand, permit to assembled and understood the information units based on the context (the knowledge "shape" of the system). Indeed, it is precisely the interpretative schemes that determine the transformation of non-specific data into information relating to a given context. They serve as filters acting on information units through particular elaborations. These are organizational patterns because have the primary task to rationally organize the information. Generally, a schema can be defined as a cognitive framework that represents organized knowledge [information] developed through experience [owned interpretation schemes] about people, objects, or events (Schermerhorn 2010, pp. 87). Within the coordination function of a schema it can be described the attention role, the selection role, the organization role, the interpretation role, and the retrieval role. Furthermore, interpretation schemes are devised in *general interpretative schemes* (G-Sint) and *synthesis interpretative schemes* (S-Sint) (Barile, 2009, 2011). The first have a general character in the sense that have a larger perspective of observation comparing with synthesis schemes that are more technical and specific. Whereas synthesis schemes are pro tempore, general schemes are more constant. In addition, synthesis schemes are derived by general schemes.

An interesting aspect concerns the existence of interpretative schemes that refer not to the individual (understood as a viable system) but to communities (of viable systems). Just the language seems to have, besides the other specific properties, the ability to provide the conditions for a possible "*consonance*" both decisional and operative between members of the same community and related communities.

The third factor concerns the *categories of values*, which are the basic values and

strong beliefs of the system (the resistance to change) that influence the way in which the interpretative schemes are used. The categories of values characterize the context ethics with respect to the generic moral, inspire and allow the activation of the criteria through which it is possible to express an opinion on events and facts and orientate general schemes to derive synthesis schemes.

3.3.3. Consonance and resonance for information variety management

In a turbulent context, in which the viable systems, as individuals, organizations, communities, etc., interact, the configuration of the information variety is in continuous evolution. The fundamental force/driver that maintains the viable systems together, expressed through their compatibility degree in terms of shared objectives and interests, is called *consonance* [13](Golinelli, 2011). This refers to the degree of integration among viable systems' structures in order to create the compatibility conditions for potential exchanges of resources. It is a structural concept because it refers to the systems' structures and the relation between their logical and physical components. The first considerations and applications of consonance from the paradigm of VSA are made at the whole organizational level, trying to find the harmony between organization's governing body (i.e. the observer or the viable system) and super-systems that populate the external environment, characterized by different information varieties. In this way, the information variety $v_1$is transformed by the effect of an interaction with other information variety v_k.

In particular, is possible to define the consonance between the information variety $v_1$and the information variety v_2 in this way:

$$C= \lim_{u_1 \to u_2} \frac{v_1 - v_2}{u_1 - u_2} = \frac{\delta v}{\delta u}$$

The consonance between two different varieties $v_1$and v_2 defines, in terms of the information units used (u = u_1 -u_2), the greater or lesser potential that the two information varieties have to align, in a vector space, their knowledge. The term "*align*" indicates the ability of mutual understanding demonstrated by the two viable

[13] For further information see: De Falco et al., 2008; Calabrese, De Renzi, & Gatti, 2012.

systems, whose varieties of information are $v_1$and v_2. By simplifying, very close-knit people, that they understand themselves on any question simply by looking into their eyes, implies, in terms of popular wisdom, the existence of a high level of consonance between the information varieties of these two individuals. In the same way, people who, although debating a question for days and days, never arrive at a shared synthesis, unequivocally indicates that there is a very low level of consonance between the two interlocutors. When the consonance refers to the compatibility degree between only two viable systems it is called *dyadic* consonance; when it considers the relation between more actors, it is called *contextual* consonance (Liguori and Proietti, 2008; Gatti and Proietti, 2011).

When conditions of consonance between viable systems are secured, then the viable systems are able to interact or to enter in *resonance* with each other. If the consonance is a relational concept the resonance is an interactional one: is a shift from static to dynamic states. It means that resonance creates acceleration or deceleration on levels of consonance during systems' interaction. In general lines, resonance is an ideal development of consonance. It is a sharing of trust, objectives, and strategies, accompanied by membership, tuning, and a progressive attenuation of structural boundaries due to the openness degree of systems as participants of a new inclusive system (Golinelli 2000).

The resonance conceptually and mathematically is a derivate of consonance and is defined as follow:

$$R = \lim_{U_1 \to U_2} \frac{C_1 - C_2}{u_1 - u_2} = \frac{\delta C}{\delta u}$$

According to Barile (2011), the resonance, therefore, represents the change that consonance can have during the expansion of the information variety. It expresses the intensity with which the levels of sensitivity of the consonance vary while implementing the perception of new information. Therefore, the concept of resonance intervenes to modify the levels of consonance and succeed, from time to time, in orienting the choices. The way in which an information variety dynamically transforms itself in the context represents, substantially, the level of consonance sensitivity that it manifests towards the supersystems with which it interacts sharing new information.

Reconnecting to the information variety framework, the role of the categorical values is particularly relevant because they are responsible for allowing and directing interaction, the degree of system openness, the information sharing process and the outcome of the interaction. In sum, the categorical values decide the overall degree of consonance (Barile et al., 2014). Thus, in order to reach a greater level of consonance, the system should consider the variety of expectations of external systems considered relevant, allowing for greater awareness of the interventions that could be aimed for reaching a greater level of consonance and ensure viability in the reference context. To this end, incorporating the social community into the decision support systems processes (Wu et al., 2018) can help the organizations to carry out a participatory logic that can guide towards a common purpose and increase the viability of the system complex. In fact, the social community as viable systems are cognitive entities and knowledge holders, responsible for decision-making and problem solving, then they can be conceived also as information varieties. This is a natural derivation if we take into account that groups as a whole, and the individuals inside them, own information, schemes, and values. Therefore, it is necessary to look for solutions that can support the decision-making process, which finds itself dealing with numerous and changing entities of the context in conditions of complexity. The aim is to harmonize the interests of the various actors and to converge towards a joint evolutionary direction, basing on the concept of context consonance (Barile and Calabrese, 2011). In this direction, the technologies can be considered as a strategic driver that allows users to communicate in order to align their information variety and improve the context consonance and the viability of the system (Barile et al., 2018).

Hence, by conceptualizing the different steps that lead from information management to the acquisition of knowledge, VSA can provide urban governance models- grounded on the relevance of human, social and technological dimensions- with the right meta-governance strategies to manage the use of technology in viable urban systems considered as social communities.

3.4 REINTEPRETING MULTI-LEVEL URBAN GOVERNANCE THROUGH VSA

The main concepts of VSA (consonance, resonance, information variety) can help reinterpreting urban territories as viable systems and identifying the right meta-governance strategies to enhance decision-making.

The territory, in fact, originally defined through the concepts of area, space and region and described, on the basis of its physical configuration, as a set of "*endowment resources*" (Barile and Saviano, 2008, 2011), is interpreted by a more recent literature (Barile and Golinelli, 2008; Barile, 2011; Barile and Di Nauta, 2011; Barile and Saviano, 2012; Barile et al., 2012), as a "*deposit of resources and entities in action for the emergence of a unitary system*" (Barile et al., 2013). The geographical area, thanks to the theoretical lens of VSA, no longer assumes a purely structural connotation, but becomes the result of interactions (relationships activated between individual and individual and between individual and environment) that evolve dynamically and develop recursively. The natural, artistic, and structural endowments included "objectively" in the definition of city, are flanked, by the systemic components (individuals, organizations, and institutions), which, with their own visions, projections, and expectations, can pursue goals not shared and not aligned (Barile and Golinelli, 2008; Barile, 2011).

Therefore, in the following sub-paragraphs, the integration of VSA with the principles of urban governance models will be proposed through: 1) the rereading of cities as viable systems (par. 3.3.1); 2) the application of information variety to the decision-making cycle of urban governance introduced in chapter 2 (par. 3.3.2).

3.4.1. The urban context as a viable system

Referring to Beer's Viable System Model (1985), a viable system can be described as a system that survives, remains united and is complete; it is homeostatically balanced both internally and externally and furthermore has mechanisms allowing it to grow and learn, develop and adapt, and thus become increasingly more effective in its environment. Simply put, a viable system is any system organized in such a way as to meet the demands of surviving in the changing environment. One of the prime features of viable systems is that they are adaptable, which is a necessary requisite to meet their finality: the survival. A system's ability to survive is determined by its capability to develop over time consonant and

resonant behaviour with subsystems and super-systems. A viable system can dynamically adjust its structure and behaviour to achieve consonance with its context, and thus preserve its stability (homeostasis). In VSA terms, a system is viable when it possesses the fundamental principles and respect all the postulates previously analysed. After these considerations comes out naturally the logic of considering also the city as viable system in harmony with the fundamental concepts and postulates discussed upon. Therefore, subsequently are described the urban context as viable systems making an application and an interpretation of the VSA's fundamental principles on urban context.

The Fundamental Principles for urban context as viable system:

- *Systems approach for urban context*: Individuals, organizations, and resources present in urban context are elements in action for the emergence of a unitary system (Barile et al., 2013).
- *Urban hierarchy and recursion*: Every social and territorial entity can own the recursion property. For instance, a social organization (level L) identifies several super-systems (level L+1) (e.g. state governance, local governance, the industry sector, the socio-economic system, etc.) and subsystems (level L-1) (i.e. the individuals inside it).
- *Reductionism and holism*: Given the complexity of urban context, it is necessary to study the resources and the social actors inside separately (e.g. cultural assets, resources, Points of Interest, actors' opinions), and in relation with each other seeing the group as a whole (e.g. urban consonance, governance performance, etc.).
- *The city as open systems and the system's boundaries*: To accomplish the purpose of survival, the city, as open systems, exchange material and immaterial resources (e.g., products, projects, energy, money, information, etc.) with the surrounding environment (e.g. with other cities, external organizations, external actors, etc.). At the same time, from the structural standpoint, every city and urban context has physical boundaries defined by local and regional demarcation.
- *Autopoiesis, homeostasis, and self-regulation of urban context*: The urban context is considered autopoietic: its individuals and assets are able to generate new internal conditions with the purpose of self-regulation (continuously aligning internal and external complexity),

maintaining at the same time a dynamic equilibrium (homeostasis).

- *Urban structure and system perspective*: From a static viewpoint the city can be described like a structure. In fact, every metropolis has a structure constituted by the internal assets, POIs, resources, and individuals inside, to which are assigned functions, roles and tasks to be performed in consideration of norms, constraints and rules. When the structure is activated and when the individuals start to interact, the urban context is considered as a viable system where emergent properties can be revealed (e.g. cohesion, decision making, social pressure, conformity, productivity, etc.).
- *Urban consonance and resonance*: In the urban field, consonance may refer to the compatibility between institutions and actors considering the respective values, attitudes, and information background. Because more actors become part of the relation, consonance should be considered in this case contextual. On the other side, resonance is the activation of the relation, transforming it into an interaction.
- *Urban viability*: When the institutions, through the conditions of internal/external consonance, base their decision on a participatory logic and are able to guarantee the survival of the urban system as a whole, at that time the city can be considered as viable.
  - *Adaptation and relationship expansion*: everything happens to the whole system affects also the city and its members. Because of it, the urban context has the obligation to adapt their structures in a changing environment, by means of systemic re-equilibrium interventions (i.e. simple adaptation, transformation, restructuring, and reconversion), with the purpose to secure the first postulate of VSA: the survival. This end can be achieved only if the city and the actors inside, reinforces, and expands relationships inside and outside the system's boundaries, developing effective communication channels.
  - *Complexity and decision-making*: The urban context develops in complex environment composed by three components: variety (or the number of states that a phenomenon presents to an observer in a specific moment, interpreted as a differentiation of the possible cases

that can occur in one and the same time); variability (or the changes undergone by that phenomenon over the time, namely, how the variety at time (t1) is transformed at time (t2), and so on); indeterminacy (the percentage of understanding during the perception of a certain phenomenon). The complexity makes decisions more difficult from the rational standpoint, because tends to increase the cognitive alignment gap between the observing system (institution, decision-maker, policy-maker, etc.) and the observed system (any kind of situation), due to a lack of knowledge.

3.4.2. Urban decision-making process in a viable systems perspective

As defined before, the urban context can be defined *viable* if it is able to *survive* in its reference context (Barile et al., 2015). This capacity derives from the ability of the institutions (e.g. decision-maker, policy maker, etc.) to establish synergic relationships, defined by the concept of *consonance*, with the actors that populate that same context. It is necessary, therefore, for the urban governing body, to base decisions on a participatory logic, which can act as a guide towards a shared objective, based on a harmony of ends. This is made possible, also by exploiting 4.0 technologies (e.g., big data, internet of things, etc.), which are able to encourage the alignment between different information varieties. Indeed, the varied set of new technologies, defined in the previous chapter, can be adopted to increase engagement with the actors which populate the same context (private and public companies, citizens and civil society) with the aim to harmonize their objectives and align them with community's overall goal. In fact, leveraging on the smart technologies and analytics tool, an effective decision-making process should harmonize all stakeholders' needs to renew and regenerate cities by bringing to the emergence of a unitary vision. Only following this perspective, the urban context can be considered as autopoietic: its individuals and assets are able to generate new conditions thanks to processes of *self-regulation*, by continuously aligning the information varieties between institutions and actors thanks smart technologies and analytics tool. This permits of maintaining a dynamic a constant equilibrium defined by the concept of *homeostasis*.

Therefore, by implementing initiatives in the interest of the city itself and adopting

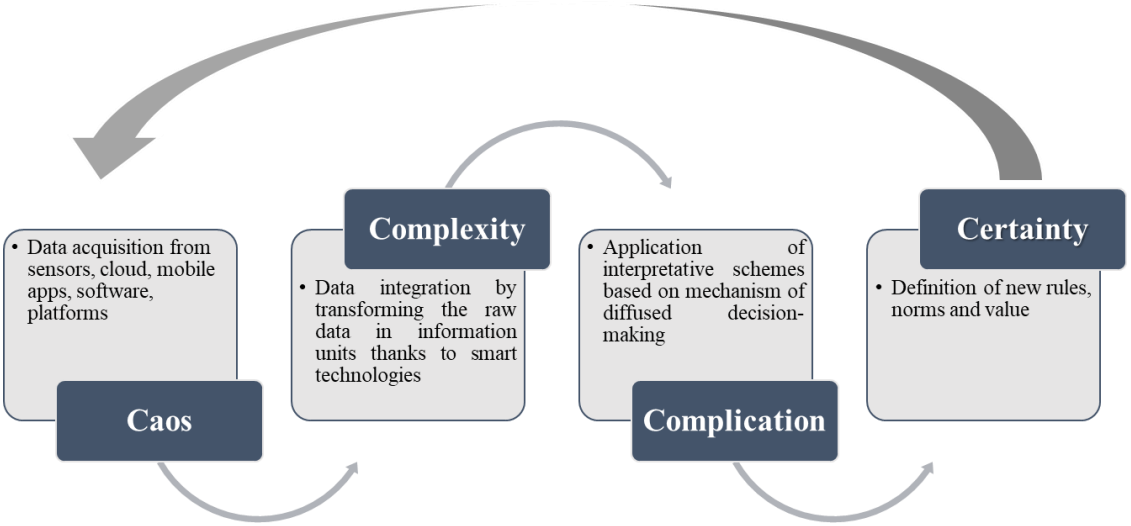
a unitary vision (resonance effect) strengths the probability of a potential transition from a pushed individualism to the emergence of a collective consciousness able of ensuring the survival of the urban context (Barile et al., 2013; Schillaci e Gatti, 2010). The process of contextualization that leads to the extraction, by the governing body, of a specific context of reference from a more general environment (Golinelli, 2002, 2005, 2011; Barile, 2009), qualifies, one of the central moments in overcoming the limits of a purely structural perspective. In this way, through the evanescence of territorial boundaries, the focus is shifted towards the systems dynamics and a wider basin of inter and intra-systemic relations that characterize the urban context, increasing the probability of survival of the system itself. The process of contextualization places emphasis on one of the key concepts of VSA: the principle of *relevance*. The qualification of the context takes place, in fact, on the basis of the degree of interest (in terms of criticality of resources and influence exercisable) aroused by a certain supersystem (individuals, companies, organizations, etc.) on the governing body (Golinelli 2005; Barile and Golinelli, 2008). In the urban case, generally the governing body is multi-subjective and has composite nature, as the urban landscape (Barile et al., 2018).

In short, with the passage from environment to context, the territorial decision-maker proceeds to the evaluation and selection of the entities with which it intends to interact and, consequently, to the mapping of the network of relations to be established with the same (Polese and Minguzzi, 2009), to the activation of these relations (Polese, 2002) and to the definition of a strategy that can interpret their needs, translate them into objectives and allow their achievement.

Thanks to new technologies and tool, the knowledge dynamic of the governing body is supported. The adoption of a strategic culture based on data (design phase) implies the re-focusing of the strategic objectives of the organizations towards the internalization of a learning orientation (to challenge chaos). The technology-mediated connections between sub-systems and over-systems is enhanced through an integrated infrastructure (Järvinen and Karjaluoto, 2015) of smart technologies which includes sensors, cloud, mobile apps, software, platforms, etc. The increase in connectivity boosts the relationships between users and providers and enrich the possibilities of interaction and, therefore, of data integration (phase of collection) which determines an increase in skills (Gupta and George, 2016), transforming thus the (raw) data in information (finalized and relevant, generating complexity). Decision makers supervise the computation of information, carried out through an integrated set of analytics, by optimizing the process (process management) and enabling the transformation of information into knowledge, thanks to the application of interpretative schemes, thus stimulating value co-creation (phase of analysis and interpretation). Diffused decision-making can help governance to adopt managerial solution able to support the decision-maker in harmonizing the interests of the various actors and in converging towards a joint evolutionary direction; in this way, the knowledge acquired can foster the transformation of complexity into

complication. The knowledge co-created thanks to the involvement of each actor in decision-making is stored within the organization and "accumulate" as a form of new value. Thus, value co-creation can encourage, in the certainty phase, the development of common policies based on shared beliefs, attitudes and norms among community's members.

Figure 3.5. The dynamic of knowledge in multilevel urban governance



Source: Author's elaboration

Therefore, cities should act as collective communities (Tocci, 2007), by overcoming individual interests, establishing shared new values and institutions to shape the beliefs and way of life of all the stakeholders engaged in the system. Thus, cities are territories, which share, shape, redefine and co-create new values deriving from information and knowledge sharing between its members basing on meta-governance mechanisms.

On the other hand, what has been described above is the origin of the typical problems linked to the urban governance, especially when the levels of complexity are particularly significant. The process of territorial esteem requires to conceive shared solutions for the complex environmental, social and economic issues at local level (Napolitano, 2000; Sciarelli, 2007; Carrubbo, 2013; Iandolo et al., 2016; Simone et al., 2018). In this direction, Simone et al. (2018) frame the complex nature of territorial

governance and related decision-making issues, proposing, respectively, an interpretative scheme of adaptation phenomena among the actors of the territory based on the systems theory of complexity and a model capable of supporting decision-makers in the face of the growing challenge of effective, efficient and sustainable territorial management (ConsulCubo VSA).

However, a managerial solution able to support the decision-maker in harmonizing the interests of the various actors and in converging towards a joint evolutionary direction is still missing.

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CHAPTER IV

Research methodology

"Esse est percipi"
— George Berkeley

Basing on the considerations of the Chapter III, the urban context can be defined viable if it is able to survive in its reference context: this derives from the ability of the governing body to establish synergic relationships, defined by the concept of consonance, with the actors that populate that same context. It is necessary, consequently, for the urban governing body, to base decisions on a participatory logic, which can act as a guide towards a shared objective.

Therefore, the governing body of a city have to understand the needs and the issues that the citizens are facing; otherwise, it may not be able to define the best strategies to improve the infrastructures and the services of the city itself. This is due to the fact that the most valuable resources of the city are the citizens themselves (Ceballos and Larios, 2016).

In this regard, the urban governance should consider in the decision-making process not only the technical and economic aspects, but also — and most of all — the social structures of the city. A good planning process should consider all the public and private interests and issues in order to try and minimize conflicts and produce a good and

sustainable planning result. According to Zeile et al. (2015), the main problem is actually to integrate the different interests of the citizens into the decision-making processes of the city itself.

As a consequence, the main research objective of this work is to find a way to measure the perception that citizens have about their urban spaces and their different facets (quality of life, safety, environment, etc.). While pursuing this objective, one must consider that the points of view of institutions and citizens are usually significantly different, and that for the former being able to capture and understand all the difficulties and daily issues of the later can be quite complex, especially in large cities. Nonetheless, the adoption of traditional investigation tools, like interviews, surveys, and reports, is not always enough to provide truthful and accurate information. Furthermore, such tools are often expensive and time consuming, and thus they usually cannot provide results in real time, or at least in the short term. In this direction, the social web can represent a valuable source of information for understanding the emotion and the perception of the citizens with respect to the quality of their urban life in the city. However, the approaches based on Sentiment Analysis techniques (Vakali et al., 2013)., most of the time they do not provide a quantitative measure that can help decision makers evaluate the differences in the perception and opinion of the community over time.

In this direction, this work aims to define and apply an innovative methodology based on different considerations and techniques in order to offer to the governing body a model for supporting decision based on the concept of collective perception of a city. The main challenge this work wants to address is the one related to the extraction of knowledge from the data present on social web and to the quantification of the collective perception, defined as the perception that a community of users has with respect to the city and to the assets in it (e.g., POIs, utilities, urban spaces, infrastructures).

For this reason, firstly the preliminary considerations about the methodology are highlighted (par. 4.1). After, the theories and the techniques which compose the proposed methodological framework are discussed in detail (from 4.2 to 4.4 paragraphs). Lastly, the decision-support model based on collective perception is presented (par. 4.5).

4.1 PRELIMINARY CONSIDERATIONS ON THE METHODOLOGY

The definition and adoption of an innovative methodology is guided by a critical

observation about the current approaches to assessing the collective perception of a city generally used by decision-makers and consulting company: classic surveys methodology and sentiment analysis techniques on a community of a social network can offer information of interest about the *sentiments*, which cannot be considered as the effective perception of the city (Bertrand et al., 2013; Ali et al., 2017). Instead, new information technologies are promising important improvement in the territorial decision-making process (D'Aniello et al., 2016; D'Aniello et al., 2017; D'Aniello et al., 2018).

On the basis of these considerations, we propose a methodological framework that allows us to define a new method of ***assessing the collective perception of a city and/or parts.***

In particular the **Lynch's theory** is followed in order to determine the most determinant elements that contribute to create the common perception of a city.

From this, it is applied an advanced sentiment analysis, the **aspect based sentiment analysis** (ABSA) [14], based on a big data-oriented approach, in order to analyse, in the reviews of an online community, the users' opinion regarding the fundamental urban elements defined before through Lynch approach.

At the end, the collective perception determined will be evaluated by a **Fuzzy Collective Map (FCM),** able to highlight the impact of the collective perception on specific urban questions (e.g. quality of transportation, level of safety, etc.). This last step can support the decision-making process of the urban governing body by addressing his interventions.

Therefore, the methodological framework of this study is based on:

► The definition of a criterion in order to understand which urban assets should be considered. According to the Lynch's theory, a mental map is created in the minds of the people who experience the city. In particular, this map is based on five

[14] For further information refer to: Barile, S., Fulco, I., Loia, F., and Vito, P., (2018), "Un modello di supporto alle decisioni territoriali tra analisi dei "sentiment" e consonanza sistemica", in *Transformative business strategies and new patterns for value creation. Referred Electronic Conference Proceedings*, pp. 257-273 (selected paper from Sinergie Conference 2018) and Iandolo, F., Loia, F., Fulco, I., Vito, P. (2019). "Merging vSa and SS. An ABSA for Smart Tourism Ecosystem" in Gummesson, E., Mele, C., Polese, F. (Eds.) (2019), *Service Dominant Logic, Network and Systems Theory and Service Science: Integrating three Perspectives for a New Service Agenda*.

fundamental urban elements (Paths, Edges, Districts, Nodes, and Landmarks) (Lynch, 1960).

- ► The definition of a big data-oriented approach able to analyse the users' opinion present on the web regarding the city assets defined by Lynch. In particular, was adapted an advanced technique of Sentiment Analysis, the Aspect Based Sentiment Analysis (Liu, 2012), generally used in marketing, to the territorial field. This analysis will give in output the Collective Perception about the city.
- ► The Fuzzy Cognitive Map (FCM) offers to the urban planners and the decision makers a powerful tool to analyse the impact of users' opinion about city issues (e.g. quality of transportation, level of safety, etc.).

4.2 THE COLLECTIVE PERCEPTION OF A CITY

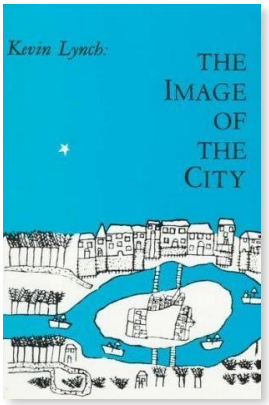
Kevin Lynch, professor and urban planner, was the first to define the concept of *perception* in architecture, precisely by referring to the city (Lynch, 1960). The author examines the formal structure of the city using the *perceptual experience* as a driver for analysis and evaluation of the urban reality. This innovative approach allows to build a method of scientific knowledge, based on *general parameters* that can be used to read any urban reality. This approach has roots in psychology where the perception is considered through a series of selections and configurations by schemes[15]. Starting from this, Lynch analyses the process of perception and memorization of the urban structure and the methods of construction of the reference schemes that, by attributing identity to the elements that make up the urban scene perceptually, allow the inhabitants to identify the shape of the city and to orient themselves within it.

Therefore, the process of analysis that leads to the awareness of perceptual mechanisms is also indispensable for the *urban governance* as a methodology suitable to make figurable, and therefore visible, the significant elements and to facilitate their

[15] Gestalt psycology is an approach based on a macroscopic view of the psychological behaviours rather than a microscopic approach (Verstegen, 2010). Gestalt school is based on understanding and perceiving the whole sum of an object rather than its components. In particular, Gestalt theories of perception are based on human nature being inclined to understand objects as an entire structure rather than the sum of its parts (Pohl, 2016).

identification by making possible the perceptual structuring.

Figure 4.1. The Image of the city

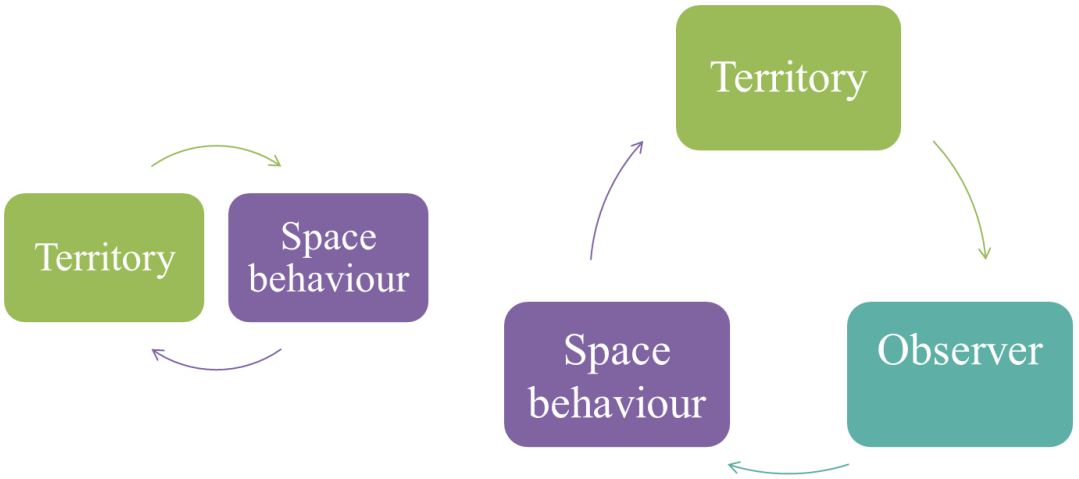


Source: Lynch (1960)

Before Lynch the *image of the city* was considered as result of a process of interaction between the urban scene and the single actor which acts in the urban context. Indeed, the actor elaborates his perception on the basis of his own experience, his own disposition, and his own culture. In this way, the urban image can vary considerably from one observer to another. Lynch, on the other hand, considers the *collective image of the city*, i.e. the mental picture that a large stratum of the population carries with it.

Furthermore, the actors, also called *observers* as shown in Figure 4.2, are not considered irrelevant elements in territorial phenomena, but as a variable whose presence and behaviour can be decisive in urban context and can modify the space behaviour of the considered territory. In this way, there is the shift from a deterministic to a more articulated vision. This new perspective of the territorial space is connected to the Chapter 3, in which the passage from a structural vision of the territory to a systemic one is discussed.

Figure 4.2. The traditional territorial vision *vs* the Lynch's territorial vision



Source: Author's elaboration

Also, the author speaks about the *imageability*: the ability of an urban plant to remain imprinted in the mind and memory. It is precisely the figurativeness that guides the orientation of an individual, determining the conditions for the assumption of choices and behaviours in urban space. Lynch, in particular, showed that people perceive the urban space they frequent or live through *common mental elements* and patterns, which constitute the image of the city. In particular, according to Lynch, observers create mental maps of urban space through the use of *five elements* (Figure 4.3.):

- PATHS: roads, walks, passages, footpaths, waterways, railways, public transport lines. People observe the city by moving along them and relate the image to the routes they use. In this way, the observers know where the routes came from and where they will led. In particular, the unusual routes, narrow or width, attract people's attention;

- EDGES: banks of rivers, beaches, railway surveys, urban walls, limits of the built environment. The margins are linear interruptions of continuity, elements of separation but also elements of continuity, suture, connection between areas. The boundaries of an urban space are not always fixed and absolute, people like to test themselves against them, or they can put themselves on the right, on the side or on the opposite side;

- DISTRICT: relatively large sections of the city with specific characters and their own identity. Neighbourhoods are based on the user's understanding of an atmosphere, general and non-specific similarities in a space. A neighbourhood, unlike the other spatial elements of Lynch, can also be simply a set or product of experiences, not just a visible

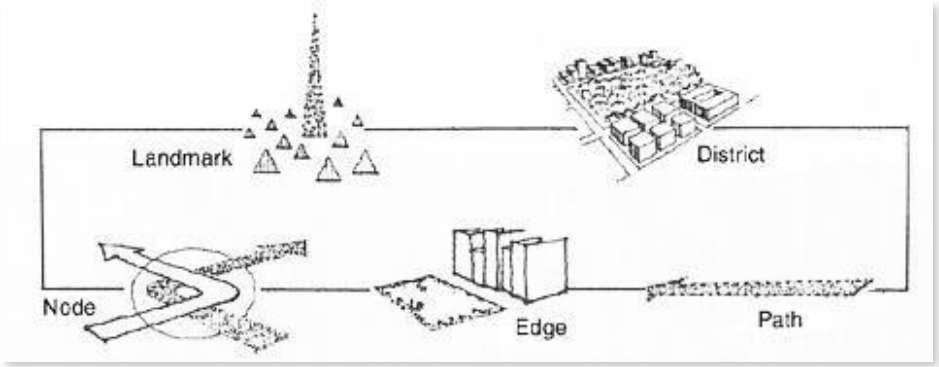
fact;

- NODES: crossroads of streets, squares or places of relationship, terminals of transport lines, focal points of the city, intersections between communication routes, meeting points. The nodes are linked to the route, as they constitute the terminals, and to the neighbourhood, as they constitute the focal point. The nodes are indicated as strategic, places of greater awareness and decision-making process: people slow down or stop in them, make choices about what to do next and where they are going, so as to define their route. At the crossroads people have close encounters, they are points of convergence but also points of divergence.

- LANDMARKS: buildings, signs, bell towers, shops, hills. The references are used as clues of identity of a neighbourhood or as elements of identification and orientation of a path. The reference points can often be seen from a certain distance and, the observer does not enter them, remaining above the urban fabric, in contrast "of scale" with the surrounding environment.

Actually, according to the author, the attribution of urban elements to the various categories is not to be applied rigidly: each element considered can be placed in different categories.

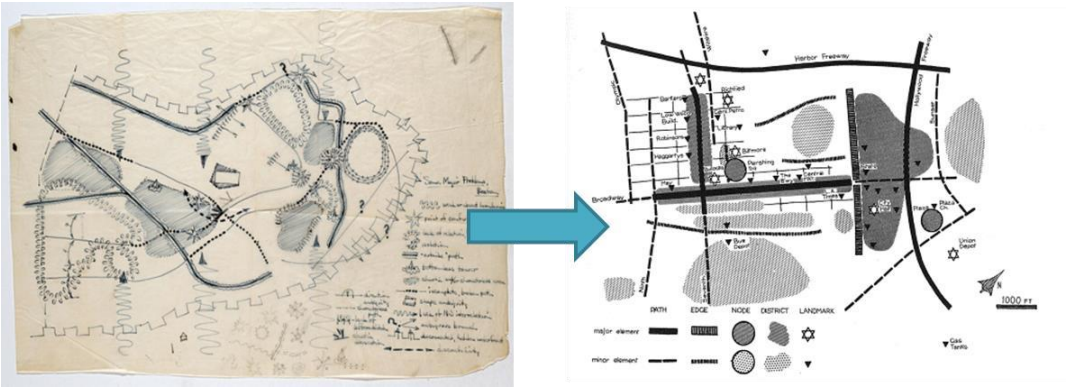
Figure 4.3. The 5 elements of mental maps



Source: Lynch (1960)

Through these elements, as shown in Figure 4.3, it is possible to represent again the map of a city, highlighting the elements that contribute to build the mental map of the observer.

Figure 4.4. From a *map* to a *mental map*



Source: Author's elaboration from Lynch (1960)

In addition, Lynch also defines *10 general physical characteristics* attributable to the elements:

- ✓ *Singularity*: being unique and distinct;
- ✓ *Simplicity in form*: a clear geometric form. Such as associating a rectangle to a dome, because complex shapes can be a distortion while a simple shape leads to greater understanding.
- ✓ *Continuity*: the maintenance of a border or a surface (like a road), a repetition of stained-glass windows; thus, creating a similarity, a harmony of parts, surfaces facilitate the perception of complex physical reality;
- ✓ *Dominance*: an element that dominates others by size, intensity or interest. Physical characteristics to radiate the conceptual image and to activate the threshold of attention of all;
- ✓ *Joint clarity*: high visibility of a joint or a joint, a clear relationship and greater interconnection. These Joints are strategic for the structure and must be highly perceptible;
- ✓ *Directional differentiation*: asymmetries, nuances and radial references that differentiate one end from another (like an uphill path, away from the sea);
- ✓ *Visual extension*: qualities that increase the range and penetration of vision really or symbolically;
- ✓ *Movement control*: qualities that make the observer "sensitive", through the visual and aesthetic senses. Qualities that strengthen and develop what an observer can do to interpret a direction or a distance;

- ✓ *Time series*: series that are measured over time, such as if reference points increase in intensity to a climax;
- ✓ *Names and meaning*: Non-physical characteristics that could reinforce the imageability of an element. Social, historical, functional, economic and individual meanings and associations that go beyond physical qualities.

All these qualities do not work in isolation, but will have the task of organizing, together, a global image of the five elements before mentioned.

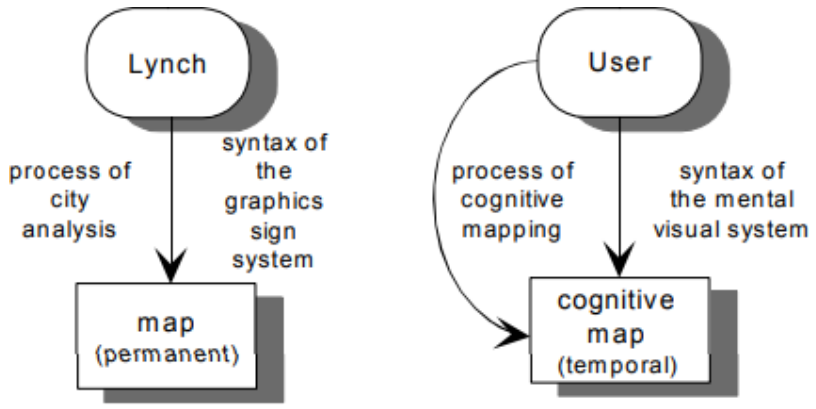
Another important concept highlighted by Lynch is the *legibility* of a place, i.e. the ability of communities to acclimatize, orient themselves and understand an urban space. In the Figure 4.5, Lynch's process describes the syntax and relationships in the visual communication process. The figure indicates two categories of maps (Šiđanin, 2007): *permanent* and *temporal*.

- The permanent map is a map created from the graphic representation, in two average dimensions (usually a sheet of paper) as the map of the city.
- The temporal map is a mental interpretation of an image (an object) of a particular space by the process of cognitive mapping. This map is always temporal, stored with a mental vision of a particular space in the human mind.

Correlated to the temporal maps are the *cognitive maps*. In Lynch's theory also they play a crucial role, related to individuals and their ability to store and retrieve information from the familiar environment. The term "cognitive maps" was used by Tolman[16] to study the behaviour of mice within a labyrinth. The animals cross the labyrinth and direct to the source of food, by integrating information about the path through the mental representation of its layout. Many studies have been derived from Tolman's experiment: people in fact can orient themselves in the environment by mentally interpreting it and by memorizing the elements and patterns in their brain.

[16] Tolman introduced a branch of psychology called "*purposive behaviourism*" which believes that all actions of behaviour are goal-oriented, including those for animals (Schultz and Schultz, 2015). Tolman's goal was to identify the complex cognitive mechanisms and purposes that guided behaviour.

Figure 4.5. Permanent map and cognitive map



Source: Šiđanin (2007)

4.3 THE SENTIMENT ANALYSIS AND THE ASPECT BASED SENTIMENT ANALYSIS (ABSA)

With the growing availability and popularity of opinion resources such as online review sites and personal blogs, new opportunities and challenges are arised for the decision-making. Also, always faster and easier is possible to use information technologies to seek out and understand the opinions of others. The opinion mining and sentiment analysis deal with the computational treatment of opinion, sentiment, and subjectivity in text, and is a direct response to the interest in new systems that deal directly with opinions as a first-class object (Pang and Lee, 2008). Therefore, sentiment analysis and opinion mining are the field of study that analyses people's opinions, sentiments, evaluations, attitudes, and emotions from written language. It is one of the most active research areas in natural language processing and is also widely studied in data mining, Web mining, and text mining. In fact, this research has spread outside of computer science to the management sciences and social sciences due to its importance to business and society as a whole. The growing importance of sentiment analysis coincides with the growth of social media such as reviews, forum discussions, blogs, micro-blogs, Twitter, and social networks. For the first time in human history, a huge volume of opinionated data is recorded in digital form for analysis and the organizations definetely can beneficiate of this phenomenon for conducting more aware decision-making process (Liu, 2012).

It is possible to classify three level of sentiment analysis:

- *Document level*: applies the classification process to an entire document, assuming that it contains only opinions on a single entity and belongs to a single author.

- *Sentence level*: applies the classification process to the single sentences or to short text messages (short-text) contained in the document, to determine, therefore, the positive, negative or neutral sentiments expressed in the single sentences or short-text.

- *Aspect level*: applies the classification process to individual words or small expressions. This is a deeper and more detailed level of analysis, which allows to identify the sentiments expressed not only towards the entity but also towards the aspects (parts, functions and components of the products).

From this last, it is developed the Aspect Based Sentiment Analysis.

The Aspect Based Sentiment Analysis (ABSA) is, therefore, an evolution of Sentiment Analysis (Pang and Lee, 2008) and is able of providing information no longer on the whole sentiment level, but on the various components of the same, allowing a more precise and accurate analysis (Liu, 2012; Pavlopoulos, 2014). Through this technique, generally used in marketing analysis, it is possible to extract useful information from the existing product online reviews of consumers. Specifically, this technique analyses and extracts sentiment polarity on product reviews based on a specific aspect of the product (Mubarok et al., 2017).

In this dissertation, by referring to previous works (D'Aniello et al., 2018; Barile et al., 2018), the ABSA is applied in an innovative way in the urban context.

The purpose is to increase the awareness of the collective opinions regarding the different characterizing aspects of points of interests (POIs) and their aggregation. In fact, it is possible to aggregate the perception of the POIs selected and offer analysis at different levels of granularity [17] in output.

According to Liu's approach, ABSA identifies the feelings expressed by the users of the community on-line under analysis, called "*holders*", with reference to the individual "*aspects*" of urban resources (monuments, places of tourist interest, services, etc.), and establishes whether they are positive or negative. In particular, in this work, the aspects of a city are selected according to Lynch theory, by considering the five elements which contribute to the collective perception.

[17] The granularity of data refers to the size in which data fields are sub-divided. Through this technique, it is possible for the decision-maker to manage both grouped data (*coarse granularity*), in order to carry out general evaluations, and data more detailed, for analysing with more precisions every aspect for each POIs identified (*fine granularity*) (Yao, 2005).

To this end, we define the *opinion-city* as a quintuple (e_i, a_{ij}, s_{ijkl}, h_k, t_l), where:

- e_i is the *name of the entity* (the city);
- a_{ij} is an *aspect* of e_i (nodes, paths, edges, districts, landmarks);
- s_{ijkl} is the *sentiment* about the aspect a_{ij} of the entity e_i;
- h_k is the *opinion holder* (user which express sentiment);
- t_l is the *time* in which opinion is expressed by h_k.

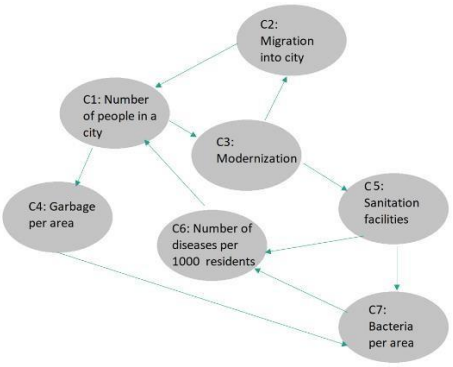
In order to apply this technique, the text extracted is analysed to represent the quintuple (Liu, 2012) and the correlated level of sentiment. After, by aggregating the results through an aggregation function, the polarities of each aspect of the analysed city and their aggregation are summarized in sheets summary.

4.4 THE FUZZY COGNITIVE MAP (FCM)

Formally, Fuzzy Cognitive Maps (FCMs) are graphs finalized to represent a variety of relationships among concepts like *events*, *processes* or *states*, by allowing qualitative reasoning on the states of complex systems (Kosko, 1986; D'Aniello et al., 2015). Therefore, it is a graphical representation which combines the *cognitive mapping* and *fuzzy logic*. Cognitive mapping is based on graph theory, which is the foundation of most algorithms: it consists of factors, or concepts, or nodes, connected by lines. Applying fuzzy values between 0 and 1 to the lines, it shows the strength of the links between the factors. Calculating the influences of the factors in an iterative way, it possible to highlight the current trend of a system or the simulation of the consequences of different scenarios.

Specifically, a *node* of the graph represents a *concept* C_i, connected via cause/effect relationships to other concepts, and making up a key factor of the modeled system. The strength of the relationship between concepts C_i and C_j is represented by a *weight* w_{ij} which, as depicted in Figure 4.6, can be negative if represents inverse causality, while positive if means direct causality.

Figure 4.6. An example of FCM of public health problem



	C1	C2	C3	C4	C5	C6	C7
C1	0	0	+0.6	+0.9	0	0	0
C2	+0.1	0	0	0	0	0	0
C3	0	+0.7	0	0	+0.9	0	0
C4	0	0	0	0	0	0	+0.9
C5	0	0	0	0	0	-0.9	-0.9
C6	-0.3	0	0	0	0	0	0
C7	0	0	0	0	0	+0.8	0

Source: Author's elaboration from Papageorgiou and Kontogianni (2012) and Montazemi and Conrath (1986)

Also, in these maps there is the activation value $A_i$of concept C_i, which is given by:

$$A_i^{k+1} = f(A_i^k + \sum_{j=1, j\neq i}^{n} A_j^k w_{ji})$$

Where:

- A_i^{k+1} is the activation level of the concept $C_i$at the k + 1 iteration;

- A_j^k is the activation level of the concept $C_j$at the k iteration;

-w_{ji} is the weight between concepts C_j and C_i;

-f is a threshold function.

Because the FCM can represent cause-effect relationships among different concepts, it has been widely employed for supporting what-if analysis. Indeed, it is possible to consider an initial scenario of simulation given by a activation vector S0 = (s1,...,sn) where si ∈ [0,1] is the activation level of concept Ci. Starting from the activation vector S0 of the initial scenario, it is possible to compute the activation values of the concepts in the following iteration of the map, resulting in a set of transitions A0 → A1 → When a limit cycle is found or a fixed state is found, it is possible to know which is the new state of the map or of specific concepts of interest. In such a way, it is clear that, starting from a baseline scenario, it is possible to simulate what will happen when the state of a specific concept changes, thus performing what-if analysis.

Thus, FCM can be considered as a useful tool to generate realistic and appropriate scenarios, to create participatory models, to compare different points of view on the

functioning of complex systems, to develop social learning, to integrate different types of knowledge, such as local knowledge, for *holistic analysis of socio-economic systems*.

Turning to specific applications of FCM analysis, a wide range of problems have now been tackled using FCM: analysis of the sensitivity of the building construction process to different sources of problem (Dissanayake & AbouRizk, 2007); representation of biological processes in bioinformatics (Ettinger, 2002); development of automated supervisory process control systems (Stylios & Groumpos, 1998); medical diagnosis (Froelich & Wakulicz-Deja, 2008), various business and financial management problems (Chytas et al., 2006) , and; failure mode and effect analysis (Paelaz & Bowles, 1996).

In the urban context, many papers explored the use of FCMs as an analytical and decision-support tool in different contexts like, for instance, to support urban resilience analysis (Olazabal and Pascual, 2016), green issues (Özesmi and Özesmi, 2004), urban planning (Habib and Shokoohi, 2009).

In this work, the goal is to offer to the urban planners and the decision makers a powerful tool to analyse the impact of the collective perception about urban relevant questions (e.g. quality of transportation, level of safety, etc.) and to understand how such a perception may influence the other issues of the city. In order to be able to activate the FCM with the collective perception, so as to perform scenario analysis, it is firstly needed to identify high level objectives for the city (i.e. why are we performing such scenario analysis?). Starting from such goals, it is possible to define a set of qualitative indicators related to the different city assets (e.g. the level of safety as perceived by the community, the quality of the urban area, etc.). Such indicators, together with the objectives, allow us to define a Fuzzy Cognitive Map supporting the reasoning on different perspectives that the stakeholders of the city have with regards to the high-level objectives.

4.5 A DECISION-SUPPORT MODEL FOR URBAN CONTEXT

Basing on the previous considerations, we define an urban decision-support model finalized to find information related to urban elements among online sources and understand in which way are perceived by users in order to support the governing body of a city.

Specifically, as depicted in Figure 4.7, the proposed model integrates a number of

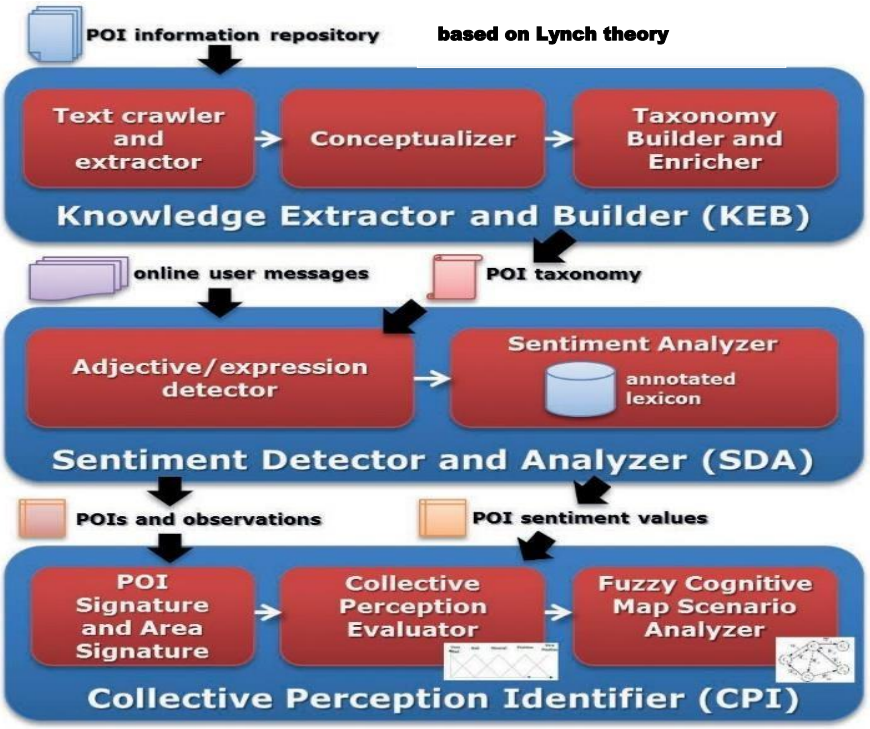
different approaches and techniques[18]:

1. **Knowledge Extractor and Builder module (KEB)**, which encapsulates software components for crawling texts from online sources and processing them via lexical analysis, NLP and wikification techniques, as well as for building taxonomies from the texts themselves;

2. **Sentiment Detector and Analyser module (SDA)**, whose purpose is to find textual references to POIs from online messages and evaluate their sentiment values in terms of the positivity, negativity or neutrality of the opinions expressed by online users;

3. **Collective Perception Identifier module (CPI)**, means define the Area perception containing more than one POI, thus evaluating the collective perception of the community with respect to the POIs and to the Area. The CP is then used in order to perform scenario analysis by using Fuzzy Cognitive Maps.

Figure 4.7. Decision-support model for urban context based on the Collective Perception



Source: D'Aniello et al. (2018)

[18] For further information: D'Aniello, G., Gaeta, M., Loia, F., Reformat, M., & Toti, D. (2018). An environment for collective perception based on fuzzy and semantic approaches. Journal of Artificial Intelligence and Soft Computing Research, 8(3), 191-210.

In brief, the Knowledge Extractor and Builder (KEB) is responsible of acquiring information about the POIs to be considered and turning it into a structured taxonomy of relevant concepts. The adoption of Lynch model has simplified this conceptualization phase. The Sentiment Detector and Analyser (SDA) executes a sentiment analysis of real users' comments from online forums, message boards or social networks. The Collective Perception Identifier (CPI), lastly, makes use of domain knowledge to evaluate the collective perception of city considered. In particular, the *domain knowledge* is embedded in two sub-tools of CPI, namely the Fuzzy Inference System (FIS) and the Fuzzy Cognitive Map (FCM), with the aim of defuzzifing the collective perception value determined by the previous module (for futher information see the Appendix).

4.5.2 The procedural steps

Below, the methodological procedural steps are presented (Figure 4.8):

<u>Preliminary operations</u>

- ✓ *City selection*

  In a first stage, the city to analyse is selected.
- ✓ *Definition of urban area of analysis*

  The area of interest to analyse is defined.
- ✓ *Definition of mental maps' elements*

According to the taxonomy defined by Lynch (Nodes, Quartiers, Margins, Paths, and references), a selection of relevant urban assets is created.

- ✓ *Social Network idenfication*

The social network where users write comments about the city is selected. For research purpose, the community must be particularly active online, sensitive to the phenomena of collective intelligence enabled to social and especially critical and attentive to the selected city.

<u>Sample identification</u>

After having identified the city and the social network, the survey protocol and the sample are defined.

- ✓ *Survey protocol*

It sets the objectives with particular reference to: the analysis purposes, the resources quantification, and the definition of research's time span.

- ✓ *Sample definition*

  Definition of the sample of the community of users, comments: work on the whole population or choose the sample.

- ✓ *Reviews extraction*

At this point the review extraction regarding the selected POIs is carried out.

Aspect Based Sentiment Analysis (ABSA)

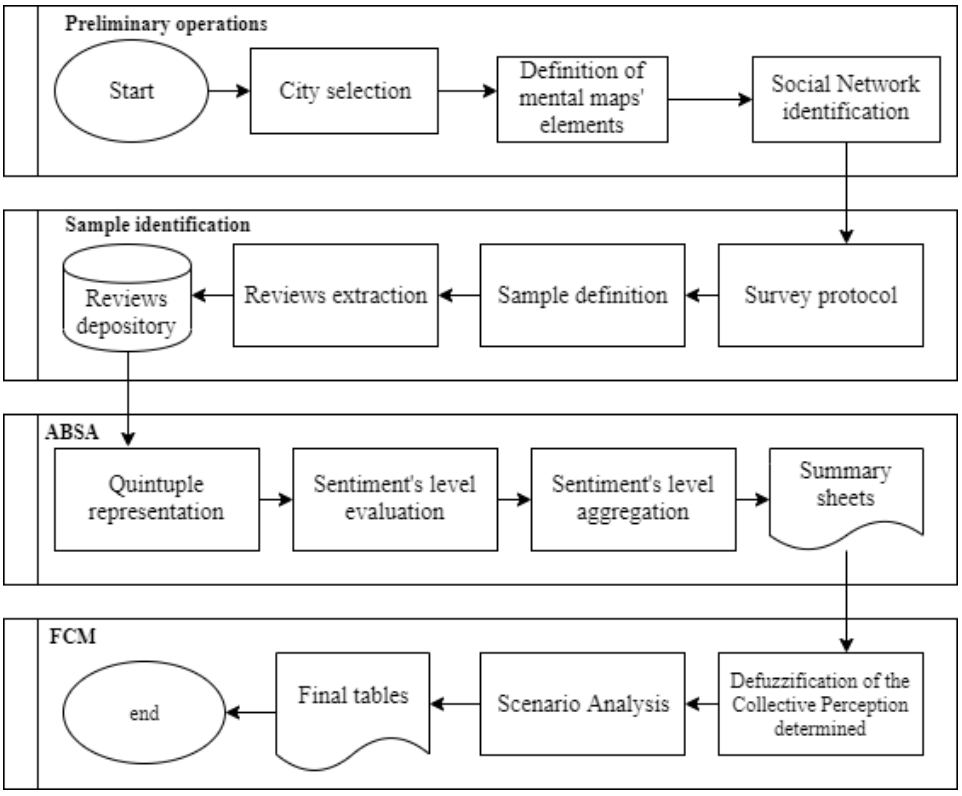
The ABSA is performed on the selected reviews (i.e. where the elements identified by Lynch's theory are present). In particular, the Liu's approach is applied:

- ✓ *Quintuple's representation;*
- ✓ *Sentiment's level evaluation;*
- ✓ *Sentiment's level aggregation,*
- ✓ *Determination of Collective Perception.*

Fuzzy Collective Map (FCM)

Once defuzzied the value of Collective Perception, the value is given to a Fuzzy Collective Map in order to highlight the impact of this on specific urban questions (e.g. quality of transportation, level of safety, etc.).

Figure 4.8. Procedural steps



Source: Author's elaboration

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CHAPTER V

Research design and interpretation of findings

SUMMARY: 5.1. Research Design –5.2. Sentiment detection and analysis of urban elements – 5.2.1. SDA for Salerno – 5.2.2. SDA for Siena – 5.3. Collective perception identification and analysis of scenario based on Fuzzy Cognitive Map – 5.3.1. Description of the FCM – 5.3.2. Simulation of base scenario – 5.3.3. Comparison between Siena and Salerno based on What-If analysis

"A town has a nervous system and a head and shoulders and feet. A town is a thing separate from all other towns alike. And a town has a whole emotion."
— John Steinbeck, The Pearl

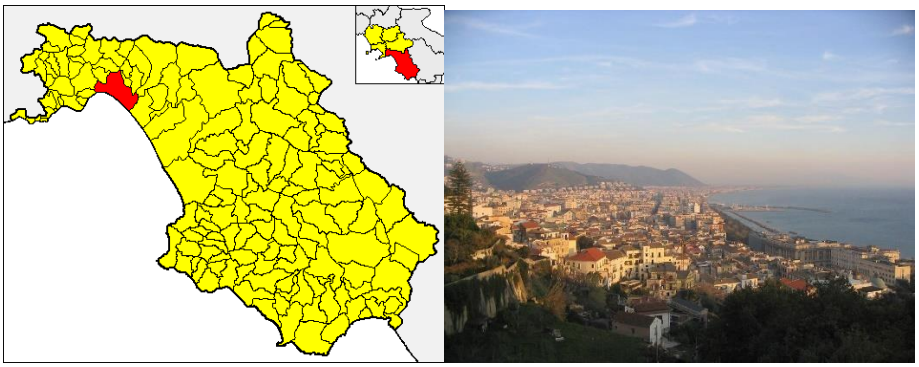
5.1 RESEARCH DESIGN

The cities selected for carrying out the large-scale text analysis are Salerno and Siena. Clearly, the cities have been chosen because they present similar characteristics (towards which it was possible to proceed to a homogeneous taxonomy), both are of a tourist nature, but belonging to different Italian areas in order to make a comparison.

The city of Salerno is an ancient city in the southwestern Italy and is the capital of the province of the same name. It is located on the Gulf of Salerno on the Tyrrhenian Sea. The economy of Salerno is mainly based on services and tourism. In fact, during the period 2016-2018 the total expenditure by foreign tourists rose from 368 to 880 thousand euro and the number of overnight stays from 3.138 million euro to 4.92 million euro[19].

[19] Salerno is very famous because is located between the Amalfitan Coast and the Cilento Coast. the city of Salerno can therefore be defined as a strategic tourist city in terms of visitor's stay, as well as a logistical "hub" to easily reach other towns in the province and the region (https://www.positanonews.it/2019/06/turismo-della-provincia-salerno/3312189/).

Figure 5.1. city of Salerno



Source: https://en.wikipedia.org/wiki/Salerno

The city of Siena is the capital of the province of Siena and is located in Tuscany. The historic centre of Siena has been declared by UNESCO a World Heritage Site[20]. It is one of the nation's most visited tourist attractions, with over 163,000 international arrivals in 2008[21]. Siena, therefore, is famous for its cuisine, art, museums, medieval cityscape and the Palio, a horse race held twice a year.

Figure 5.2. city of Siena

Source: https://en.wikipedia.org/wiki/Siena

The collection of users' opinions took place in a community of a website, *TripAdvisor.com*, a travel web portal that publishes user reviews about hotels, B&Bs,

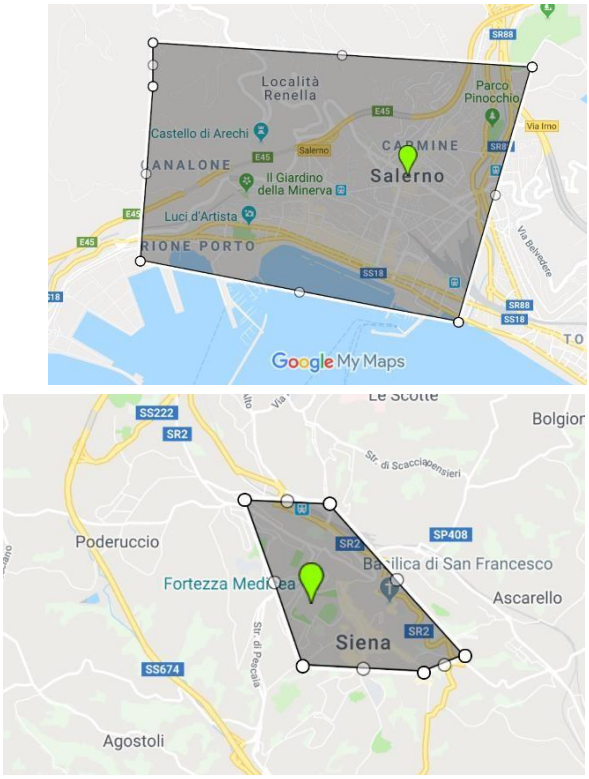
[20] Siena is a typical medieval city. Its inhabitants pursued their rivalry with Florence right into the area of urban planning. Throughout the centuries, they preserved their city's Gothic appearance, acquired between the 12th and 15th centuries. The whole city of Siena, built around the Piazza del Campo, was devised as a work of art that blends into the surrounding landscape (http://whc.unesco.org/en/list/717).

[21] "*Euromonitor Internationals Top City Destinations Ranking > Euromonitor archive*". Euromonitor.com.

apartments, restaurants and tourist attractions, which, with over 60 million reviews and opinions, represents the largest travel site in the world, capable of dynamically connecting a wide network of relationships.

According to the Lynch's theory (1960) and basing on the available reviews on TripAdvisor.com, we consider the most representative city elements which more contribute to collective perception in defined areas of interest, showed in Figure 5.3.

Figure 5.3. Area of interests



Source: Author's elaboration

In particular, as depicted in Table 5.1 and 5.2, we identify the Lynch's elements in the selected cities.

Table 5.1. Customized elements basing on Lynch's theory for Salerno

Taxonomy	**Customized elements of Salerno**
Paths	via Mercanti.
Edges	Lungomare; Acquedotto

	Medievale.
District	Historical Center; Station; Parco dell'Irno.
Nodes	San Gregorio Church; Minerva Garden; Villa Comunale; San Pietro a Corte Church.
Landmark	Duomo; Arechi Castle; Stazione Marittima.

Source: Author's elaboration

Table 5.2. Customized elements basing on Lynch's theory for Siena

Taxonomy	**Customized elements of Siena**
Paths	via di Città.
Edges	Porta Pispini; Porta Camollia.
District	Historical Center; Station; All'orto de' pecci; Museo dell'Acqua.
Nodes	Battistero di San Giovanni; Piazza del Campo; Basilica Cateriniana; Basilica di San Francesco.
Landmark	Duomo; Torre del Mangia; Palazzo Pubblico; Facciatone; Palazzo Salimbeni; Fortezza Medicea.

Source: Author's elaboration

The reviews were collected using an automated program, through a process of Web scraping, which permits for retrieving a semi-structured document from the Internet and analysing these documents to obtain data. In this case, Python programming language was used to create scripts. The process of data extraction has been implemented within the chosen online community for twelve continuous months, in particular from the beginning of September 2018 to the end of September 2019. We identified a sample size *n* equal to 7975 reviews for Salerno and 33980 reviews for Siena.

After crawling, a significant number of reviews have been analysed through sentiment analysis tool, to verify which are the positive or negative perceptions. The tools adopted for evaluation of results are deployed in the Knowledge Management and Information Systems (KMIS) laboratory of the University of Salerno. The semantic tool, therefore, outputs, for each review, the values in the interval [0,1], which represent the positivity, negativity or neutrality of each keyword analysed, whose total sum must be equal to 1.

Based on our statements, for each review, the relative values were evaluated positive Sp_i, negative Sn_i, and neutral Su_i, as shown below:

$$Sp_i = \frac{\sum_{k=1}^{K} p_k}{K}$$
$$Sn_i = \frac{\sum_{k=1}^{K} n_k}{K}$$
$$Su_i = \frac{\sum_{k=1}^{K} u_k}{K}$$

Finally, we proceeded with the aggregation of the results using the average function, in order to be able to perform evaluations at different levels of granularity, focusing on the area selected. The authors have appropriately analysed the summary sheet provided. After this, once determined the values of collective perception for both the cities, the analysis What-If basing on FCM is carried out in order to support the urban decision-making process.

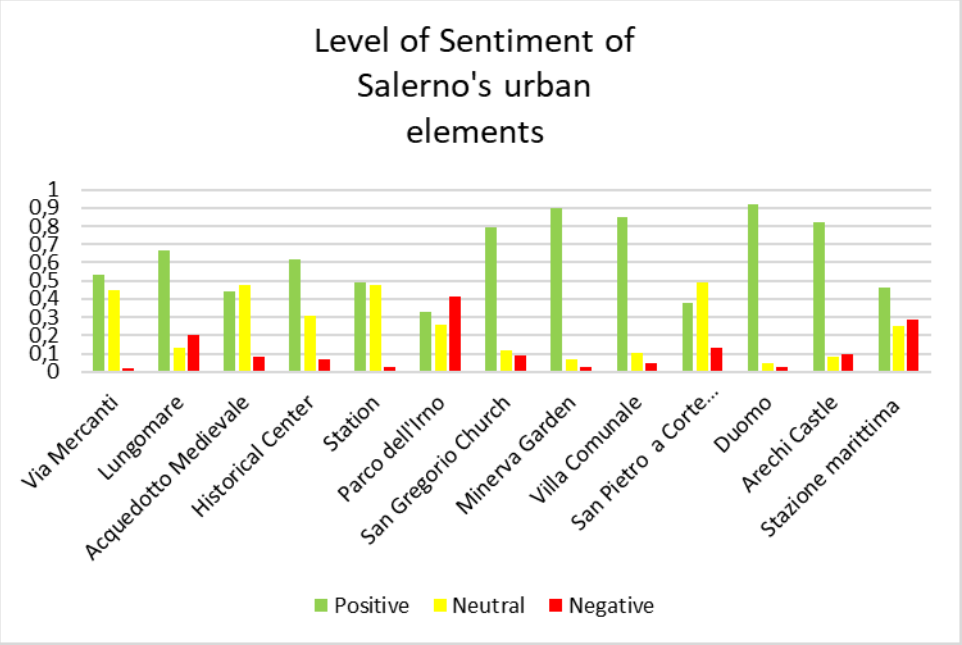
5.2 SENTIMENT DETECTION AND ANALYSIS (SDA) OF URBAN ELEMENTS

5.2.1. SDA for Salerno

Once represented the levels of sentiment of the selected urban elements, we proceed to aggregate these, in order to make general assessments on the considered POIs.

From the Figure 5.4, it appears that the collective opinions are mainly positive, confirming the highest level of attractiveness of the selected urban elements.

Figure 5.4. Urban elements' level of sentiment



Source: Author's elaboration

Table 5.3. Salerno – elements' level of sentiment

	Positive	Neutral	Negative
Via Mercanti	0,53	0,45	0,02
Lungomare	0,67	0,13	0,2
Acquedotto Medievale	0,44	0,48	0,08
Historical Center	0,62	0,31	0,07
Station	0,49	0,48	0,03
Parco dell'Irno	0,33	0,26	0,41
San Gregorio Church	0,79	0,12	0,09
Minerva Garden	0,9	0,07	0,03
Villa Comunale	0,85	0,105	0,045
San Pietro a Corte Church	0,38	0,49	0,13
Duomo	0,92	0,05	0,03
Arechi Castle	0,82	0,08	0,1
Stazione marittima	0,46	0,25	0,29

Source: Author's elaboration

In particular, it emerges that many urban elements are perceived in a very positive way. In particular, places as Duomo, Giardini della Minerva, Villa comunale are characterized by a strong positive perception. From a more accurate analysis, it should be noted that, although to a lesser extent, there are some early symptoms of discontent on the part of the community, concerning particular aspects. Only some POIs, as Parco dell'Irno, Lungomare, and Stazione Marittima are not perceived at all in a positive way. This information can be of particular relevance for the institutions, in order to invest more attention for these urban elements.

5.1.2. SDA for Siena

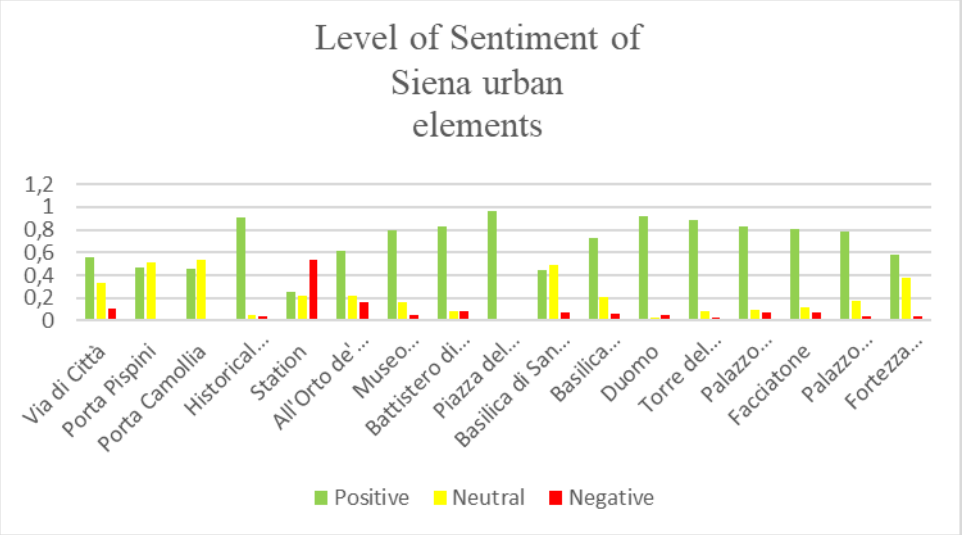
As defined regarding Salerno, also about Siena, the aspects are analysed. After, we proceeded to aggregate these, in order to make general assessments on Siena.

From the Figure 5.5, it appears that the collective opinions are mainly positive, confirming also regarding Siena the high attractiveness of the selected urban elements.

In particular, it emerges that many urban elements are perceived in a strong valued way. In particular, most of Siena's urban elements are characterized by a positive perception: Historical Center, Duomo, Piazza del Campo, and Torre del Mangia are highly appreciated.

Only regarding the Station, some negative impressions are highlighted.

Figure 5.5. Urban elements' level of sentiment



Source: Author's elaboration

Table 5.4. Siena – elements' level of sentiment

	Positive	Neutral	Negative
Via di Città	0,56	0,33	0,11
Porta Pispini	0,47	0,51	0,02
Porta Camollia	0,46	0,53	0,01
Historical Center	0,91	0,05	0,04
Station	0,25	0,22	0,53
All'Orto de' Pecchi	0,62	0,22	0,16
Museo dell'Acqua	0,79	0,16	0,05
Battistero di San Giovanni	0,83	0,09	0,08
Piazza del Campo	0,96	0,02	0,02
Basilica di San Francesco	0,44	0,49	0,07
Basilica Cateriniana	0,73	0,21	0,06
Duomo	0,92	0,03	0,05
Torre del Mangia	0,89	0,08	0,03
Palazzo Pubblico	0,83	0,1	0,07
Facciatone	0,81	0,12	0,07
Palazzo Salimbeni	0,78	0,18	0,04
Fortezza Medicea	0,58	0,38	0,04

Source: Author's elaboration

5.3 COLLECTIVE PERCEPTION IDENTIFICATION AND ANALYSIS OF SCENARIO BASED ON FUZZY COGNITIVE MAP

5.3.1 Description of the FCM

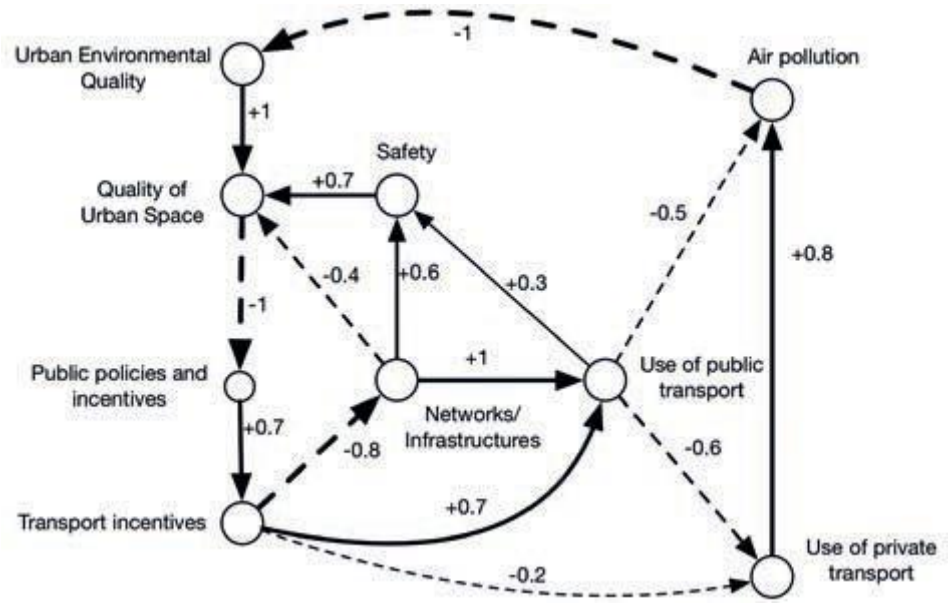
The FCM used for the evaluation of results is shown in Figure 5.6. The map has been developed by integrating the maps proposed by domain experts in urban planning (Olazabal and Pascual, 2016; Shiau and Liu, 2013) and considering only the concepts of interest for our subject matter.

As we can see from Figure 5.6, it includes concepts related to "*perceived safety"*, "*environment"* and "*transportation"*. In particular, these concepts refer to:

- *Air Pollution*: refers when harmful or excessive quantities of substances including the gases (CO_2, CO, SO_2, etc.), particles (both organic and inorganic), and biological molecules are introduced into the urban atmosphere. Urban air pollution is a major environmental problem in the developing countries of the world (Mage et al., 1996).
- *Urban Environmental Quality*: can be treated as a generic indicator that objectively represents the physical and socio-economic condition of the urban and built environment (Faisal and Shaker, 2017).
- *Use of public Transport*: considers to system of transport for passengers by group travel systems available for use by the general public, typically managed on a schedule, operated on established routes, and that charge a posted fee for each trip. In order to increase public transport usage, the service should be designed in a way that accommodates the levels of service required by customers and by doing so, attract potential users (Beirão and Cabral, 2007).
- *Use of private Transport*: is the personal or individual use of transportation vehicles which are not available for use by the general public, where essentially the user can decide freely on the time and route of transit.
- *Transport Incentives*: referring to the effect on travellers' choices of changes in price, speed of travel, quality, information, new infrastructure, better use of existing infrastructure, and planning on transport choices (Goodwin, 2008).

- *Network and Infrastructure*: are focused on providing energy, water, waste, telecommunication and transportation services in the urban context (Moss and Marvin, 2016).
- *Public Policies and incentives*: refer to the development of policy instruments designed to manage urban growth and protect open space (Bengston et al., 2004) and using incentive pay to improve public-sector efficiency (Burgess and Ratto, 2003).
- *Quality of Urban Spaces*: a multifaceted concept which includes aspects such as quality of buildings, cultural and tourist attractions and so on (Hong and Jeon, 2015). In this work, as defined in the previous chapter, this concept is correlated with the types of POIs indicated by the Lynch model.

Figure 5.6. The FCM



Source: D'Aniello et al. (2018)

An interesting aspect of FCMs is their simplicity of understanding and immediacy. From Figure 5.6 it is easy to comprehend that there is a negative influence of "Quality of Urban Space" on "Public Policies and incentives". This means that a decrease of the value level of "Quality of Urban Space" requires an effort to increase the investments on "Public Policies and incentives" to maintain the equilibrium values of the map. Similar considerations can be done if we consider the influence of "Safety" and "Urban

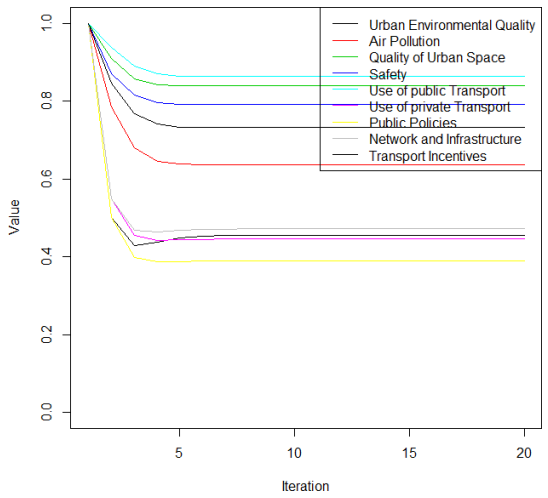
Environmental Quality" on the "Quality of Urban Space". In this case, there is a positive influence meaning that the quality of an urban space is perceived "better" if the citizens feel safer and the quality of environment is good.

5.2.2. Simulation of base scenario

First, as mentioned in the 4.4 Paragraph, a base scenario has been simulated.

For the base scenario we have found the equilibrium of the map by considering an activation level of "Quality of Urban Space" equal to **0.84** that refers to the case for which the citizens perceive a good quality. The equilibrium values for the base scenario are reported in Figure 5.7.

Figure 5.7. Base Scenario Equilibrium Value



Concept	Equilibrium Value
Urban Environmental Quality	0.4545990
Air Pollution	0.6367047
Quality of Urban Space	**0.8402714**
Safety	0.7914187
Use of public Transport	0.8638592
Use of private Transport	0.4453935
Public Policies	0.3890768
Network and Infrastructure	0.4715364
Transport Incentives	0.7318926

Source: Author's elaboration

Equilibrium values are the values that concepts reach when, after a certain number of interactions (~ 20 in our case, see Figure 5.7), the map arrives in a stable state. These values are achieved on the basis of the domain knowledge formalized in the relations of mutual influence (positive and negative) between concepts. The base scenario provides, therefore, indications on the necessary levels of public policies, transport, quality of the environment of an "ideal city" so that the perceived Quality of Urban Space is high (i.e., around 0.84).

5.2.3. Comparison between Siena and Salerno based on What-If analysis

To compare Siena and Salerno with the base scenario, we iterate the FCM by using, in the activation vectors, their values of defuzzied CP.

Therefore, the inferred value of CP is defuzzied and used as activation level of the "Quality of Urban Space" concept of a FCM both in the case of Salerno and Siena, in order to provides domain knowledge in terms of cause-effect relationships among concepts of urban planning. The defuzzied values of collective perception (CP) are respectively for Siena **0,77731** while for Salerno **0,75291**.

Table 5.5 and Table 5.6 report the results of a what-if analysis. In this kind of analysis, basically, we ask what happens to the ideal city if we change the value of Quality of Urban Space from that of the base scenario to the ones of, respectively, Siena and Salerno. The urban decision makers, by analysing the differences in the equilibrium values of the concepts, can thus take decisions in terms of actions and policies to be implemented.

Table 5.5 reports the comparison between the base scenario and Siena. Values are rounded to the fifth decimal.

Table 5.5. Comparison between base scenario and Siena

Concept	Base	Siena	Difference	%change
Urban Environmental Quality	0,45460	0,45463	0,00003	0,00667
Air Pollution	0,63670	0,63661	-0,00009	-0,01445
Quality of Urban Space	0,84027	0,77731	-0,06296	-7,49334
Safety	0,79142	0,79132	-0,00009	-0,01197
Use of public Transport	0,86386	0,86405	0,00020	0,02262
Use of private Transport	0,44539	0,44513	-0,00026	-0,05837
Public Policies	0,38908	0,40893	0,01986	5,10376
Network and Infrastructure	0,47154	0,47064	-0,00090	-0,19010
Transport Incentives	0,73189	0,73527	0,00338	0,46134

Source: Author's elaboration

Siena appears to have a quality of urban space that is about 7.5% lower than the base scenario. This has two main implications when we compare Siena to the ideal city of the base scenario: on the one hand, we observe the need to increase the value relative to investments for public policies of about 5% and, on the other, the need to implement a series of actions aimed at encouraging transport (increase of Transport Incentives about

0.46%) favouring the use of public transport (+ 0.02%) and discouraging the use of private transport (- 0.05%). We also note the need to reduce the impact of networks and infrastructures to leave more "liveable" space for citizens. Moreover, although quite obvious, it can be observed that a reduction in the perception of the quality of urban space is correlated to a reduction in the perception of safety, and requires an increase in environmental quality and a consequent reduction in air pollution.

Likewise, we iterate the process regarding Salerno. Table 5.6 reports the comparison between the base scenario and Salerno. Similar considerations can be done.

Table 5.6. Comparison between base scenario and Salerno

Concept	**Base**	**Salerno**	**Difference**	**% change**
Urban Environmental Quality	0,45460	0,45464	0,00004	0,00927
Air Pollution	0,63670	0,63658	-0,00013	-0,02009
Quality of Urban Space	0,84027	0,75291	-0,08736	-10,39642
Safety	0,79142	0,79129	-0,00013	-0,01665
Use of public Transport	0,86386	0,86413	0,00027	0,03144
Use of private Transport	0,44539	0,44503	-0,00036	-0,08115
Public Policies	0,38908	0,41674	0,02766	7,10974
Network and Infrastructure	0,47154	0,47029	-0,00125	-0,26428
Transport Incentives	0,73189	0,73659	0,00469	0,64140

Source: Author’s elaboration

In the case of Salerno, the city appears to have a quality of urban space that is about 10.4% lower than the base scenario. Therefore, compared to the ideal city: it is necessary to increase the value relative to investments for public policies of about 7% and to carry out a series of actions aimed at encouraging transport (increase of Transport Incentives about 0.64%) favouring the use of public transport (+ 0.03%) and discouraging the use of private transport (- 0.08%).

Table 5.7, lastly, reports a comparison between Siena and Salerno. Specifically, the chart compares Salerno to Siena, by analysing the difference and the rate of change of each equilibrium concept value.

From our analysis, the perception of Quality of Urban Space of Salerno is around 3%

lower of that one of Siena. This is a good indication for Salerno that, in the time window under analysis, has improved the perception that citizens and tourists have of its quality. This is also due to execution of attractive events (such as Luci D'Artista, Fantaexpo, and so on) in general well perceived by the users providing the reviews and comments analysed, and from some choices of city managers, such as the opening of a superficial subway, devoted to facilitate urban connections, which have been perceived positive from the analysis of the textual corpus of reviews and comments.

Also thank to these actions, Salerno has greatly increased its perceived quality, making it comparable to cities in the center-north of Italy where, historically, the quality of life and urban space is better perceived. The percentage variations between the equilibrium values of Siena and Salerno are not excessive. As a consequence, it emerges that Salerno requires only limited actions to be in line with the perceived quality of Siena.

Table 5.7. Comparison between Siena and Salerno

Concept	**Siena**	**Salerno**	**Difference**	**% change**
Urban Environmental Quality	0,45463	0,45464	0,00001	0,00260
Air Pollution	0,63661	0,63658	-0,00004	-0,00564
Quality of Urban Space	0,77731	0,75291	-0,02439	-3,13823
Safety	0,79132	0,79129	-0,00004	-0,00467
Use of public Transport	0,86405	0,86413	0,00008	0,00882
Use of private Transport	0,44513	0,44503	-0,00010	-0,02279
Public Policies	0,40893	0,41674	0,00780	1,90858
Network and Infrastructure	0,47064	0,47029	-0,00035	-0,07432
Transport Incentives	0,73527	0,73659	0,00132	0,17923

Source: Author's elaboration

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Euromonitor.com

CHAPTER VI

Discussion and conclusions

SUMMARY: 6.1. Discussion – 6.2. Summary of the research findings – 6.3. Implications: academic and managerial – 6.4. Limitations and recommendations for future research – 6.5. Conclusions

"Cities are more than the sum of their infrastructure. They transcend brick and mortar, concrete and steel. They're the vessels into which human knowledge is poured.".
— Rick Yancey

6.1 MANAGING URBAN COMPLEXITY THROUGH A VIABLE DECISION-MAKING MODEL BASED ON COLLECTIVE PERCEPTION

By integrating the social, human and technological sphere, the decision-making model proposed herein aims to enhance the awareness of the urban governing body about the collective perception of a city and its impact on specific urban questions (e.g. quality of transportation, level of safety, etc.). Therefore, by leveraging on an innovative methodology based on big data approach, the work shows that the decision-making process of urban governing body can be supported by the evaluations of the level of sentiment regarding city-assets and by scenario analysis through the FCM. If, from on hand, the governing body can analyse summary sheets on the level of sentiment regarding the fundamental Points of Interest, on the other, carrying out a What-If simulation, he can understand how the current collective perception affects other important urban issues and how, changing the collective perception through targeted interventions, the urban context will react. Therefore, the urban governing body can obtain reliable information and can benefit on "*social dimension*" for defining new policies and establishing targeted interventions, able to lead to the development of the entire urban context. The relevance of citizens' participation and social inclusion underlines the importance of a redefinition of

urban governance models, more and more focused on the harmonization of top-down and bottom-up power distribution, cooperation and competition.

Thus, the findings obtained confirm the need to adopt meta-governance models based on the key role of collaborative dimension to improve the holistic well-being of a community (Da Cruz et al., 2019). In fact, governance in digital era, by leveraging on the data collected thanks to smart technologies and automated research techniques, such as the innovative methodology adopted (the ABSA), can harmonize several perspectives and projections by including them in decision-making process, firstly, and policy-making, secondly.

The city interpreted as viable system which, in a dynamic and recursively way, interact with the actors which compose it, acts as scenery: the city is an example of a complex social system. In fact, the turbulence of urban context — characterized by heterogeneity of components, richness of interactions between them and uncertainty— is always increasing. Hence, information fluxes are huge and the decision maker risks to not possess all the information to understand the complex system and its dynamic. At the basis of the distinction between problem solving and decision-making[22], the uncertainty and evolutionary dynamics of the decision-making context typical of urban contexts involve a continuous and substantial remodelling of the problematic environment: it is impossible to codify solutions prepared on the basis of a series of fixed problems. The concept of rationality from time to time must be adapted to the characteristics of the external context (Simon, 1984). Also, Friedman argues that the strategic choices depend on an *emerging path* characterized by successive adaptations and approximations: the process of modification is not rationalized; it should be traced back to the actors present in the context and involved in the general goal (1953).

According to the Ashby's Law (1957), the understanding of a complex system (requisite variety) depends on the information variety endowment owned by the decision makers. Starting from these premises, in order to understand and manage effectively a complex urban context, the more the complexity of a system (expressed in terms of its variety) increases, the more the level of the information variety (i.e. richness, diversity of the information endowment) possessed by the

[22] The problem-solving concerns decisions in the technical sense, for which are known the problem, the conditions, and factors which should be taken into account to reach the solution. On the other hand, decision-making concerns decisions that regard less formalised problems, generally to be traced back to conditions of discomfort for which useful guidelines for the choice are not yet evident (Barile, 2009).

observer/decision maker must increase. The recognition of the limitation implied by the law of requisite variety, over time, may also be useful, by ensuring that strategies for the complex urban context shall be redefined, through constant adaption to the special peculiarities of the complex system. This is of crucial relevance for understanding the challenges of the urban governance.

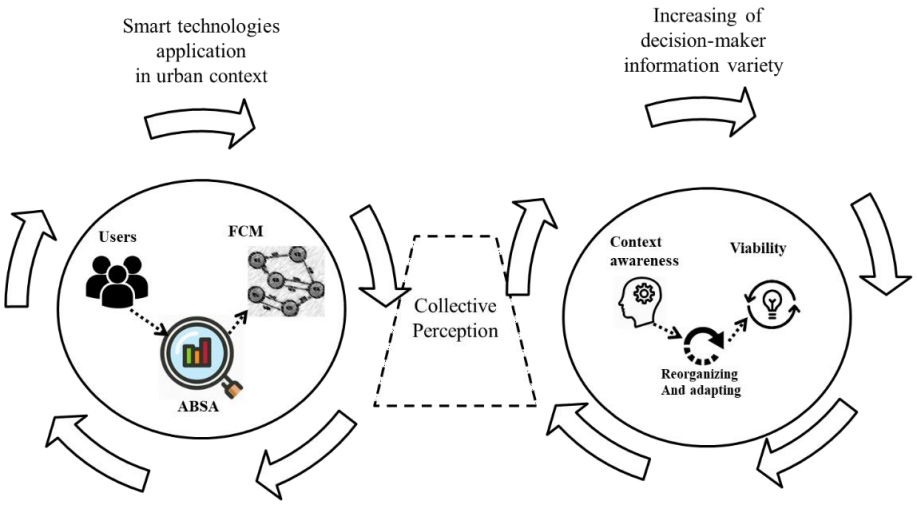
Furthermore, the urban governance issues configure typical wicked problems (Rittel and Webber, 1973) that do not have univocal solutions and these solutions are usually just "satisficing" (i.e. often far from the "one best way), by involving a non-objective stopping rule. Thus, the full feedbacks of the solutions cannot be foreseen at all until the effects have entirely run out, and they are affected by the subjective and bounded information variety endowment of the decision maker (policy maker, urbanist, architect etc.). In this complex and dynamic context, the decision-making model proposed can enrich the information variety endowment of the decision makers to manage effectively the complexity of the urban context, consistently with the Ashby's Law (1954; 1956): "*variety can destroy variety*". In this way, the governing body is able to implement a series of interventions, aimed at establishing the conditions for a context consonance, by obtaining an overall view composed by the different perceptions of the community (Irvin and Stansbury, 2004; Barile, 2009; Calabrese et al., 2011; Simone et al., 2018).

The methodology employed to perform the empirical research enlightens why some cities behave as a "structure" without effectively acting as a "system". In fact, certain cities, although possessing a virtuous structure, characterized by their physical configuration, from a dynamic point of view do not work well. The cause arises from the unawareness of the needs of the stakeholder who experience the city every day and which compose it. Also, the concept of "delay" characterises urban systems in relation to new social and economic situations, such as, for example, the change in the rules of social interaction, the growing demand for security and the greater environmental awareness: "*the political and administrative structures which should governing new social and economic situations are seriously behind schedule*" (Bertuglia and Vaglio, 2019, p. 165). In so doing, the level of sentiment on urban assets and the analysis through the FCM represent relevant tools able to support the decision-making process as they allow the governing body to understand more in-depth the complexity of the urban landscape and expand the urban decision makers' cognitive endowment. This process can increase the possibility that a structure collapses into a system.

As depicted in Figure 6.1, the results of the analysis show a close relation between the

will to survive, the ability to understand the context dynamically and the need to choose the most appropriate strategy to adopt. The final purpose is, therefore, to leverage on an increase in the information variety of the decision maker and on the correlated satisfaction of the urban actors to increase the probability of city survival. Then, only when the institutions, by creating the conditions of consonance, base their decision on a participatory logic and are able to guarantee the survival of the urban system as a whole, the city can be considered as a viable system.

Figure 6.1. A viable decision-making model for the urban context based on collective perception



Source: Author's elaboration

6.2 SUMMARY OF THE RESEARCH FINDINGS

Starting from the definition of a new decision-making model for urban context, the results obtained from the two cases studies permit to address the research questions introduced in the first section of the study and to synthesize further the findings of the empirical research.

Research Question 1 (RQ_1):

How can decision-making processes in urban viable systems be reframed and boosted by the application of smart technologies and automatized research techniques for big data management?

Governance in digital era should harmonize technological advancements by including them in daily life to improve decision-making, firstly, and policy-making, secondly in order to take into account the stakeholders' needs.

However, even if the existence of multiple touch points with customers-citizens offers great advantages, there is the need to understand how the big flow of data can be optimized in order to exploit the potentials of the current ICTs (information and communication technologies) by avoiding to turn these advantages into threats (Gandomi and Haider, 2015).

Democratic and multilevel governance seems to be the most adequate governance model to take into account the complexity and multidimensionality of smart community and to enhance decision-making. An urban multilevel governance is intended as the application of a set of norms, rules and values (Deakin 2011) that can improve well-being in different urban areas, from economy to environment and social inclusion, in cities intended as collaborative technology-mediated networks.

This implies a rethinking of the process of decision-making which assumes a collaborative dimension.

In this direction, the interpretative lens of the VSA underlines the main challenge of governing boy is to harmonize the stakeholders' heterogeneous expectations and objectives: successful governance lies in the capability to mediate between conflicting interests and harmonize the stakeholders' objectives with overall system goals. Only, thus, establishing synergic relationships with the actors that populate that same urban context, the cities can survive in their reference context (Barile et al., 2015).

Research Question 2 (RQ_2):

Is it possible to formalize a decision-making model able to support urban governing body in the exploration of actors' (e.g. citizens and tourists) collective perception regarding the city?

The second research question (RQ2) is connected directly with the model and the results obtained. The proposed decision-making process of the urban governing body is supported by evaluations of the level of sentiment regarding city-assets and by scenario analysis through the FCM.

Firstly, the model offers to the governing body summary sheets regarding the level

of sentiment regarding the fundamental Points of Interest. Already on the basis of these results it is possible to understand some POIs which are strongly perceived positively and other which instead present veiled signs of discontent. The urban governing body, at this point, will have to implement actions aimed at limiting this negative perception, before it is shared by a larger number of users.

Moreover, the model offers also to carry out a What-If simulation thanks to the Fuzzy Cognitive Map: the governing body can understand how the current collective perception determined affects other important urban issue, how this influences the interventions which should carry out, and how, changing the collective perception through targeted interventions, the urban context will react.

Therefore, the proposed methodology has the potential to enhance the urban decision makers' information variety about the city, supporting him to better and deeper understand the reference context and to choose the most appropriate strategy to adopt. In this way it is possible of increasing the satisfaction of the urban actors and the probability of city survival.

6.3 THEORETICAL AND MANAGERIAL IMPLICATIONS

The work offers interesting theoretical implications, thanks to the combination, in an integrated model, of the Viable System Approach, interpretative lens of the reality, with IT tools as the Aspect Based Sentiment Analysis and the Fuzzy Cognitive Map.

Starting from a critical rereading of the city as a viable system, an innovative decision-making model is defined for the urban context. The aim is to allow not only the collection, analysis, and simulation of data but also offer an interpretative approach of the complex urban landscape. Furthermore, the study aims to analyse the interactions between single individuals, observers of a complex system and complex system itself. These different points of view led to the definition of a model capable of describing social systems effectively, in an attempt to define the relationship between the micro (individual) and macro (social) levels in the study of urban complexity. In this direction, the systems approach, combined with the smart techniques mentioned before, permits to explore the evolving dynamics of processes of value co-creation (Barile e Polese, 2010). In fact, the VSA recognizes in general the complexity of social phenomena, and, particularly, of urban decision-making processes, and contributes to the identification of how to manage the numerous information without losing a system vision. The aim is to co-create value through increasingly dynamic interactions of context actors.

The proposed decision-making model, referring not only to the complexity of the

urban system, but also to the complexity of the individuals, of the perceptions and sensations they receive from the environment in which they are immersed, supports the decision-maker in the overcoming of individual interests, by redefining and co-creating new values deriving from information and knowledge sharing between the social actors. In fact, in a strongly globalized society, characterized and forged by innovative and smart technologies, the science of complex systems can provide useful tools for understanding the economic, social and environmental phenomena that are typical not only of urban systems, but of all social systems at different territorial scales. The institutions should engage conscious citizens, capable of judging and producing knowledge, to harmonize the process of value co-creation and establish durable relationships with the actors leading to win-win situations. By encouraging actors' participation, the viability of the city and the POIs in it can increase by gaining sustainable competitive advantage and creating the conditions for context consonance.

From these conceptualizations, it emerges clearly that the city is to be considered a common asset, well characterized not only by social welfare, but also by aspects related to the identity and appropriation of urban space: each citizen can be considered as a part of a multilevel urban governance and can contribute to guarantee that the collective interest prevails over the individual.

Besides, the work also highlights the strong interconnection between technology, people and institutions, three main dimensions behind the definition of smart city (Nam e Pardo, 2011). Infrastructure integration, technology-mediated services, social learning to strengthen human infrastructures, governance systems for institutional improvement and citizen engagement are just some of the components on new governance models should be based according to smart city vision (Pellicano et al., 2019). In fact, the model of smart cities reflects not only the importance of focusing on pollution issues, congestion and scarcity of resources, but also to reconnect to urban governance connotation as an approach to reach a greater social and territorial aggregation. In fact, an intelligent governance vision aims, above all, to exploit and coordinate citizens' enthusiasm and skills to represent their interests more effectively and efficiently. The awareness of the advantages deriving from the adoption of a smart city model leads to the emergence of social creative innovations, which in turn can ensure an increase in citizen confidence and the development of collaboration agreements between the various social actors involved.

Other scholars (Eriksson-Zetterquist et al., 2011) have highlighted how smart cities, understood as true learning organizations, are able not only to create, develop and acquire knowledge but especially to influence the behaviour of people and organizations through the exploitation of new knowledge and skills. In this regard, collaborative relationships

within a smart city allow overtaking traditional partnerships between public sector organizations, leaving space for the spread of government models that can generate greater value than the sum of the individual parties involved in the processes.

Similar considerations show how the use of the ICT is not sufficient for the birth and dissemination of smart cities, but it is also necessary to activate profitable and creative networks of stakeholder relations, in various ways, concerned with value-generation processes. In other words, technological platforms designed to ensure high-tech performances must be properly integrated into social platforms, thus enabling all the actors involved to become an active part of value creation mechanisms (Anttiroiko, 2012). This shift of perspective gives a different role to the technological and social platforms, increasingly defined as facilitators for the activation of collaborative networks among social stakeholders (Wachhaus, 2011).

Furthermore, the proposed model based on the application of a Fuzzy Cognitive Map refers to a vision of the urban system able not only to adapt to critical issues but also to modify itself by building new social, economic and environmental responses that allow to withstand the externals tensions and the structural difficulties in the long run. Transformative change for urban landscape calls for the use of new governance approaches that take into account the complexity of urban systems and the key role of stakeholder knowledge and perceptions: Fuzzy Cognitive Mapping approach permits to develop plausible policy scenarios that support the resilient vision of a city. Scenario analysis can indicate that a combination of local institutional and social action may encourage effective and sustainable transformation of urban context (Olazabal and Pascual, 2016). This finding is in line with the definition of resilient cities, able to resist and absorb threats and capable of adapting and recovering from shocks and stresses (Meerow et al., 2016). This is a fundamental condition for the wellbeing of society (Labaka et al., 2019). The strategies for urban management should no longer be defensive; it is necessary to turn the vulnerabilities into opportunities, by considering the critical questions in order to move towards a more resilient state in the future, by taking complexity and uncertainty into account. This vision is affected by a multiplicity of economic, social, spatial, and physical factors and its planning involves a wide range of stakeholders (Jabareen, 2013).

From a managerial point of view, the model can concretely support urban decision makers: if, on the one hand, it offers relevant insights regarding the level of sentiment of users respect to the relevant Point of Interest, on the other hand, it highlights how the collective perception of the city influences important urban questions and how the governing body should intervene to realize a viable city. This model, thus, permits to

broaden the information endowment of the decision-maker by highlighting the relationship between the different dimensions of the urban context which are not always immediately observable.

The practical procedure to implement the model can be realized in a very short time: in this way, it is possible to reduce the delay which characterizes the urban systems in relation to a critical situation perceived by the community and to the fulfilment of the interventions required by the institutions. The faster changes in social interactions, the growing demand for security and the greater environmental awareness can find an answer in a quite immediate model able to frame the collective perception analysed in a predefined time frame.

Another relevant finding regards the capacity to depict graphically the results for the managers: the proposed model offers summary sheets and the map's representation which can strengthen the awareness regarding the results obtained. According to Aristotle, the soul never thinks without images: as can be shown theoretically and empirically, processing information through the visual system can significantly increase the capability to manage complexity (Rode 2000; Osterwalder, 2004). Therefore, the application of the model enables to frame the urban context not only with numerical results but also thanks to graphical support which contributes to make the considerations more interpretable.

Furthermore, the proposed model offers a simplified representation of the perception about the complex urban landscape, by capturing and promoting a common language between urban decision makers and stakeholders to get the ideas out of their minds in order to formulate them in a way that everybody understands. Thanks to the shared collective perception between institutions and actors, it is possible to shed light on the bundle of users' sentiments and to expressing them in a more "visible" (i.e. codified and measured) way to help urban decisions makers to communicate and share their understanding of the urban context among them and with the stakeholders. Starting from the value of collective perception, the Fuzzy Cognitive Map supports directly the manager by showing summary tables regarding the intensity of the different areas of interventions.

Moreover, based on the mechanisms of feedback and homeostasis, the decision-maker can verify the ongoing congruity of the operations of governance implemented within the urban context by measuring consistency with the program, emphasizing the links between urban policies and the related implementation processes and the congruence of governance. Also, this process can enable the measurement of the consistency of the implemented policies in correlation with the overall land policies (e.g. at regional or national level).

6.4 LIMITATIONS

Even if the results of the study provide some significant insights for theory and practice, the work shows some limitations, which may affect the generalizability of the model.

A considerable limit of this research is the number of reviews which compose the sample and the non-normal distribution of the reviews for each Point of Interest selected. This choice has been conducted in accordance with the adoption of the Lynch's model: in fact, based on the conceptual model, it is important to consider also some POIs which, although characterized by a limitated number of reviews, can influence the value of collective perception.

Another limit is related to the type of technique used to collect and analyse data. In fact, beyond the advantages offered by big data analysis (primarily the possibility of analysing a huge amount of data in real time), ABSA is characterized by a certain superficiality, since it does not allow going deep into the understanding of people's opinions (Ciasullo et al., 2018). In fact, although the sample is particularly large (a huge amount of reviews extracted in a period span of 12 months), the automated collection of people's comments has prevented from performing an in-depth analysis of users' thought.

In this regard, another structural limitation concerns the possibility that the textual analysis does not examine the reviews correctly because of sarcasm. In this direction, research is developing further advancements in order to detect the "sarcastic sentiment" (Rajadesingan et al., 2015; Bamman and Smith, 2015).

6.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Thanks to the adoption of a constructivist approach and the shaping of a viable model for the urban decision-making process, this study offers some interesting insights, even if it can be improved especially regarding the methodological framework adopted. In fact, the work follows a very innovative approach which cn be considered, however, only as a first exploratory step and that can be improved and refined in further works.

Firstly, it can be interesting to define a more sophisticated aggregation function, in order to carry out an ABSA with greater precision.

Also, this work could be improved by providing a weight to the user's review depending on the level of user activity. This attempt can allow guaranteeing more reliable information.

In this direction, to strengthen the results of the case studies carried out, it can be very thought-provoking to compare the results obtained from Tripadvisor.com with the results

obtained from other social networks. This comparation can be reinforce the results obtained and can ensure greater consistency of the results for supporting the decision maker in a more accurate way.

Another interesting aspect could be the use of qualitative approach (such as in-depth interviews) to assess the collective perception of a city or of its assets: the obtained results can be compared with the finding from the decision-making model based on the IT tools defined in this dissertation.

Finally, some improvements can be carried out also to measure the degree of context consonance reached. In fact, it would be of great interest both from a managerial and theoretical point of view to integrate into the defined model a possible evaluation of the levels of consonance and resonance obtained, in order to provide the decision maker with information on the effectiveness of the territorial policies implemented, in a virtuous circle aimed at the pursuit of survival in the considered context. For instance, once evaluated the interventions which will be carried out based the opinion of users, these can be compared with the institutions' opinion, in order to understand if there is consonance between the systems intended as the ability of mutual understanding. After that, monitoring the change of opinion while the institutions implement the define policies, it is possible to understand if there is an increase or decrease of the consonance level: if there is a major alignment between governing body and context actors' then the resonance creates an acceleration of the consonance levels during the systems' interaction. In this way, a sharing of trust, objectives and strategies, accompanied by membership, tuning and a progressive attenuation of structural boundaries- due to the openness degree between urban governing body and social actors- create a new inclusive vision of the city (Golinelli, 2000).

6.6 CONCLUSIONS

In line with the results obtained, and with the related implications of the study, it can be concluded that the 4.0 technologies, including big data and new information technologies, are promising to bring new value creation opportunities across all major sectors. However, there are few models and processes designed to think systemically. In this direction, this work aims to offer a valid support to decision-making, by proposing community-shared evaluations regarding urban landscapes and scenario analysis which underline how collective perception affects other important urban issues and how, changing the collective perception through targeted interventions, the urban context will react.

Today's complex context requires the ability of the decision maker to have more and

more awareness about the context. In fact, the modern information environment appears able to accelerate the processes of enrichment of the information variety, by acting on the dimensions and the characteristics of which it is constituted (Barile et al., 2015), in particular on the levels of the information units and of interpretative schemes.

Lastly, the reinterpretation of the city as a viable system, performed thanks to the adoption of research techniques such as ABSA and FCM, which contributes to increase the awareness of the links that bind each entity in a network (Capra, 1997), arises from the need to rethink the approach for the analysis and resolution of problems related to the governance of any system, especially considering a multi-stakeholder and multi-dimensional entity such as the urban context. The variety of expectations, perspectives and interests present in the context of reference of urban systems is the origin of the typical problems linked to the governance of the territory. In this direction, the proposal of a model able to support the decision-making process of the urban governing body allows the overcoming of the traditional perspective, focused exclusively on the physicality of its structural components, by shifting the emphasis on the interactions between the systemic components and on the key concepts of consonance and resonance, central in the decision-making process. This change of perspective underlines the broader and more general vision of the city viability.

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Appendix

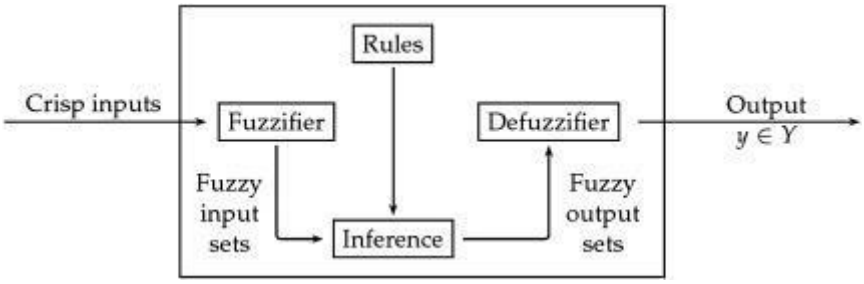
Domain knowledge: Fuzzy Inference System and Fuzzy Cognitive Map

The domain knowledge d consists of: a set of *if then* rules to evaluate the collective perception of an area, and the formalization of cause-effect relationships among different concepts of urban planning. The first is referring to the Fuzzy Inference System (FIS), the second is based on a scenario analysis through a Fuzzy Cognitive Map (FCM).

Basically, a FIS is a system that uses fuzzy set theory (Zadeh, 1965) to process the inputs in outputs: based on "*IF…THEN*" rules with connectors "*OR*" or "*AND*" can infer decision rules. A typical FIS, shown in Figure 1, consists of the following blocks:

- Fuzzifier that converts the crisp quantities into fuzzy quantities;
- Defuzzifier that performs the inverse operation;
- Rules that contain the domain knowledge in terms of if-then rules;
- Inference engine that performs operations on rules.

Figure 1. FIS – An example of Fuzzy Inference System

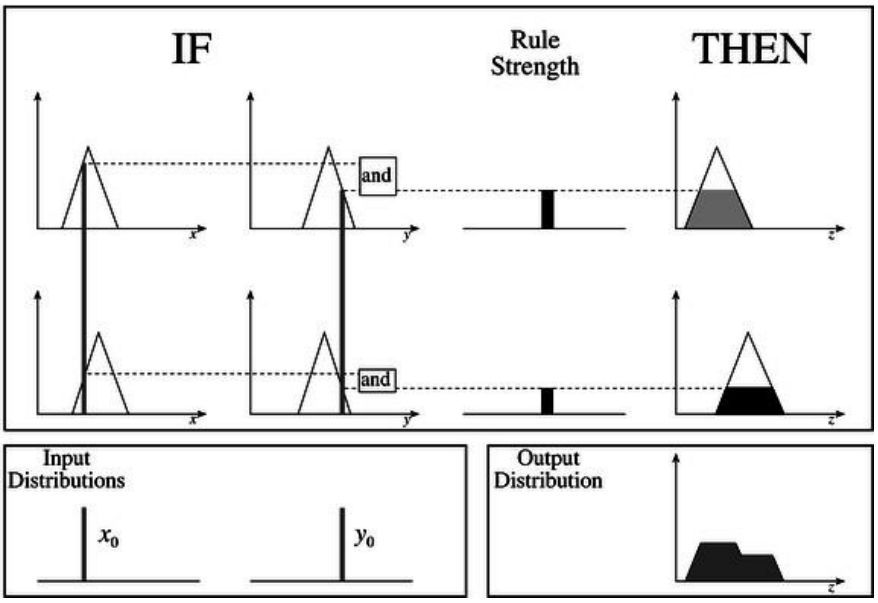


Source: Hossain (2018)

The most adopted FIS is Mamdani type (Mamdani and Assilian, 1975). In particular, regarding this type of FIS, the output of each rule is a fuzzy set derived from the output membership function and the implication method of the FIS. A Mamdani type FIS is intuitive, and presents an interpretable rule base: these advantages motivate its adoption. To clarify how a Mamdani FIS works it is possible to refer to Figure 4.9 which shows the behaviour of a two input FIS with a two rules base. To compute the output the FIS fuzzyfies the inputs using well-defined input membership functions, combines the fuzzified inputs according to the fuzzy rules to establish a rule strength, and finds the consequence part of the rule by combining the rule strength and the output membership

function, lastly it defuzzifies the output.

Figure 2. Two input, two rules basing on Mandani type



Source:https://www.cs.princeton.edu/courses/archive/fall07/cos436/HIDDEN/Knapp/fuzzy004.htm

The FIS adopted for our evaluation works as described above (Figure 3).

The rules block contains the domain knowledge. For our evaluation, the set of rules are extracted from D'Aniello et al. (2018) and reported in Figure X. Indeed, there are nine rules, in the "if…then" form, combining degrees of positivity (P), objectivity (O) and negativity (N) to infer an overall value of Collective Perception (CP) for an area under investigation. The subset of useful rules includes rules with a low level of objectivity in order to evaluate the collective perception. In particular, H (High), L (Low), M (Medium) are fuzzy labels for the three input variables while VP (Very Positive), P (Positive), N (Neutral), B (Bad), VB (Very Bad) are fuzzy labels for the output variable.

Figure 3. Rules set from

	P	O	N	CP
R1	H	L	L	VP
R2	H	L	M	P
R3	H	L	H	N
R4	M	L	L	P
R5	M	L	M	N
R6	M	L	H	B
R7	L	L	L	N
R8	L	L	M	B
R9	L	L	H	VB

Source: D'Aniello et al. (2018)

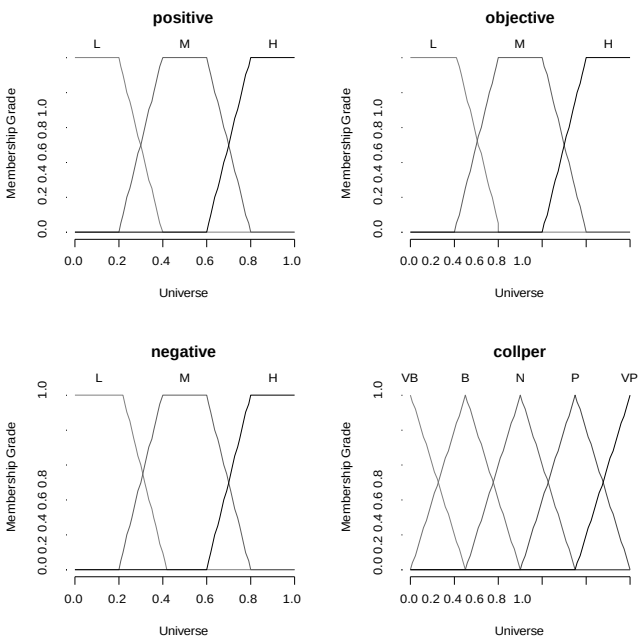
Just as example, the rule 1 (R1) should be reading as follows:

R1: if P is H and O is L and N is L then CP is VP

It means that if the perceived degree of positivity correlated to an area is high, and the perceived degree of objectivity is low, and perceived degree of negativity is low, it is possible to infer that the collective perception of the area is very positive.

Furthermore, the membership functions are the ones defined in D'Aniello et al. and shown in the Figure 4.

Figure 4. Input and Output membership functions



Source: D'Aniello et al. (2018)

Therefore, the inferred value of CP is defuzzified and used as activation level of a concept of the FCM, discussed in the 4.4 Paragraph.

In this way it is possible to carry out the what if analysis in terms of cause-effect relationships among concepts of urban governance.