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ANALYZING SMART CITY DEVELOPMENT THROUGH AN EVOLUTIONARY APPROACH

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ANALYZING SMART CITY DEVELOPMENT THROUGH AN EVOLUTIONARY APPROACH

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RESUMO

As cidades sempre foram locais onde as economias de aglomeração atingiram seus maiores rendimentos, produzindo benefícios culturais, econômicos e sociais sendo o principal locus de empreendedorismo e inovação. No entanto, a rápida urbanização criou muitos problemas como desigualdade, poluição, doenças, insegurança e assim por diante, que acabam por restringir a dinâmica de criação de valor no século XXI. Isso está desafiando as "cidades industriais" a repensar e remodelar suas estruturas para superar esses problemas. Nesse sentido, o modelo de 'cidade inteligente' tem ganhado destaque no desenvolvimento urbano. Muitas cidades de diferentes países estão desenhando estratégias e implementando-as por meio de iniciativas e projetos para o desenvolvimento de cidades inteligentes. Nota-se que essas experiências são idiossincráticas, pois as cidades são inerentemente diferentes e possuem questões diversas que devem ser resolvidas de forma particular. A primeira questão que surge é: como tornar uma cidade mais inteligente? Apesar da visão contrastante dos frameworks e de sua multiplicidade de dimensões e abordagens, a literatura aponta que as cidades devem ter elementos específicos para induzir processos de inovação por meio de soluções digitais e da colaboração entre stakeholders para enfrentar os desafios locais e, assim, aumentar a competitividade local e qualidade de vida. No entanto, não é uma tarefa fácil e envolve um conjunto de stakeholders que podem não estar dispostos a colaborar e promover o desenvolvimento de cidades inteligentes. De fato, as principais dificuldades de uma estratégia surgem durante a fase de implementação, pois muitos dos desafios para as cidades se tornarem ou serem inteligentes excedem o escopo e as capacidades de suas atuais organizações, arranjos institucionais e estruturas de governança. Com efeito, a falta de formações estruturais e organizativas adequadas não favorece o envolvimento dos atores locais e dificulta a organização e coordenação das diferentes atividades necessárias para alcançar um desenvolvimento urbano sustentável. Então, a segunda questão que surge é: que tipo de organização pode fomentar o desenvolvimento de cidades inteligentes? Nesse sentido, a literatura lança luz sobre a necessidade de discutir modelos alternativos de governança para superar esses desafios, combinando apoio político e social com planejamento estratégico e pensamento criativo para lidar com a complexidade da cidade inteligente. Alguns autores apontam que é necessário criar uma organização dedicada a liderar a colaboração entre as partes interessadas neste processo de transformação urbana. A partir dessa discussão, o que parece claro é que a análise do processo de desenvolvimento de uma smart city em suas diferentes dimensões e unidades de análise demanda um embasamento teórico que permita à academia e à indústria captar a dinâmica da evolução e, assim, compreender como as smart cities mudam com o tempo. É preciso incorporar teorias e conceitos que considerem não apenas a noção de espaço-tempo, mas principalmente que se aprofundem em como as relações entre os elementos do ecossistema interagem e se complementam. Então, nossa terceira pergunta é: como analisar esse processo de desenvolvimento urbano dinâmico, dependente do contexto e de longo prazo para que uma cidade se torne mais inteligente? Alguns autores apontam a possibilidade de uma aproximação teórica entre a abordagem evolutiva e a literatura de cidades inteligentes, afirmando que devido à complexidade do desenvolvimento de cidades inteligentes, o planejamento de cidades inteligentes também é moldado por processos evolutivos. Assim, é necessário incorporar a noção de evolução nos processos de transformação urbana e que eles ocorram em uma determinada localização geográfica sendo condicionados por fatores contextuais locais. Como

mencionado anteriormente, as cidades são inerentemente diferentes e têm problemas diferentes. Assim, medir o nível de desenvolvimento existente é crucial para prever os passos certos para aumentar a inteligência urbana. A inteligência deve ser vista como um continuum, no qual as partes interessadas podem implementar iniciativas para criar, melhorar ou alterar os elementos da cidade inteligente nessas diferentes dimensões da cidade. A noção de smartness pode ajudar as cidades a entender como esse processo de transformação urbana afeta suas dimensões e seu desempenho e, consequentemente, analisar o que deve ser feito para acelerá-lo. Nesse sentido, é importante que as cidades avaliem seu atual estágio de desenvolvimento. A avaliação do desenvolvimento de cidades inteligentes pode trazer múltiplos benefícios para diferentes partes interessadas. Permite identificar os pontos fortes e fracos da cidade, comparar cidades, monitorar e acompanhar a implementação de projetos, aumentar a transparência nos investimentos, possibilitar a formulação de políticas com base em evidências, aumentar a conscientização do cidadão e assim por diante. A quarta questão que surge é: como medir a inteligência de uma cidade? Em termos de avaliação de cidades inteligentes, muitos acadêmicos, organizações e empresas desenvolveram índices, kits de ferramentas e benchmarking para medir e classificar cidades inteligentes. Esses esquemas de avaliação podem fornecer uma boa visão geral sobre as características da cidade e seus pontos fortes e fracos, além de serem usados para mostrar sua posição competitiva. No entanto, a maioria deles negligencia os múltiplos processos inter-relacionados relacionados ao desenvolvimento da cidade inteligente, adotando uma abordagem somativa. Essa abordagem apresenta algumas limitações que não capturam adequadamente a inteligência de uma cidade. Considerando isso, os objetivos deste estudo são (1) identificar as dimensões e os elementos impulsionadores para tornar uma cidade mais inteligente, (2) entender o papel da organização dedicada a cidades inteligentes na governança de cidades inteligentes, (3) propor uma abordagem evolutiva framework para a análise do desenvolvimento de cidades inteligentes e (4) criar um modelo para medir a inteligência de uma cidade usando diferentes métodos, considerando o tipo de dados, sua manipulação e análise. Para atingir esses objetivos, a pesquisa se concentrou em entender o conceito de cidades inteligentes e que seu desenvolvimento depende de um processo não linear, que deve seguir algumas etapas como desenhar estratégias, implementá-las por meio de projetos para resolver os problemas urbanos atuais. Para isso, o estabelecimento de uma estrutura de governança é crucial para o sucesso do desenvolvimento de cidades inteligentes, pois é necessária a colaboração para criar soluções complexas e a legitimidade de uma visão. Portanto, uma organização dedicada é importante para articular as partes interessadas e impulsionar o desenvolvimento de projetos e iniciativas. No entanto, apenas redes colaborativas não resolverão os problemas urbanos per se. Deve ser identificado como criar, melhorar, mudar os elementos das dimensões hard e soft de uma cidade (ou seja, econômica, social, ambiental). É importante destacar que uma estratégia, projeto ou solução inteligente para ser inteligente de fato deve considerar que essas dimensões estão integradas e então afetam e são afetadas umas pelas outras. Além disso, é necessário incorporar neste discurso de planejamento e gestão urbana a noção de tempo e espaço, pois eventos passados podem afetar o atual estágio de desenvolvimento e as decisões presentes impactarão o futuro da cidade. Como processo evolutivo, cada cidade certamente seguirá caminhos diferentes, pois a dinâmica de seu desenvolvimento depende de como o (eco)sistema se configura e qual é o seu nível de inteligência. Também deve ser considerada a história da cidade e seu contexto para definir estratégias e projetos mais assertivos. Assim, para a análise do desenvolvimento de cidades inteligentes, é necessário aplicar um quadro evolutivo capaz de vincular o micro-

comportamento aos macroprocessos que ocorrem em cada território ao longo do tempo. Ao considerar o desenvolvimento de cidades inteligentes como um processo que muda o ambiente urbana e o comportamento dos stakeholders ao longo do tempo, há a necessidade de medir como isso está de fato ajudando (ou não) o desempenho urbano e como as cidades podem alcançar um desenvolvimento sustentável em uma forma mais eficiente. Este artigo tem como foco a mensuração da inteligência de um ecossistema de inovação urbana, pois fornece uma visão geral do estágio atual de desenvolvimento e a relação entre os elementos e dimensões, o que poderá orientar os formuladores de políticas e a sociedade sobre o que investir, como projetar uma estratégia abrangente e quando implementá-la.

Palavras-chave: cidade inteligente; desenvolvimento urbano; governança; evolucionário; inteligência.

ABSTRACT

Cities have always been places where agglomeration economies attained their highest yields, producing cultural, economic, and social benefits being the main locus of entrepreneurship and innovation. However, rapid urbanization created many problems such as inequality, pollution, diseases, insecurity and so on, that end up restraining the dynamic of value creation in 21st century. This is challenging 'industrial cities' to rethink and to reshape their structures to overcome these issues. In this sense, the 'smart city' model has gained prominence in urban development. Many cities from different countries are designing strategies and implementing them through initiatives and projects towards smart city development. It is noted that these experiences are idiosyncratic, because cities are inherently different and have different issues that must be solved in a particular way. The first question that arise is: how to make a city smarter? Despite the contrasting view of frameworks and their multitude of dimensions and approaches, the literature points out that cities must have specific elements to induce innovation processes through digital solutions and the collaboration between stakeholders in order to address local challenges and, thus, increase local competitiveness and quality of life. However, it does not an easy task and involves a set of stakeholders that may not prone to collaborate and to promote smart city development. In fact, the main difficulties of a strategy emerge during the implementation phase, because many of the challenges for cities to become or to be smart exceed the scope and capabilities of their current organizations, institutional arrangements, and governance structures. Indeed, the lack of appropriate structural and organizational formations does not foster the involvement of local stakeholders and makes it difficult to organize and coordinate the different activities needed to achieve sustainable urban development. Then, the second question that emerge is: what kind of organization can foster smart city development? In this sense, the literature sheds light on the need to discuss alternative governance models to overcome those challenges by combining political and social support with strategic planning and creative thinking in order to deal with smart city complexity. Some authors point out that it is necessary to create a dedicated organization to lead the collaboration between those stakeholders in this process of urban transformation. From that discussion, what seems clear is that the analysis of the development process of a smart city in its different dimensions and units of analysis demands a theoretical background that enables academia and industry to capture the dynamics of evolution and, therefore, understand how smart cities change over time. It is necessary to incorporate theories and concepts that consider not only the notion of space-time, but especially that delve into how the relationships between the elements of the ecosystem interact and complement each other. Then, our third question is: how to analyze this dynamic, context-dependent, long-term process of urban development so that a city becomes smarter? Some authors point out the possibility of a theoretical approximation between evolutionary approach and smart city literature affirming that due to complexity of smart city development, smart city planning is shaped by evolutionary processes too. Thus, it is necessary to incorporate the notion of evolution in the processes of urban transformation and that they occur in a certain geographical location being conditioned by local contextual factors. As aforementioned, cities are inherently different and have different issues. Thus, to measure the existing level of development is crucial to foresee the right steps to enhance urban smartness. Smartness should be seen as a continuum, in which stakeholders may implement initiatives to create, improve or alter smart city elements across those different city dimensions. The notion of smartness may help cities to understand how this process of urban transformation affects their dimensions and their performance, and, consequently, analyze what should be done to accelerate it. In this sense, it is important that cities assess their current stage of development. The assessment of smart city development may bring multiple benefits for different stakeholders. It enables the identification of city strengths and weaknesses, comparison among cities, monitoring and

tracking projects implementation, increasing transparency on investments, enabling to make policies based on evidences, enhancing citizen awareness, and so on. The fourth question that emerges is: how to measure the smartness of a city? In terms of smart city assessment, many scholars, organizations and companies have developed indexes, toolkits, and benchmarking to measure and rank smart cities. These assessments schemes may provide a good overview about the city's characteristics and both its strengths and weaknesses, as well as being used to showcase its competitive position. However, most of them neglect the multiple interrelated processes related to the smart city development by adopting a summative approach. This approach presents some limitations that do not properly capture the smartness of a city. Considering that, the objectives of this study are to (1) identify the dimensions and the driving elements to make a city smarter, (2) to understand the role of smart city dedicated organization on smart city governance, (3) to propose an evolutionary framework for the analysis of smart city development and (4) to create a model to measure the smartness of a city using different methods, considering the type of data, its manipulation and analysis. To achieve these objectives, the research focused on understanding the concept of smart cities and that their development depends on a non-linear process, which should make some steps like designing strategies, implementing them through projects to solve the current urban issues. For that, the establishment of a governance structure is crucial to smart city development succeed since collaboration is needed to create complex solutions and the legitimacy of a vision. Therefore, a dedicated organization is important to articulate the stakeholders and boost the development of projects and initiatives. However, just collaborative networks will not solve the urban issues per se. It should be identified how to create, improve, change the elements from the hard and soft dimensions of a city (i.e., economy, social, environment). It is important to highlight that a smart strategy, project, or solution to be smart in fact must consider that these dimensions are integrated and then affect and are affected by each other. In addition, it is needed to incorporate in this urban planning and management discourse the notion of time and space, because past events can affect the current stage of development and the present decisions will impact future of the city. As an evolutionary process, each city will certainly follow different paths, because the dynamics of its development depends on how the (eco)system is configured and which is his level of smartness. It also should be considered the history of city and its context to define more assertive strategies and projects. Thus, for the analysis of smart city development, it is necessary to apply an evolutionary framework capable to link micro-behavior to macro-processes that occur in each territory over time. By considering smart city development as a process that changes the urban realm and the behavior of stakeholders over time, there is a need to measure how this is in fact helping (or not) the urban performance and, how cities can achieve a sustainable development in a more efficient way. In this study, it focusses on the measurement of smartness of an urban innovation ecosystem, because it provides an overview of the current stage of development and the relationship among the elements and dimensions, which could guide policymakers and the society on what invest, how to design a comprehensive strategy and when to implement it.

Keywords: smart city; urban development; governance; evolutionary; smartness.

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INTRODUCTION

Cities have always been places where agglomeration economies attained their highest yields, producing cultural, economic, and social benefits being the main locus of entrepreneurship and innovation (Glaeser, 2011). They are hubs of knowledge and creativity that provide a set of advantages and opportunities for different stakeholders to sustain their activities and thrive (Belitski & Desai, 2016; Florida et al., 2017; Johnson, 2008; Levenda & Tretter, 2019).

However, rapid urbanization created many problems such as inequality, pollution, diseases, insecurity and so on, that end up restraining the dynamic of value creation in 21st century (Caragliu et al., 2011; Komninos et al., 2019; Neirotti et al., 2014). This is challenging 'industrial cities' to rethink and to reshape their structures to overcome these issues (Boykova et al., 2016; Lim et al., 2019).

In this sense, the 'smart city' model has gained prominence in urban development agenda in the last decades (Mora, Deakin, & Reid, 2019b). In spite of that, smart city still is a fuzzy concept, which imposes a set of constraints on determining the strategies and mechanisms that could accelerate this process of urban transformation (Mora, Deakin, & Reid, 2019a).

This 'fuzziness' is because the concept has evolved from a technocentric perspective into a holistic perspective (Mora et al., 2017). In early studies, smart cities were linked exclusively with the application of information and communication technologies (ICT's) in the urban realm (de Jong et al., 2015; Komninos & Mora, 2018). In counterpoint, many scholars criticized this technology-driven approach, suggesting that other dimensions such as social, institutional, environmental and economic should also be considered in a holistic perspective (Albino et al., 2015; Giffinger et al., 2007; Hollands, 2008; Leydesdorff & Deakin, 2011; Nam & Pardo, 2011; Zygiaris, 2013).

Smart City Development

Many cities from different countries are designing strategies and implementing them through initiatives and projects towards smart city development (Angelidou, 2015, 2017; Caragliu et al., 2011). It is noted that these experiences are idiosyncratic, because cities are inherently different and have different issues that must be solved in a particular way (Dameri et al., 2019; Pancholi et al., 2017; Yigitcanlar et al., 2018). **Then, the first research question that arise is: how to make a city smarter?**

Some frameworks have been proposed to understand this complex process of transformation and help cities on articulating their dimensions in a coherent way (Komninos & Mora, 2018). Despite of their contrasting views and their multitude of dimensions and approaches, these frameworks have in common the notion that this geographical location must have specific elements to induce innovation processes through digital solutions and the collaboration between stakeholders in order to address local challenges and, thus, increase local competitiveness and quality of life (Appio et al., 2019; Camboim et al., 2019; Fernandez-Anez et al., 2018). In short, the smart city is a model to transform and boost the urban innovation ecosystem.

Smart City Development and Governance

However, it does not an easy task and involves a set of stakeholders that may not prone to collaborate and to promote smart city development. In fact, "the main difficulties of a strategy emerge during the implementation phase" (Siokas et al., 2021, p. 3), because "many of the challenges for cities to become or to be smart exceed the scope and capabilities of their current organizations, institutional arrangements, and governance structures" (Ruhlandt, 2018, p. 1). Indeed, the lack of appropriate structural and organizational formations does not foster the involvement of local stakeholders and makes it difficult to organize and coordinate the different activities needed to achieve sustainable urban development (Coletta et al., 2019). **Then, the second research question that emerge is: what kind of organization can foster smart city development? which are the governance characteristics and role of this organization in different contexts?**

In this sense, the literature sheds light on the need to discuss alternative governance models to overcome those challenges by combining political and social support with strategic planning and creative thinking in order to deal with smart city complexity (Boykova et al., 2016; Nesti, 2020; Siokas et al., 2021). The transition from a top-down to a bottom-up approach, the formation of coalitions based on collaboration and the myriad of smart projects under development demand new structures and organizations that will be responsible to coordinate and organize these processes over time (Ooms et al., 2020; Ruhlandt, 2018; Viale Pereira et al., 2017).

Considering different experiences around the world, there is some evidence that a part of the strategy to make a city smarter involves reorganizing existing government structures and introducing new organizational arrangements to provide the future smart city with a better

governance system (Nesti, 2020). Some authors point out that it is necessary to create a dedicated organization to lead the collaboration between those stakeholders in this process of urban transformation (Gianoli & Henkes, 2020; Lee et al., 2014; Ruhlandt, 2018).

These organizational arrangements, the so-called 'smart city dedicated organizations' (Camboim et al., 2019), are created to overcome fragmentation and lack of coordination among municipal units and foster collaboration with other agents (Coletta et al., 2019). They can be created in the initiation phase of smart city development, but some authors pointed out that they might play a more relevant role in the implementation phase (or growth phase) (Ooms et al., 2020). Whatever the best phase, there is clearly an evolutionary process to be taken into account.

Smart City Development and Evolutionary Approach

From that discussion, what seems clear is that the analysis of the development process of a smart city in its different dimensions and units of analysis demands a theoretical background that enables academia and industry to capture the dynamics of evolution and, therefore, understand how smart cities change over time. It is necessary to incorporate theories and concepts that consider not only the notion of space-time, but especially that delve into how the relationships between the elements of the ecosystem interact and complement each other. **Then, our third research question is: how to analyze this dynamic, context-dependent, long-term process of urban development so that a city becomes smarter?**

Komninos et al. (2019) bring out the possibility of a theoretical approximation between evolutionary approach and smart city literature affirming that "due to complexity of smart city development […], smart city planning is shaped by evolutionary processes too" (p. 2). Thus, it is necessary to incorporate the notion of evolution in the processes of urban transformation and that they occur in a certain geographical location being conditioned by local contextual factors (Meijer et al., 2016; Mora, Deakin, & Reid, 2019b; Yigitcanlar et al., 2018).

In this sense, the seminal work of Boschma & Frenken (2006) presents some propositions on how to combine the evolutionary approach in the field of economic geography in order to explain the dynamics of innovation on different spatial scales (e.g., cities, regions, etc.). The Evolutionary Economic Geography (EEG) takes an explicit dynamic perspective, in which capabilities of organizations become central (Dosi et al., 1988; Nelson & Winter, 1982), as well as the co-evolution of them with institutions (Hodgson, 1998; North, 1991). This co-evolution occurs in a systemic way and relies on a set of contextual factors, which determines

and helps to explain the uneven development among territories (Boschma & Martin, 2007; Boschma & Martin, 2013; Martin & Sunley, 2006).

It provides a multiscale perspective through the notion of capabilities (i.e., micro-level) and institutions (i.e., meso-level) that interplay in a certain spatial innovation system (i.e., macro level) in order to explain the uneven development among territories (Boschma & Martin, 2007). This current of thought considers the feedback mechanisms in the different levels of analysis and supports the use of mixed methods, which could help on the experimentation of non-trivial techniques (Boschma & Frenken, 2011).

In this context, the evolutionary approach is the appropriate theoretical background to fill the gaps in the current smart city literature for the analysis of smart city development. It provides enough concepts to understand the interaction among elements, contextual factors, systems and especially their change over time. Consequently, the evolutionary approach can enhance the assessment of smart city development, being useful to capture what are the outputs and outcomes of this process in order to guide the paths, strategies and projects that should be followed.

Smart City Assessment and Smartness

As aforementioned, cities are inherently different and have different issues. Thus, to measure the existing level of development is crucial to foresee the right steps for smartness. "Smartness should be seen as a continuum" (Gil-Garcia et al., 2015, p. 79), in which stakeholders may implement initiatives to create, improve or alter smart city elements across those different city dimensions (Bibri & Krogstie, 2017b). The notion of smartness may help cities to understand how this process of urban transformation affects their dimensions and their performance, and, consequently, analyze what should be done to accelerate it (Gil-Garcia et al., 2016; Manitiu & Pedrini, 2016).

In this sense, it is important that cities assess their current stage of development. The assessment of smart city development may bring multiple benefits for different stakeholders (Caird & Hallett, 2019; Sharifi, 2019). It enables the identification of city strengths and weaknesses, comparison among cities, monitoring and tracking projects implementation, increasing transparency on investments, enabling to make policies based on evidences, enhancing citizen awareness, and so on (Sharifi, 2019).

Smart city development is more likely to occur "in cities that are already endowed with smart characteristics" (Caragliu & del Bo, 2016, p. 667). It means that cities are in

different stages of development where some of them are smarter than others, denoting different 'degrees of smartness' (ben Letaifa, 2015). **The fourth research question that emerges is: how to measure the smartness of a city?**

In terms of smart city assessment, some attempts have been made for this purpose. Many scholars, organizations and companies have developed indexes, toolkits and benchmarking to measure and rank smart cities (Caragliu et al., 2011; Caragliu & del Bo, 2012; Giffinger et al., 2007; Hara et al., 2016; Kourtit et al., 2012; Lazaroiu & Roscia, 2012; Lombardi et al., 2012; Marsal-Llacuna et al., 2015). These assessments schemes may provide a good overview about the city's characteristics and both its strengths and weaknesses, as well as being used to showcase its competitive position (Sharifi, 2020).

However, most of them neglect the multiple interrelated processes of specific resources related to the (smart) city development by adopting a summative approach (Sharifi, 2020). This approach presents some limitations that do not properly capture the smartness of a city (Caird & Hallett, 2019; Castelnovo et al., 2016; Sharifi, 2019).

First, few of them consider that a smart city will 'not be built in a day' or, in other words, a time perspective (Angelidou, 2014; Fernández-Güell et al., 2016). Second, much of them focus on what the city has in terms of resources and assets without considering their interplay (Huovila et al., 2019). Third, metrics are based on a simple, linear input-output logic, which does not allow us to comprehend the dynamics and outcomes of the urban interventions (Ahvenniemi et al., 2017; Huovila et al., 2019). Fourth, few studies look beyond this aggregate level of analysis (i.e., city-level) to assess smart city development, by neglecting those complex interdependent networks of stakeholders of those projects and their evolution over time (Caird & Hallett, 2019; Mora, Deakin, & Reid, 2019b; Mora, Deakin, Reid, et al., 2019). Last but not least, there is a lack of concern on the effects of contextual factors such as morphology, natural resources, history, institutions and stakeholders' capabilities in its own development or, in other words, a micro-spatial perspective (Angelidou, 2014; ben Letaifa, 2015; van den Buuse & Kolk, 2019).

In sum, the current 'assessment schemes' are not enough to evaluate if the city development is succeeding towards a smarter level (Sharifi, 2020). It requires the creation of a new metric in the ecosystem-level that takes into account that each city will follow at some level different development paths (Komninos et al., 2019; Mora, Deakin, & Reid, 2019b).

Considering that, **the objectives of this study are to (1) identify the dimensions and the driving elements to make a city smarter, (2) to understand the role of smart city**

dedicated organization on smart city governance, (3) to propose an evolutionary framework for the analysis of smart city development and (4) to create a model to measure the smartness of a city through the use of different methods, considering the type of data, its manipulation and analysis. By doing so, we expect to help cities on designing more assertive strategies and projects that may lead them on achieving a sustainable development.

The study

To achieve these objectives, the research focused on understanding the concept of smart cities and that their development depends on a non-linear process, which should make some steps like designing a strategy, implementing them through projects to solve the current urban issues. For that, the establishment of a governance structure is crucial to smart city development succeed since collaboration is needed to create complex solutions and the legitimacy of a vision. Therefore, a dedicated organization is important to articulate the stakeholders and boost the development of projects and initiatives.

However, just collaborative networks will not solve the urban issues *per se*. It should be identified how to create, improve, change the elements from the hard and soft dimensions of a city (i.e., economy, social, environment). It is important to highlight that a smart strategy, project or solution to be smart in fact have to consider that these dimensions are integrated and then affect and are affected by each other. In addition, it is needed to incorporate in this urban planning and management discourse the notion of time and space, because past events can affect the current stage of development and the present decisions will impact future of the city.

As an evolutionary process, each city will certainly follow different paths, because the dynamics of its development depends on how the (eco)system is configured and which is his level of smartness. It also should be considered the history of city and its context to define more assertive strategies and projects. Thus, for the analysis of smart city development, it is necessary to create an evolutionary framework capable to link micro-behavior to macro-processes that occur in a given territory over time.

By considering smart city development as a process that changes the urban realm and the behavior of stakeholders over time, there is a need to measure how this is in fact helping (or not) the urban performance and, how cities can achieve a sustainable development in a more efficient way. In this study, it focusses on the measurement of smartness of an urban innovation ecosystem, because it provides an overview of the current stage of development and the

relationship among the elements and dimensions, which could guide policymakers and the society on what invest, how to design a comprehensive strategy and when to implement it.

This PhD dissertation addresses those issues through four sequential papers written from 2018 to 2022 based on an evolutionary, multidimensional, and holistic approach to analyze the transformation of cities towards a smarter level. In this sense, the four papers are presented in a logic sequence to broaden the debate on each of the proposed questions.

The first paper discusses what is a smart city and which are the city dimensions and the driving elements that can make a city smarter; the second paper analyzes the role of smart city dedicated organization in the governance of smart city development; the third paper proposes an evolutionary framework to analyze smart city development, and finally the fourth paper presents and test a model to measure the smartness of an urban innovation ecosystem. Table 1 presents the highlights of each paper.

Table 1. Highlights of the papers of the PhD dissertation

N#	Paper Title	Main objective	Publication
1	Driving Elements to Make Cities Smarter: Evidences from European Projects	The purpose of this paper is to disclose the driving elements that make a city smarter.	Technological Forecasting and Social Change, 142, 154-167. doi.org/10.1016/j.techfore.2018.09.014
2	The Role of Dedicated Organizations in the Governance of Smart City Development: A Multiple Case Study	This paper aims to analyze the structure, tools, and mechanisms of smart city dedicated organizations around the world and to characterize their role in the governance of smart city development.	Early version of the paper has been presented at the IAMOT 2022, Nancy.
3	Towards an Evolutionary Framework for the Analysis of Smart City Development	This paper aims to build an evolutionary framework for the analysis of smart city development.	Early version of the paper has been presented at the R&D Management Conference 2019, Paris.
4	Measuring the Smartness of an Urban Innovation Ecosystem	This paper aims to define the concept of smartness and to build a model to assess its relationship with urban performance.	Submitted to Sustainable Cities and Society

Based on the literature, interviews with experts, and insights from smart cities existing projects (Amsterdam, Barcelona, Lisbon, Vienna), the **first paper** shows that a smart city is an urban innovation ecosystem in which knowledge easily flows from a deliberated interaction and collaboration among different stakeholders to create wealth, supported by a flexible institutional structure, an integrated-participative governance model, a digital-green infrastructure and a functional urban design with diversified amenities and facilities. And, to

become smarter, the cities should upgrade the elements related to their different dimensions, the techno-economic activity, the enviro-urban configuration, and the socio-institutional structures, in an integrated manner, guided by an integrated and comprehensive governance model, by designing strategies and implementing them through projects.

The **second paper** discusses precisely the importance of governance for smart city development to succeed. Due to the difficulties that emerge during the implementation phase in terms of leadership and collaboration, cities may create a dedicated organizational structure to lead the collaboration between stakeholders in this process of urban transformation. This paper aims to analyze the structure, tools, and mechanisms of smart city dedicated organizations around the world and to characterize their role in the governance of smart city development through multiple case studies from European and South American cities. It offers insights on how to structure a new governance model for smart cities development in different contexts and how this dedicated organization can play an important role in the urban innovation ecosystem.

The **third paper** discusses the challenges and needs on defining what theories and concepts can be helpful to comprehend this complex evolutionary urban transformation process. More recently, some scholars have been incorporating the evolutionary approach in the smart city literature as a way to analyze the relation between sustainable urban planning and development. The evolutionary approach provides some concepts to understand the interaction among elements, contextual factors, systems and especially their change over time in a given territory. Considering that, this paper aims to build an evolutionary framework for the analysis of smart city development. It has intertwined the building blocks of evolutionary urban economics with the processes of smart city development, expecting to help cities on designing more assertive strategies and projects that may lead them on achieving a sustainable development.

The **last paper** focuses on defining what are the elements that compose smartness (Ahvenniemi & Huovila, 2020), going beyond the technology dimension by considering also social, environmental, and economic dimensions (Ahvenniemi et al., 2017). It proposes a model to measure the smartness of a city and tests it with data from European cities, which determines the main constructs and the relationship between smartness and urban performance.

After that, the conclusion is presented, highlighting the main findings and contributions for scientific literature and practitioners. Moreover, the limitations and suggestions for future research are discussed.

PAPER 1

DRIVING ELEMENTS TO MAKE CITIES SMARTER: EVIDENCES FROM EUROPEAN PROJECTS[1]

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DRIVING ELEMENTS TO MAKE CITIES SMARTER: EVIDENCES FROM EUROPEAN PROJECTS

ABSTRACT

Industrial cities still maintain structures for a mass production and consumption dynamics, which result in several issues such as unemployment, homeless, traffic jams, pollution, diseases, violence and so on. This urban industrial configuration no longer fits with the value creation principles of the new techno-economic paradigm. In order to overcome this crisis, cities of the future must find suitable trajectories and become smart cities. However, there is no consensus about what really makes a city smarter. What are the elements that a smart city must have in order to offer high quality of life and a prosperous environment for creativity and innovation? This paper aims at disclosing the driving elements that make a city smarter, based on the literature, interviews with experts, and insights from smart cities existing projects (Amsterdam, Barcelona, Lisbon, Vienna). Results show that a smart city is an urban innovation ecosystem in which knowledge easily flows from a deliberated interaction and collaboration among different stakeholders to create wealth, supported by a flexible institutional structure, an integrated-participative governance model, a digital-green infrastructure and a functional urban design with diversified amenities and facilities. We conclude that cities, to become smarter, should upgrade the elements related to their different dimensions, what is the techno-economic activity, the enviro-urban configuration and the socio-institutional structures in an integrated manner, guided by an integrated and comprehensive governance model.

Keywords: smart cities; elements; dimensions; quality of life; innovation.

1. INTRODUCTION

The term “Smart City” has been attracting the attention of many scholars, firms, S&T institutions and governments around the world (Caragliu et al., 2011; Neirotti et al., 2014). The number of publications and projects related to smart city grows exponentially in the last ten years (Lee, Hancock and Hu, 2014; De Jong et al., 2015). However, one should ask: What is a smart city? Why should a city become smarter?

Since Ancient ages, urban agglomerations have been true incentives for settlement, because they bring real gains of concentration by merging population density and geographical proximity (Glaeser, 2011). Moreover, cities stimulate creativity and innovation, reduce transaction costs, provide scale economies, raise firms’ productivity, and enhance quality of life by engendering face-to-face interactions (Florida, 2002; Asheim and Coenen, 2005; Shapiro, 2006; Asheim et al., 2007; Cuberes, 2009; Asheim, Boschma, and Cooke, 2011).

In sum, cities are innate engines for the socioeconomic development (Rogerson, 1999). However, most of them are facing the challenge of overcoming issues such as unemployment, homeless, social inequality, traffic jams, pollution, diseases, and violence (Dodgson and Gann, 2011; Neirotti et al., 2014).

Remarkable is that the triumph of cities and the urban decay are both legacies of the Industrial Revolution (Glaeser, 2011). The astonishing urban growth in the Industrial age transformed small towns into huge metropolises (Skojberg, 1955; Stearns and Bell, 1974; Fujita, Krugman and Venables, 1999). On the one hand, never before in history, people reached so high welfare state (Roser, 2018). On the other hand, cities were not prepared for this rapidly urbanization process. This issue has increased the negative impacts, not only making cities lose their superb gains of proximity and density, but also making them hard places to live (Gil-Garcia, Pardo and Nam, 2015).

Actually, the industrial city model is producing more negative than positive externalities, which hinder cities to thrive and also accelerate their urban decline (Eeckhout, 2004; Dirks and Keeling, 2009). This model no longer fits with the value creation principles of the new techno-economic paradigm (Bell, 1976; Perez, 2004). The creation of wealth in the 21st century flows through the innovation primacy, mostly enabled by knowledge-intensive digital applications widespread by creative and sustainable industries (Freeman and Perez, 1988; Florida, 2014; De Jong et al., 2015; Schwab, 2017).

The new paradigm encompasses a set of assumptions, principles and values, which can foster the emergence of new business models, new industries, new technologies, new market

relations and new society (Florida, 2014; Schwab, 2017). Sustainability, connectivity, mobility, accessibility, transparency, inclusiveness, collaboration, diversity, and meritocracy are in the core of this revolution (Stearns and Bell, 1974; Perez, 2004; Florida, 2014). These characteristics enhance and recover the importance of cities as the major catalysts for socioeconomic development.

The smart city model emerges thus as a well-recommended alternative to cope with those issues and also encompasses the dynamics of the new paradigm in order to redeem the very essence of cities (Yigitcanlar et al., 2010; Neirotti et al., 2014; Angelidou, 2014). It is urgent that industrial cities become smarter.

Despite different definitions, there is no consensus about what really makes a city smarter (Neirotti et al., 2014; Angelidou, 2015; Albino, Berardi and Dangelico, 2015). We understand that the literature has focused too much on discussing definitions and broad dimensions related to smart city concept, without considering the inherent evolutionary process of urban transformation. To go further, we look forward at fulfilling the gap about the different features, especially the driving dimensions' elements, for the transition of the traditional industrial configuration and dynamics of cities into a prosperous urban innovation ecosystem.

Analyzing some empirical evidences of smart cities projects, it is possible to affirm that there is no fully-fledge smart city yet. It is an undergoing process, in which some elements are present in different space-time perspective. We argue that these elements should have specific features that can enhance "the smartness of a city". Then, we should ask which are in fact the key elements that would drive the transition of cities towards a smarter level.

Therefore, **this paper aims at disclosing the driving elements that make a city smarter.**

To reach this objective, we explored the concept of a smart city through a systematic review. The definition of an integrated concept enabled us to draw multidimensional framework that was used to analyze how some projects and initiatives are driving smart city development. Within this work, we expect to help practitioners to enhance the assertiveness of smart city strategies in order to speed up the transformation of industrial cities into smart cities.

The paper is divided into five sections. After this introduction, we discuss about the smart city concept. In the third section, the research method is described. After that, we present and discuss the results. Finally, concluding remarks are exposed.

2. THE IMPORTANCE OF CITIES IN THE NEW TECHNO-ECONOMIC PARADIGM

The discussion about how cities should cope with their chronic issues has become a trending topic (De Jong et al., 2015). There is a sort of consensus that, if cities maintain an industrial configuration, they will perish in the next few years.

The fact is that most of urban issues are intimately connected with an industrial city model driven by mass production and consumption of declining manufacturing industries, which are supported by outdated buildings and infrastructures, stuck institutional frameworks, and a laggard knowledge base (Carter, 2013; Hajkova and Hajek, 2014; Bolívar and Meijer, 2016).

2.1. The New Innovation Process and The Emergence of Innovation Ecosystems

This industrial model does not fit anymore within the new dynamics of innovation. In the new techno-economic paradigm, the innovation process is becoming highly interactive and collaborative, often multidisciplinary and multidirectional, because firms cannot successfully perform research and development (R&D) and innovation activities by their own (Rothwell, 1994; Chesbrough, 2003; 2006; Ritala et al., 2013). Firms and stakeholders establish relationships to develop complex market solutions, based on the application of state-of-art knowledge (Carayannis et al., 2009).

In order to understand this new process, "there has been a succession of attempts to research the systemic dimension of innovation at many different levels of economy and society" (Papaioannou et al., 2009). National, regional and sectoral innovation systems are some of frameworks used to describe, understand and explain how the contextual factors shape and influence the innovation process (Lundvall, 1992; Nelson, 1993; Edquist, 1997; Braczyk, 1998; Cooke and Morgan, 1998; Malerba, 2002; 2004).

More recently, however, it has been argued that this systemic approach does not fully capture the complex dynamics of the process of innovation (Papaioannou et al., 2009; Russell and Smorodinskaya, 2018). The system approach does not explicitly consider the influential process of adaptation, which limits its explanatory power about the "system transformations" (Weber and Truffer, 2017).

To overcome this limitation, the literature highlights the emergence of innovation ecosystem as a new approach, which could help to understand the "interdependency among

different actors, as well as the co-evolution that binds them together over time" (Jackson, 2011; Ritala and Almpanopoulou, 2017).

However, there is a lack of clarity regarding the concept. Although the term 'innovation ecosystem' has become a buzzword, some authors understand that this concept is "a flawed analogy that does not necessarily add much value to the existing literature" (Oh et al., 2016). The term is mentioned in several contexts with different units and scales of analysis (Oh et al., 2016) and have a set of variations such as business ecosystem (Moore, 1993), entrepreneurship ecosystem (Prahalad, 2005; Isenberg, 2010) and knowledge ecosystem (Van der Borgh, Cloodt, and Romme, 2012; Clarysse et al., 2014).

2.2. The City as an Urban Innovation Ecosystem

Within this context, Scaringella and Radziwon (2017) suggest that the literature related to territorial approach would help to strengthen the foundation of the field of ecosystems. Many scholars have been trying to understand (at different levels) how to facilitate these interactions in order to enhance innovation outcomes (Boschma and Frenken, 2006). As a matter of fact, proximity is an essential factor in the dynamic process of innovation, because it brings many economic advantages for all actors involved in this process (Boschma, 2005).

In this sense, the literature reinforces the importance of agglomerations as the locus where these interactions often occur (Storper and Venables, 2004; Boschma and Frenken, 2006). Urban agglomerations concentrate (density) and approximate (proximity) these agents, which facilitate the creation of (formal and tacit) knowledge and the exchange of ideas (Glaeser, 2011).

Considering that, we propose that urban agglomerations (i.e. cities) should be an adequate scale of analysis of innovation ecosystems. Defining the boundaries of an innovation ecosystem could help to clarify the concept and to pave the way for establishing measures to evaluate its performance (Oh et al., 2016; Ritala and Almpanopoulou, 2017).

Camboim (2018) refers to that as "urban innovation ecosystem", where

> "knowledge easily flows from a deliberated interaction and collaboration among different stakeholders (i.e. firms, government, S&T institutions and citizens), supported by a flexible institutional structure, an integrated-participative governance model, a digital-green infrastructure and a functional urban design with diversified amenities and facilities in order to ensure a high quality of life and a prosperous environment for creativity and innovation in the most sustainable way." (p. 31)

In this sense, the major concern lies on how to redeem the inherent city advantages in order to start a new cycle of wealth creation. Thus, there is an emergent need to think in new models to transform cities (Nam & Pardo, 2011; Yigitcanlar et al., 2018). Considering the different city models (De Jong et al., 2015), there are some evidences that the smart city model has been elected as the most appropriated alternative for cities to overcome those issues and at same time leapfrog them into the new paradigm, under the idea of an urban innovation ecosystem (Almirall and Wareham, 2013; Komninos, Pallot and Schaffers, 2013; Zygiaris, 2013; Angelidou, 2014; Zubizarreta et al., 2016).

* * *

However, the term "smart city" does not present a solid definition yet (Komninos and Mora, 2018), which may restrain the model adoption by those industrial cities (Albino et al., 2015). Thus, it is essential first to understand the concept to explore it in practice later on.

3. RESEARCH METHODS

Considering the complexity of the study object and the topic "newness", we did a qualitative research to explore this phenomenon. In order to reach the aim of this paper, the research method was divided in two stages.

First, we performed a systematic literature review in order to clarify the smart city concept and its dimensions, as well as to define its driving elements. After that, we analyzed, through the use of the proposed multidimensional framework, what some cities are doing to become "smarter". These steps are detailed below.

3.1. Systematic Literature Review on Smart Cities

Considering the lack of a solid definition about smart city, we have followed a protocol for systematic review, so that relevant papers on smart city concept could be analyzed. Data gathering criteria included only scientific papers in English published between 1990 and 2016 from Web of Science and Scopus Elsevier databases, which showed up "smart city/smart cities" in their title, abstract and/or keywords. Subject areas related to social sciences, business and management, economics, planning and development, and urban studies were defined, considering the authors' background. Results identified 361 documents in Scopus database and

142 documents in Web of Science database. Subsequently, duplicated works from the initial sample were excluded, remaining 410 papers to be further analyzed.

After that, a new selection was conducted by analyzing the abstracts and introduction according to the following excluding criteria: a) papers that do not present a clear definition of smart city concept; b) papers that discuss only a specific topic in a city (e.g., public transport, security, health, etc.) and try to make a relation with smart city concept; c) papers that only present a technology application in a city (i.e. big data, smart grid, open data, etc.). The final sample had 110 papers. This selection flow was presented in Figure 1.

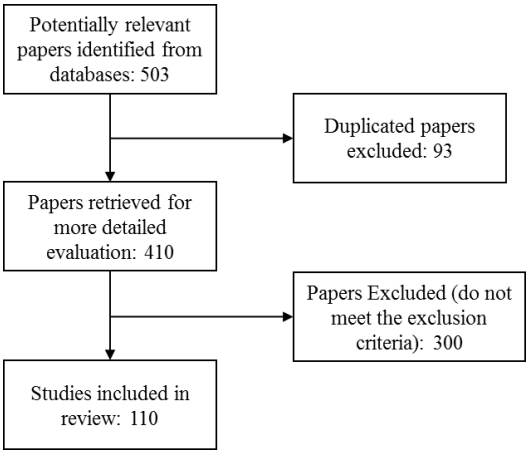

Figure 1 – Systematic Review Flow Diagram

Then, these papers were divided in two groups: 1) most cited papers – citation-based analysis is widely used as a measure of paper quality and means that these papers have already made theoretical/empirical contributions towards knowledge accumulation and development about the theme (Saha et al., 2003); and 2) recent papers – recognizing that the citation-based method may discriminate against recent publications, an additional group from the most recent papers (2014–16) was formed.

The main entry was retained in the first group under consideration, while duplicated entries were eliminated from the subsequent group. Thus, abstracts, introduction, theoretical background and methodological procedures from all selected papers were read in order to extract the main definitions related to the smart city concept. These several definitions were condensed and integrated in a comprehensive definition that required a content analysis in order to clarify some of these concepts.

Considering that, the content analysis was performed following the three stages proposed by Bardin (1977): pre-analysis, exploration, and data treatment. All papers were read in a fluctuant mode and preliminary hypothesis and assumptions were formulated.

Besides that, we extracted the most frequent words from all 110 publications (with the software NVIVO 11) in order to identify which are the composing dimensions of a smart city. Then, it was applied the content analysis technique following the steps proposed by Bardin (2011).

First, it was realized a pre-analysis of those most frequent words in order to understand in which context these words were used. After that, considering the literature review, the most frequent words were codified and grouped into similarity proximity (clustering). This step is based on a dendrogram where words that co-occur are clustered together.

Finally, each group was named following that similarity, enabling us to categorize four smart city dimensions for analysis, presented in Table 3.

3.2. Exploring Smart Cities Projects

After the systematic literature review, we realized that was necessary to illustrate, to refine and, thus, to support the different concepts and elements of each proposed dimension. Thus, we analyzed projects related to smart cities in the European Union website, websites linked to European lighthouse projects, reports from big tech vendors (IBM, SIEMENS, CISCO and so on), reports and forecasts from major consulting firms, plans and projects related to innovation districts, such as 22@ Barcelona and websites from different City Halls. This documental analysis aimed to identify which conceptual definition is applied on public and private projects/initiatives[2] related to smart city around the world.

Some emblematic European cities (Amsterdam, Barcelona, Lisbon, and Vienna) were chosen based on "Mapping smart cities in the EU[3]" (Manville et al., 2014) in order to know more about their smart city initiatives/projects. Six experts who work or have worked in smart city projects/initiatives in each of these cities were interviewed to illustrate the elements and their characteristics (Table 1).

[2] Some studies use the terms "projects" and "initiatives" as synonym, but we understand that an initiative is composed by several projects.

[3] This is a widely used report, commissioned by the European Parliament's Industry Research and Energy Committee, which analyzed different cities in Europe and ranked them according to their smart initiatives.

The experts were chosen based on three main criteria: a) continent – Europe surpassed all stages of the industrialization process and was also one of the first continents to suffer the deindustrialization process. Thus, European cities had to adapt to this process earlier than other cities in the rest of the world and, based on that, there are now several projects funded by the European Union to implement smart city solutions that are already in advanced stages; b) cities – these specific cities figure in the top positions of smart cities ranking of that report ; and c) experts – these experts work/worked in smart city projects or in smart cities initiatives implemented in one of those cities.

Table 1 – Description of Interviewed Experts

City	Expert	Expert Background	Actual Organization	Project/Initiatives involved	Actor
Lisbon, Portugal	Director of the Strategic Planning Department	Geographer and Urbanist	Lisbon City Hall	Municipal Health Development and Quality of Life Plan	Government
Barcelona, Spain	Former Director of Services and Planning and Director of Urbanism at Barcelona City Hall	Architect and Urbanist	Consultancy Firm	22@ Barcelona: Innovation District	Government
Barcelona, Spain	Professor and Architect	Engineering and Architect	Consultancy Firm and University of La Salle Barcelona and	22@ Barcelona: Innovation District (since 2011)	Firm
Vienna, Austria	Coordinator in EU projects related to sustainability	Sustainable Development	Private company	Smart City Wien Agency	Firm
Amsterdam, Netherlands	Professor	Economics	Amsterdam University of Applied Sciences	Smart Entrepreneurial Lab	University
Amsterdam, Netherlands	Project Manager and program developer	Arts and Computer Science	Waag Society (Innovation Lab)	Smart Citizens Lab	People

These experts represent all-important actors that are present in a city (i.e. government, S&T institutions, firms and citizens). Interviews were conducted in Portuguese (Lisbon) and English (Amsterdam, Barcelona and Vienna) based on a semi-structured questionnaire (Appendix I) with questions related to each dimension.

All interviews were recorded and transcribed. This final stage served to confirm with experts the relevance of each element for a city and for specific projects related to smart cities. A qualitative analysis of each interview was performed, highlighting important statements related to each question. Each statement was allocated with the related dimension in order to cross these results with the literature review.

4. THE SMART CITY MODEL: DEFINITIONS AND DIMENSIONS

In this section, we present the results of the systematic literature review that enable us to propose a smart city definition and also to set the dimensions and elements of a smart city. Considering that, we used the four analytical dimensions (i.e., city governance, enviro-urban configuration, socio-institutional structure, techno-economic dynamics) in order to identify which should be the driving elements that can make cities smarter.

4.1. Smart City Definitions

Based on the systematic literature review, we highlight in Table 2 the relevant definitions according to the most-cited and recent papers on smart city concept.

Table 2 – Main ideas regarding Smart City definitions

Author(s)	Definitions
Hollands (2008, p. 315)	"…progressive smart cities must seriously start with people and the **human capital** side of the equation, rather than blindly believing that **IT** itself can automatically transform and improve cities"
Caragliu et al. (2011, p. 70)	"We believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high **quality of life**, with a wise management of natural resources, through participatory governance."
Leydesdorff and Deakin (2011, p. 61)	"Such cities are "smarter" at exploiting **information and communication technologies** and are not only creative or intelligent in generating intellectual capital and creating wealth, but also in selecting environments governing their knowledge production, making them integral parts of emerging innovation systems."
Nam and Pardo (2011, p. 286)	"... a city is smart when investments in **human**/social capital and **ICT** infrastructure fuel **sustainable** growth and enhance a **quality of life**, through participatory governance."
Zygiaris (2013, p. 218)	"Smart city conceptions as "**green**" referring to urban infrastructure for environment protection and reduction of CO2 emission, "interconnected" related to revolution of broadband economy, "intelligent" declaring the capacity to produce added value information from the processing of city's real-time data from sensors and activators, whereas the terms "innovating", "**knowledge**" cities interchangeably refer to the city's ability to raise innovation based on knowledgeable and creative human capital"

Angelidou (2014, S3)	"Smart cities are all urban settlements that make a conscious effort to capitalize on the new Information and Communications Technology (**ICT**) landscape in a strategic way, seeking to achieve prosperity, effectiveness and competitiveness on multiple socio-economic levels."
Lee, Hancock and Hu (2014)	Smart Cities have to consider a global vision to develop and implement a set of policy-mechanisms through an alternative institutional **governance** model to change this scenario.
Neirotti et al. (2014)	Smart City concept goes beyond the focus of **ICT** vendors on digitalization, and also takes into consideration some of the aspects that are related to soft components that have crucial importance on the urban, social and economic development of a city, such as human capital.
Albino, Berardi and Dangelico, (2015, pg. 3;7)	"The smart city concept is no longer limited to the diffusion of ICT, but it looks at **people** and community needs. People are the protagonists of a smart city, who shape it through continuous interactions and the community of a smart city needs to feel the desire to participate and promote a (smart) growth."
De Jong et al. (2015, pg. 34)	"The concept of 'smart city' is also relatively new in origin, although it stems from, or can at least be seen as a more advanced successor to, the older 'information city', 'digital city' and the 'intelligent city' categories (...) The more recent definitions are more comprehensive. Considering an apparent resemblance with the category 'knowledge city', 'smart city' is seen to be the desirable direction for urban development is similar: **information** and **knowledge**-intensive production without high **environmental** impact.
Zubizarreta et al. (2016, 04015005-7)	"Smart cities are not only an aggregation or a merger of some applications, they represent a new cultural idea of cities. **Technology** is a driver, a facilitator for the city development, but if there is not a strategy and a purpose that technology must follow, the risk is disorder."

The citations above-mentioned shed light on the idea of being smart. Smart does not only relate to ICT and technology – it goes beyond. In reality, to be considered a smart city, besides being connected through ICT, the city must provide human capital development opportunities, as a way to foster knowledge and creativity; must deal with sustainability solutions, to cope with the changing urban environment; and must offer, at the end of the day, quality of life to its citizens.

In other words, the essence for becoming a smarter city is that technology should enable the city to reduce transactions costs, human capital to offer new creative solutions over time, and sustainability to reduce negative urbanization impacts. Thus, quality of life becomes a natural consequence of a smart city. Which means that becoming smart can be perceived as a way to reduce the impact related to the issues of typical industrial cities.

As stated by Yigitcanlar et al. (2018), to better conceptualize the term 'smart city', it is necessary first to understand its multidimensionality. Aligned to that, Gil-Garcia, Pardo, & Nam (2015) and Fernandez-Anes, Fernández-Güell and Giffinger (2018), based primarily on the works of Giffinger et al. (2007) and Monzon (2015), perceive smart city as an integrated

and multidimensional system that aims to address urban challenges through a multi-stakeholder partnership.

From this definition, it is possible to affirm that the smart city model comprehends different **social**, **economic**, **urban**, **institutional**, **technological** and **environmental** aspects in a (eco)systemic approach (Hollands, 2008; Nam and Pardo, 2011; Neirotti et al., 2014; Angelidou, 2015). This is the reason why smart city is perceived as an urban innovation ecosystem.

Therefore, we understand that is necessary to define analytical dimensions to ease the understanding of the possible trajectories of any smart city, especially, the interplay of the different ecosystem features of the city.

4.2. Dimension and Elements of the Smart City

The results of the content analysis enable us to identify four dimensions (Table 3) that encompass different elements.

Table 3 – Most Frequent words and categorized dimensions

Frequent Words	Dimensions	Main References
▪ development ▪ governance ▪ planning ▪ management ▪ public services ▪ strategies ▪ policies ▪ initiatives ▪ collaboration ▪ participation ▪ integration ▪ flexibility ▪ data ▪ information	City Governance	(Dodgson and Gann, 2011; Kuk and Jansen, 2011; Herrschel, 2013; Lee, Hancock and Hu, 2014; Vanolo, 2014; Dupont, Morel and Guidat, 2015; Gil-Garcia, Zhang and Puron-Cid, 2016; Castelnovo, Misuraca and Salvodelli, 2016; Bolívar and Meijer, 2016; Dameri and Benevolo, 2016)
▪ design ▪ mobility ▪ digital ▪ infrastructure ▪ urbanization ▪ environment ▪ sustainability	Enviro-Urban Configuration	(Caragliu et al., 2011; Lee, Phall and Lee, 2013; Carter, 2013; Paroutis et al., 2014; Neirotti et al., 2014; Bifulco et al., 2016)
▪ institutional ▪ culture ▪ quality of life ▪ inclusion	Socio-Institutional Structure	(Hollands, 2008; Albino et al., 2015; Capdevila and Zarlenga, 2015; Betz, Partridge and Fallah, 2016; Thomas et al., 2016; Vanolo, 2016)

▪ accessibility ▪ people ▪ social		
▪ entrepreneurship ▪ business ▪ industries ▪ economy ▪ technology ▪ creativity ▪ networking ▪ competitiveness ▪ innovation ▪ knowledge ▪ research ▪ education ▪ human capital	Techno-Economic Dynamics	(Shapiro, 2006; Leydesdorff and Deakin, 2011; Winters, 2011; Bakici, Almirall and Wareham, 2011; Zygiaris, 2013; Kraus, Richter, Papagiannidis, Durst, 2015; Markkula and Kune, 2015)

From this categorization, we assume that every smart city presents four integrated dimensions that encompass different urban elements creating thus an urban innovation ecosystem (Yigitcanlar et al., 2010; Caragliu et al., 2011; Zygiaris, 2013; Neirotti et al., 2014; Camboim, 2018).

Based on the frequent words, we can see that each dimension has a main driver. For instance, words like planning, strategies and policies show that the governance dimension is related to a more strategic driver. Environ-urban dimension is much related to words like mobility, infrastructure and environment, which highlight a focus on tangible assets. The two remaining dimensions, socio-institutional and techno-economic are much more related to community and its internal and external networks, but with different drivers. On the one hand, socio-institutional dimension has a focus on people related issues. On the other hand, the techno-economic dimension is more business-oriented. These four different dimensions were detailed below:

The **governance dimension** of a smart city has a central focus on collaboration between the different stakeholders that actively participate in a collective decision-making process to make or implement public policy or manage public programs or assets (Gil-Garcia, Nam and Pardo, 2015; Castelnovo, Misuraca and Salvodelli, 2016). This dimension also considers the different mechanisms, instruments, and processes (Dameri and Benevolo, 2016) that are used to change the traditional functions of government (Meijer and Bolívar, 2016) in order to adapt city structures into the new paradigm (Gil-Garcia, Zhang and Puron-Cid, 2016). The governance is also important to improve the city administration in order to deliver value to citizens (Gil-Garcia, Nam and Pardo, 2015; Meijer and Bolívar, 2016). The use of technologies

in the government (e-government) should improve public services and also make it more open, transparent and democratic (Bolívar and Meijer, 2016). Aligned to that, smart cities must provide security to citizens, with monitoring cameras, lighting and more police on the streets (Chiodi, 2016), tackle health issues and provide education for all residents (Shapiro, 2006; Winters ,2011; Neirotti et al., 2014).

The **environ-urban dimension** is composed by the built infrastructure, mobility, urban design, facilities and amenities and natural environment (Caragliu et al., 2011; Neirotti et al., 2014; Gil-Garcia, Nam and Pardo, 2015). Focusing on wealth generation, through the attraction of new business, and quality of life of citizens, a city must provide an adequate infrastructure (Caragliu, Del Bo and Nijkamp, 2011). Smart people want to live in cozy smart places; therefore, urban design is a key asset (Salvesen and Renski, 2003; Shapiro, 2006; Miguelez and Moreno, 2014; Betz et al., 2016). Urban amenities and facilities implementation must be conducted towards a sustainable environment, involving the improvement of lighting technology through solar panels and LED, as well as sidewalks, streets, bike paths and integrated urban design roads (Lee, Phaal and Lee, 2013). This dimension stresses the importance of a good urban mobility, which means that a smart city should present multimodal accessibility to ease citizens commuting (Caragliu, Del Bo and Nijkamp, 2011). It is also required to analyze the building potential of existing areas and to propose new uses to them if necessary, as well as to recover them to maintain their attractiveness in the urban landscape.

The **socio-institutional**[4] **dimension** involves elements related to diversity and plurality, civic engagement and social cohesion, and normative-legal framework. This dimension encompasses both formal (i.e. rules, laws and municipal ordinances, etc.) and informal institutions (i.e. partnerships, negotiations, networks) that are arranged in order to solve problems, enforce rules, or allocate resources (Smith et al., 2016). Within a social context, smart cities should stimulate creativity through a culture of flexibility, collaboration and tolerance in order to bring together heterogeneous people (i.e. gender, age, nationality, ethnic, religion and so on) who already experience this dynamic lifestyle (Nam and Pardo, 2011). Culture is extremely related with knowledge economy, because a creative perspective relies on symbolic knowledge that enable cites to change their set of values and assumptions related to a traditional economy (Florida, 2002; 2009). Besides this sociocultural perspective, it is important to consider the importance of citizens and communities in smart city development (Hollands, 2008; Vanolo, 2016). Civic engagement is crucial to legitimize this urban

[4] The term institution here is used as "the rules of the game" (see North, 1990).

transformation within a bottom-up approach, because empowered and participative citizens should give feedbacks for smart cities projects, which may help in improving the place where they live (Capdevila and Zarlenga, 2015; Thomas et al., 2016).

The **techno-economic dimension** of a smart city considers the dynamics of the knowledge economy. This dimension comprehends all aspects that can foster innovation and entrepreneurship activities in a "glocal" perspective (Neirotti et al., 2014). The literature highlights the importance of human capital, science and technology institutions and knowledge intensive firms in order to raise up the knowledge base of a city through intensive-research and education activities (Hajkova and Hajek, 2014; Markkula and Kune, 2015). Besides that, this dimension also encompasses the collaborative networks among various stakeholders that should create competitive advantages for developing a local innovation ecosystem to produce global creative solutions (Leydesdorff and Deakin, 2011; Zygiaris, 2013; Hajkova and Hajek, 2014; Markkula and Kune, 2015). Thus, the startups, accelerators, incubators, technological parks and clusters of innovation should modify the present dynamic, in order to reach a sustainable socioeconomic development (Leydesdorff and Deakin, 2011).

* * *

If we take for granted that the four dimensions are settled over different features, as we have seen above, such details help on better understating the functioning of each one of them. We will define those specific features as the elements of smart city dimensions. Furthermore, dissecting the results from the literature review show us the main elements related to each dimensions of a smart city (see Table 4).

Table 4 – Elements and Features of a Smart City

Dimensions	Elements	Features	Main References
City Governance	Funding and Investments	Proportional and regular investments in infrastructure from public and/or private organizations in order to make the city more functional, to increase the citizens' accessibility of public services and create economic incentives to make city more business-friendly. The city should develop new kinds of revenues and investments (bonds, taxes, interests, subsidies. Either only public, only private or hybrid investments)	Caragliu and Del Bo (2016) Dameri and Benevolo (2016)
	Partnerships	Stimulate alliances, cooperation and partnerships between public and private organizations to increase efficiency, improve quality and diminish bureaucracy of projects	Dupont, Morel and Guidat (2015)
	Dedicated Organizations	Specific and independent organizations formed by different stakeholders aiming at the implementation of the strategic plan through the coordination of smart city projects/initiatives	Lee, Hancock and Hu (2014) Scholl and AlAwadhi (2016)
	E-governance	Established practices of open governance through digital tools in order to enhance transparency, inclusiveness and participation (open data, e-democracy, etc.). Democratic, transparent, inclusive, decentralized but integrated	Lee and Lee (2014)
	Public Services	Web and ICT-based services oriented in a citizen-centric approach, focusing on Health, Security, Transportation, Education, Energy, Sanitation, Waste Management	Cruickshank (2011) Nam, T., & Pardo, T. A. (2014)
	Decision-Making	Future-oriented within a mix of bottom up and top-down strategies that stimulate the community participation on city planning process	Gil-Garcia, Zhang, Puron-Cid (2016)
	Strategic Plan	Define a long-term vision setting some strategies and major transversal objectives driven by a sustainable approach (i.e. resource-efficiency, quality of life and innovation), which should be formulated in a collaborative way	Angelidou (2015) Letaifa (2015)
	Quadruple-Helix Approach	It is easy to make interactions and partnerships between government, industry, universities and society in order to solve the city problems	Leydesdorff and Deakin (2011) Van Waart, Mulder, and de Bont (2016)
	Actions/ Initiatives/ Projects	Projects are based on the strategic plan and have different scope and scale relying on which kind of objective they must achieve within well-defined metrics and indicators to monitor the city development	Neirotti et al. (2014) Letaifa (2015)
Enviro-Urban Configuration	Urban Design	Preserve historical heritage and stimulate the construction of new iconic buildings. Besides that, it seeks urban densification through the balance between workers and residents in order to reduce the urban sprawling and other urban issues.	Chiodi (2016) Roche (2016)
	Innovation Districts	Delimited region of a city that concentrates high-skilled people, high-tech firms and S&T institutions in order to achieve economic growth and social development	Bakici, Almirall, and Wareham (2013)

	Living Labs	Delimited area of a district used to test ideas and technologies	Cosgrave, Arbuthnot and Tryfonas, T. (2013)
	Infrastructure	Deployment of digital and green technologies in infrastructure, such as sensors, meters, smart grids that provide a huge amount of data that can be analyzed in order to make cities more efficient and connected	Carter (2013) Schiller (2016)
	Mobility	Mix of walkable streets and multimodal transportation in order to reduce commuting time and make cities more environmentally-friendly by reducing carbon emissions	Mattoni, Gugliermetti and Bisegna (2015)
	Amenities and Facilities	Provide a wide range of entertainment, culture, and catering venues and green public spaces for leisure, which enhance the quality of life of city inhabitants.	Florida (2002) Shapiro (2006)
	Natural Resources	Balance between preservation and efficient use of natural resources in order to reduce the environmental impact	Herrschel (2013) Bifulco et al. (2016)
Socio-Institutional Structure	Spirit of Community	Engaged community that care about common problems and act together to solve them	Thomas et al. (2016)
	Smart Citizens	Participative citizens that not propose improvements, but also are proactive agents for urban change following their rights and duties	Capdevila and Zarlenga (2015)Vanolo (2016)
	Social and Cultural Plurality	Preserve the local identity while being tolerant to differences on cultural, ethnic, religious and gender orientation.	Nam and Pardo (2011)
	Rule of Law	Trust-based, Formal, Adaptive rules and laws through an efficient legal-normative framework that encompass different interests on win-win situations	Dameri and Benevolo (2016)
	Land Use	Pro-Development of real estate stimulating mix residential and commercial areas and high-rise buildings. It makes city more vibrant, because it is possible to build compact neighborhoods with high-density strategy	Marsal-Llacuna and Lopez-Ibanez (2014) Fernández-Güell et al. (2016)
Techno-Economic Dynamics	Economic Activities	The economy is based on creative and knowledge industries that present a good ratio of startups, knowledge intensive business services and advanced manufacturing firms	Zygiaris (2013) Hajkova and Hajek (2014)
	Human Capital and Entrepreneurship	Presence of young and high-skilled workers that have an entrepreneur mindset	Winters (2011) Miguelez and Moreno (2014)
	Research, Education and Technology	These elements rely on S&T Institutions that should produce the state-of-art knowledge, train people for those knowledge jobs and foster entrepreneurship culture	Markulla and Kune (2015)
	Collaborative Spaces	Presence of spaces for entrepreneurship and innovation such as incubators, accelerators, fab labs, co-workings that should promote collaboration, improve networking and enable the prototyping of goods, enhancing a “maker culture”	March and Ribera-Fumaz (2016)
	Global Business Networks/ Internationalization	Presence of multinational companies and global research centers. Besides that, the local market solutions focus on the global market enabling large export volume of goods with high added value	Angelidou (2014) Hayat (2016)

The categorization of the main elements and their features in each dimension ease our understanding what would really make a city smarter. However, to the best authors' knowledge, there is no empirical study that show how these elements and dimensions interplay with each other. Thus, we tried to empirically illustrate these links through the analysis of some emblematic smart city projects.

5. EVIDENCES FROM EUROPEAN SMART CITY PROJECTS

Considering the results from all interviews and documental analysis, the projects of the four chosen cities were described following their chronological order.

5.1. Describing the Case Studies

5.1.1. Barcelona

In 1999, the Barcelona City Hall decide to start its most emblematic smart city project, which is the 22@ Barcelona – Innovation District. The 22@ Barcelona project involves the transformation of an old industrial district (Poblenou District) into an innovation district, which aims at perform a massive urban refurbishment and achieve an outstanding social and economic revitalization (Pareja-Eastaway, 2015). These three different axes (i.e. urban, social and economic) encompass some strategies that shaped the implementation of several projects (22@ Barcelona Plan).

The refurbishment plan aims at upgrading urban environment in order to improve quality of life and of workplace. It comprehends the construction and improvement of social housing, facilities and green spaces, new mobility model (i.e. mix of walkable streets, exclusive bike and bus lanes, trams and metro lines and so on), advanced infrastructures (i.e. pneumatic waste selection, central heating and cooling, optical fibers and underground galleries of energy and telecommunications).

The social and economic revitalization aims at shifting traditional economic activities into knowledge intensive activities in order to boost local economy and promote better opportunities for new and old habitants. The main strategy was the formation of innovation clusters by attracting knowledge intensive firms and universities linked with Life Science, ICT's, Biotechnology, Energy and Design sectors.

It is important to highlight that this mega project (22@ Barcelona) started with public investments in infrastructure (estimated in €310 millions), but after this, the major investments were spent by private organizations, which were benefited with tax breaks, new rules of land use and financial incentives (Barcelona City Hall, 2017).

The implementation of the plan has been coordinated and carried out by the "Barcelona Activa", since 2000, which is an urban development agency linked to City Hall. This agency offers a set of services and facilities to support local business and entrepreneurial activities, and promotes training programs for workers that are searching for employment (Barcelona Activa, 2017).

5.1.2. Amsterdam

In Europe as well as worldwide, Amsterdam is at the forefront of smart city projects. The city has a long tradition of innovation that makes Amsterdam one of the most prominent ecosystem to start new projects.

In 2009, the Amsterdam Smart City Program was initiated by some public and private organizations that created multi-stakeholder platform, called "Amsterdam Smart City - ASC". This platform was created to address urban challenges through collaboration between diverse stakeholders in order to speed up and facilitate different projects that would benefit quality of life and sustainability in the metropolitan region (Van Winden et al., 2016). The platform takes a broader perspective of smart city projects by also including projects without a strong technology approach. Instead of defining a strategic plan, the city's stakeholders made a joint effort to start the urban transformation of Amsterdam.

The ASC platform has strategic and project partners that have different functions and responsibilities. The latter are involved on the different projects in order to develop innovative urban solutions. The formers compose the board during minimum three-year with renewable commitment to discuss latest concepts, questions and calls for urban issues and pay an annual fee to maintain the staff of ASC organization.

Actually, the ASC organization acts as an enabler and facilitator in this process through the community website "www.amsterdamsmartcity.com", which serves as connector between urban stakeholders that want to start a smart city project with experts that can help its development (Van Winden et al., 2016). Besides that, the strategic partners, such as Amsterdam University of Applied Sciences (AUAS) and Waag Society,

have been developing projects and initiatives in order to make Amsterdam an even more innovative, inclusive and sustainable place.

The Smart Entrepreneurial Lab is a project created by Amsterdam University of Applied Sciences that aims at connecting university and companies to co-create solutions for different urban issues. The college students join in a research project during fourteen weeks, in which they have to solve real problems in practice for a company. In other words, this smart city project provides real experiences for students that prepare and motivate them to solve other urban issues. Besides these problem-solving activities, the university organize some workshops and academic events to discuss about relevant questions related to smart city topics.

The Waag Society perform a different role in this ecosystem. Waag Society is an institute for art, science and technology that explores how emerging technologies (digital, biotech and cognitive sciences) interact with society. It offers multifunctional spaces that are used to realize events, to promote training and to develop experiments and pilot projects that focus on open, fair and inclusive technologies. This institution created the Smart Citizens Lab, which is a project that aims to empower the people in the city by measuring their related-issues, such as water quality, air quality, noise pollution and so on. In this Lab, they can develop integrated solutions for the city by incorporating a citizen-centric approach.

5.1.3. Lisbon

In Lisbon, among the different projects related to smart city, stand out two projects: "Sharing Cities" and “BIP/ZIP Program”.

In 2011, Lisbon City Hall created the “BIP/ZIP” Program, freely translated as “Neighborhoods and Priority Areas of Intervention”. Every year the City Hall supports and funds local activities and projects in specific vulnerable areas that are proposed by residents’ associations, non-governmental organizations, companies and so on. This project aims to foster public-private partnerships, citizen engagement and minor interventions in specific areas in order to strengthen the socio-territorial cohesion in the municipality (Lisbon City Hall, 2017).

The “Sharing Cities” program is a consortium among three lighthouse cities (Lisbon, London and Milan) and other three fellow cities (Bordeaux, Burgas and Warsaw), which started in 2016 and received 24 million euros in European Union

funding. This 5-year project seeks to develop affordable, integrated and commercial-scale smart city solutions with high market potential, such as e-mobility, energy management, smart lamp posts, urban sharing platform, user-centric services and retrofitting of buildings (Sharing Cities, 2016).

This project has been transforming specific areas of each city's district into a "living lab" where different technologies and ideas are co-created and tested. All practices, experiences and results are shared among cities of consortium and the validated smart city solutions are implemented across different European cities.

5.1.4. Vienna

In 2014, the Vienna City Hall launched the Smart City Wien - Framework Strategy, which is a long run term project that aims at transforming the city until 2050 into the most sustainable, livable and innovative place around the world. The framework strategy was developed though multi-stakeholder process that city administration; research institutions, private sector and civil society discussed about what city they want for the future (Smart City Wien, 2017).

In order to achieve the key goal of this project that is "offer optimum quality of living, combined with highest possible resource preservation, for all citizens", it is necessary that all stakeholders work together considering cross-cutting smart city concept (Vienna City Administration, 2014). Then, the main question was: how to bring together stakeholders with different agendas in order to achieve those strategic goals in a multi-sectorial manner?

Considering that, in 2012, the City of Vienna commissioned as part of a service mandate the existing company TINA VIENNA as official Smart City Wien Agency (Tina Vienna, 2017). This agency is an independent company that serves as an external support unit to the local administration in relation of smart cities.

Actually, the Smart City Wien Agency is the main link between all relevant initiatives and programs of the City of Vienna that foster new ways of collaboration in order to implement the Smart City Wien framework strategy. Therefore, the agency's major tasks are connecting people, coordinating groups and establishing governance structures to support the framework implementation at operational, strategic and decision-making level.

Furthermore, the Framework Strategy assumes that individual larger lighthouse projects with an innovative character will contribute to the attainment of key Smart City objectives. Similar to the Lisbon lighthouse project, the City of Vienna is involved in a project called “Smarter Together”. This is a joint project with other lighthouse cities (Munich and Lyon) and other follower cities (Santiago de Compostela, and Venice) and observer cities (Kiev and Yokohama) that focus on finding the right balance between ICT technologies, citizen engagement and institutional governance to improve citizen’s quality of life through smart and inclusive solutions (Smart Together, 2017).

To achieve these goals, it was chosen six neighborhoods in different European countries to experience new ways of adding value in urban societies that encompass urban refurbishments, co-creation process and new sustainable business models. The results will serve to deepen the knowledge in these different fields and will enable a large-scale replication of successful solutions at city level and in other cities.

After describing the projects of each city, it was necessary to make a deepen analysis about which are the relevant elements of a smart city in the view of experts.

5.2. Disclosing the Driving Elements of a Smart City

In further sub-sections, the statements of interviewees are intertwined to the literature, following the four dimensions of a smart city. The goal is to highlight whose of those above mentioned elements of each dimension (Table 4) are, in fact, the driving ones for the selected cities’ projects, towards smarter levels.

5.2.1. City Governance

Reinforcing the results of Angelidou (2014) and Neirotti et al. (2014), the expert in Lisbon said that “cities do not become smart overnight”. A smart city as a model for urban development requires a long-term plan that encompass the identification of issues, the analysis of needs and opportunities, the proposition of improvements, the implementation of these proposed improvements and the measurement of results.

She highlighted that **“strategic plans** involving a mix of top-down and bottom-up approaches are required to tackle social, economic and environmental issues”. This statement confirms what Letaifa (2015) and Mora and Bolici (2015) pointed as the crucial stage for smart city development. Complementarily, an expert in Barcelona mentioned

that the plan for the innovation district 22@ Barcelona could only be implemented due to big amount of financial resources provided by the government and private organizations for **investments**. To enable the operation, changes in the legislation were required, as well as the creation of new models of governance involving a **dedicated organization** – "Barcelona Activa", in that case. The "Barcelona Activa" (which incorporated the agency 22 ARROBA BCN) promoted the implementation and development of strategic content in the new spaces created, integrates both public and private interests, and favors international visibility of new business, scientific, teaching and cultural activities. The agency also acts to strengthen the city's brand in the global scenario in order to bring investments and companies to Barcelona.

The City of Vienna also create its own agency with the function of "breakdown already existing patterns and already existing structures", as said by the expert. The Smart City Wien Agency has also a mandate to foster new ways of collaboration and organize the background behind it, functioning as a fundamental actor in the **decision-making** process. It was mentioned a specific organization to deal with this governance structure that is divided between leaders and supporting actors. They have a steering group with the CEO of the city of Vienna and a group of 15-20 people who are chiefs in different departments like information, economy, housing, energy and mobility. Supporting the steering group, there is a working group just one hierarchical level lower, which meets regularly and monitors systems for implementing several plans related to the "Smart City Wien - Framework Strategy". These evidences illustrate the importance of dedicated organizations as implementors of smart city projects (Lee, Hancock and Hu, 2014).

In Amsterdam, the organization "Amsterdam Smart City Platform" was created to speed up and facilitate initiatives and projects gathering different stakeholders in a **quadruple helix** approach (government, industry, university, and society). It is a social platform where members can develop projects and initiatives, learn new skills, and share experiences.

Among those initiatives, there is the "Smart Entrepreneurial Lab", develop by the Hogeschool Van Amsterdam, which aims to train students in smart city projects, promoting workshops and allocating them to work with real ongoing projects.

Besides that, the city also presents the Waag Society, which is recognized by municipality as an official digital media institute and therefore receives ca. 0.5% of **funding**. Waag Society is an institution in constant and close contact with society, promoting the connection between municipality representatives and citizens. By doing

so, they are able to identify and create solutions to help citizens, offering thus **public services** in a smart way. They also enable **e-governance** to take place, since they focus on a digital and participative culture in the city, trying also to secure that municipalities will make way of the legacy systems, to become a more knowledge partner instead of ICT vendor.

Therefore, they work to bring the idea of service design to municipality as a way to create better, clear, open services for citizens, as pointed out in the studies done by Cruickshank (2011), Lee and Lee (2014), and Nam & Pardo (2014).

In sum, different governance models show some convergent elements. The very first, and present in all projects, is the building and functioning of a governance agency. This body of city stakeholders should embrace both public and private agents, dividing the roles of leaders and supporters. The second element is the existence of a strategic plan to ease the decision-making process on whether investing, changing or recovering. Third is financing. The availability of funding from both public and private sources is crucial for the starting of a city transformation process. Finally, supporting elements, such as digital technologies and platforms for connecting stakeholders and coordinating the different actions are necessary.

5.2.2. Environ-Urban Configuration

Regarding the enviro-urban dimension, Lisbon programs involve urban regeneration projects in vulnerable areas, as well as the focus to establish creative districts in central regions close to universities, retail stores, and entertainment options. Within this context, the plan for the **innovation district** 22@Barcelona also involved regeneration of a delimited area with projects related to new **mobility** alternatives, public spaces renewal, new energy and broadband networks, selective pneumatic waste collection, new heating and cooling systems and underground galleries.

One expert in Barcelona highlighted that the city must be attractive to retain talent far beyond the working hours and, to be so, **urban design** must be detailed planned. In accordance to that, he highlights that planning buildings is essential to cope both real estate agents and citizens' interests. He remarks the importance of a mixed building landscape, which preserve architectonic heritage for new uses and build new iconic sites involving both business and living spaces, so that people can walk around during 24 hours in a day. Moreover, the focus on preservation and efficient use of **natural resources**

should be included on urban plans and building restrictions in order to take advantage from what is already built (e.g., brownfields regeneration).

Besides that, one expert in Barcelona highlighted that cities must be able to deal with technology, in terms of ICT, and that everything must be connected. Thus, as Carter (2013) already highlighted, cities must consider dealing with **infrastructure** in a long-term manner, to set the foundations for the future in terms of optical fiber, water, energy and weather-related issues.

The expert from Lisbon also remarked that cities should offer special public **amenities and facilities** to ensure quality of life, especially in terms of elementary schools, public spaces for interaction, bike parking lots, health equipment and health hubs for hospital and emergence care. Related to that, the expert in Vienna stated that cities should provide all kind of public services that are close to the daily life of people in an integrated way, such as housing, mobility, energy provision, but also environmental protection as the basics needs of resources. Therefore, the efficient use of resources is fundamental to a fast-urban growth.

This dimension has a set of more objective but not less important elements. Urban design, amenities and facilities, the regeneration and recovery of ancient and historical buildings and areas, natural resources and sustainability are the basics to meet the expectations people have in terms of quality of life.

5.2.3. Socio-Institutional Structure

Linking the enviro-urban structure to the social-institutional structure, the expert in Vienna highlighted that mobility and infrastructure must be planned together. She said, “We current have a big Horizon 2020 project implementation project, a lighthouse project called Smart Together that is a collaboration with Munich and Lyon and there is a specific area of Vienna that we are implementing refurbishments and implementing mobility interventions”.

Besides that, the Vienna agency also plans to encompass vulnerable regions due to social and economic segregation. At the Simmering area, for example, they are working to include low-skilled people that live there in the labor pool, by promoting courses and training with civic engagement. Through their perspective, such people have their own social dynamics and must be inserted into the new economy, so that **social and cultural**

plurality is not censured, but stimulated. In this context, Lisbon expert remarked that attracting some people does not need to end up in expelling others.

The expert in Amsterdam also remarked that the social and cultural plurality is stimulated by universities, because these S&T attract many young people. He highlights that "People come here to study and they leave, but have a lot of things to do here, there are lots of entertainment". Aligning entertainment and business interest, young people find in Amsterdam the city to start a company, debating sites and visiting places to get inspiration. The expert in Barcelona stated "it is fundamental to attract young people to city districts, as a way to invigorate the area". These findings show that a mix of demography should help cities to tackle issues related to aging population.

Another important topic highlighted by the expert from Waag Society is that "if you are a smart city, you will make sure your citizens become smart (**smart citizens**)". It does not mean that citizens are "dumb", but now "they are responsible for the city, which more accurately describes the role that everybody like you mean take responsibility about what is happening and become active part". This statement reinforce that cities are mainly made by people (Hollands, 2008; Capdevila and Zarlenga, 2015).

Also, regarding smart citizens and civic engagement, one expert from Amsterdam highlighted that there is growing effort from all institutes to do activities together in terms of arts, startups hubs and co-living spaces. "You could literally visit fifteen meetups every night around the week", as he said. Within this context, he detailed, "The **community** is crucial. Without the community there is no smart city". Therefore, organizations as the previously mentioned Amsterdam Smart City, the Waag Society and Parkhuis de Zwijger are fundamental, since they organize meetups and presentations to discuss about different urban issues.

The expert in Amsterdam also remarked that the city has many young people, because of the universities. "People come here to study and they leave, but have a lot of things to do here, there are lots of entertainment". Aligning entertainment and business interest, young people find in Amsterdam the city to start a company, debating sites and visiting places to get inspiration. Related to that, one expert in Barcelona stated that it is fundamental to attract young people to city districts, as a way to invigorate the area. In this context, Lisbon expert remarked that attracting some people does not need to end up in expelling others. The gentrification process must be avoided.

In that way, Smith (2016) already stressed that the formal and informal institutions can influence the smart city development. as stated by one expert, "the government can

use its **power of law** to gain efficiency and change the local dynamic of living, working and entertaining". For example, the expert from Barcelona suggested that a smart **land use**, coping living and business activities, with mix residential and commercial activities and high-rise buildings should make the city more compact, which could influence the enviro-urban and techno-economic dimensions. These empirical results corroborate with other studies (Marsal-Llacuna and Lopez-Ibanez, 2014; Dameri and Benevolo, 2016; Fernández-Güell et al., 2016).

In sum, the major concern on becoming smarter is to overpass the major socioeconomic issues that the industrial paradigm has left for the traditional cities. The paths of modernization and wealth involve reducing inequalities, poverty, unemployment, homelessness, etc. Not only legal and institutional tools must be employed, but also the creation of a community mindset. Actually, collaboration and consciousness are some of the major building blocks for this new urban paradigm.

5.2.4. Techno-Economic Dynamics

Within the context of techno-economic dimension, universities are seen as important **human capital** source (Shapiro, 2006; Winters, 2011; Markkula and Kune, 2015). The expert who works at a university in Amsterdam stated that there are university spaces being transformed into incubators, so that "students can start a company and fit in our definition of smart city projects". Such students may work together in **partnership with big companies**. He said "we also have CISCO and IBM, they also trying to learn with startups. So every organization is in this vibe. So I think, it is like a mindset". It shows the importance of universities to stimulate an entrepreneurship culture among their students.

In that sense, the expert from Barcelona stated that the universities and young people are the engines of transformation, because they connect research, education and technology. Aligned to that, the expert from the agency in Vienna mentioned that they function as an integrator, but they could not provide all expertise in all fields related to smart city. Therefore, they work connecting people, coordinating and finding the right people to collaborate with – enabling, thus, promising **networks**. To increase these interactions and to create new jobs, the expert in Lisbon informed that there is great interest from companies to transform former industrial buildings into **collaborative**

spaces for innovation such as incubators, accelerators, fab labs, hacker spaces and coworking.

Thus, cities must attract and retain high-qualified economic agents (firms and consumers) by offering the maximization of their utility curves. New endeavor and businesses are the ultimate goal of any emerging smart city.

As a matter of fact, this is the very special way to create wealth and, thus, to overcome all the existing socioeconomic issues, especially by increasing social inclusion through economic inclusion. Knowledge society and technological complexity need cooperation, partnership and complementarity to generate synergy and innovation. It is increasingly harder to work alone and reach excellence. Networks, accelerators, coworking, university-industry interaction are some of the different ways to bring people together in order to establish a new entrepreneurial mindset and to create novelty and new value.

Considering these results, we propose that former industrial cities should follow some guidelines to start their transformation process. The connection among these elements are discussed and detailed in the next section.

6. DISCUSSION

From the results, it is clear that any city that wants to be smarter will have to develop smart city projects following a comprehensive plan. Our proposed major steps for city transformation are similar with the roadmap presented by Mora and Bolici (2015).

6.1 Making Cities Smarter: Transition Steps and the Interplay of Dimensions

We assume that, first, it is necessary to formulate a long-term strategic plan. This plan should contain a broad vision, strategies, policies and goals for the city of the future. Remarkable is that government should not be the unique transformation agent. The government should create an alternative governance model that stimulates the community engagement. This governance model is characterized by an integrated and decentralized management, in which flexible organizations and public-private partnerships are some elements that can help in this transformation process.

After that, the city must start projects with different scale and scope in order to achieve those goals defined in the strategic plan. These projects require leadership, funding, controlling and evaluation. Moreover, the projects will have to consider the remaining different dimensions (i.e., techno-economic, environ-urban and socio-institutional) in order to create more comprehensive and integrated solutions. Those are, in fact, the building blocks of an urban innovation ecosystem that aims at reaching sustainable socioeconomic development.

Figure 2 summarizes the steps throughout a city would be able to become smarter.

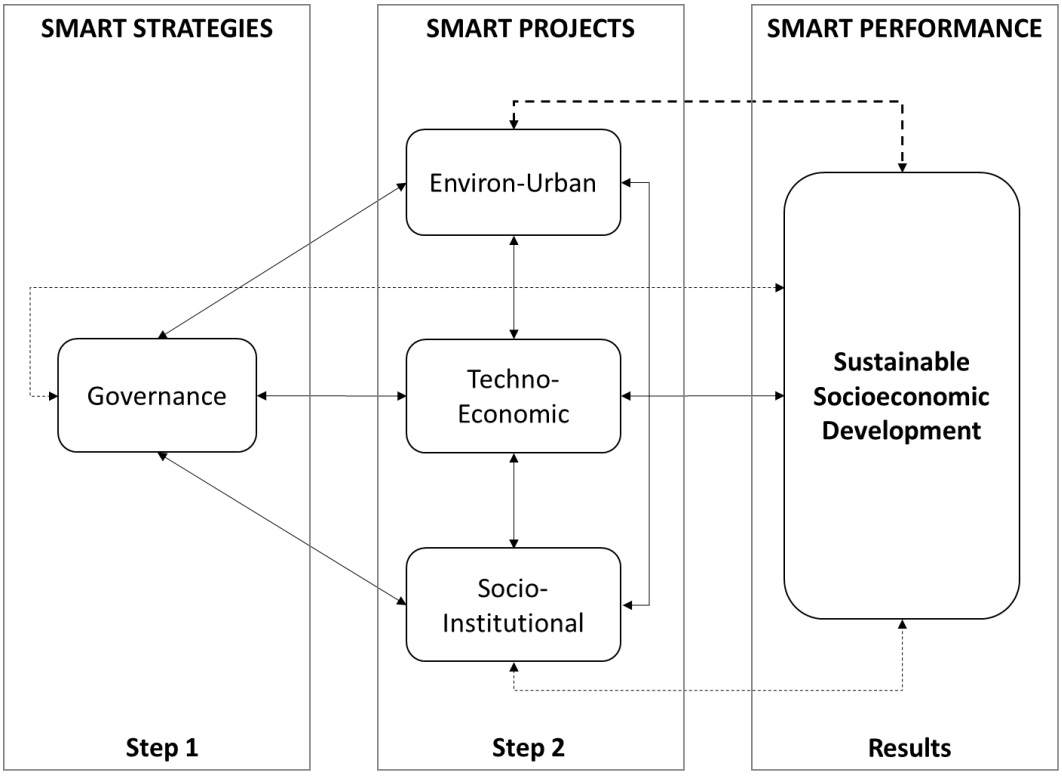

Figure 2 - Integrated Framework for Making a City Smarter

The framework suggests that is necessary to orchestrate all dimensions in an integrated and comprehensive way in order to achieve the goals of any smart city. In that way, the results pointed out that the city governance dimension is a catalyst in this process of transformation. The focus on this dimension is because the industrial city model has a very different way of governance. Weak partnerships, short-term plans, unilateral decision-making processes and high dependence of revenues from taxpayers are some of the differences between the models.

Moreover, we suppose that relationship among dimensions does not follow a linear function, because it should be taken in account the multiplier effects of their correlation. As an example, the improvement in the environ-urban dimension will influence the techno-economic dimension, and vice-versa.

In addition, the city performance measured in terms of quality of life, innovation and sustainability (dependent variable) will have a "rebound effect" in all dimensions. It is assumed that when a city offers high quality of life, it will improve all dimensions of smart city.

Within this integrated approach, it will be possible to disclose some guidelines that cities should follow in order to change their trajectories.

6.2 The Driving Elements of a Smarter City

Again, we highlight that is not possible to define which dimension should be transformed first, because cities are different and have different needs and potentialities.

Despite the difficulty to establish the sequence of smart city projects, the results presented in this study enabled us to identify which elements every city must create, develop or even improve in order to achieve a sustainable socioeconomic development. These key elements, called as "driving elements", are detailed below.

6.2.1 Quadruple-Helix Approach and Dedicated Organizations

Considering the results, we argue that none smart city project will advance if the city does not improve its governance. As previously shown, some cities (Amsterdam, Barcelona, Vienna) started bringing together the most relevant stakeholders in a quadruple-helix approach and creating dedicated organizations to think about the future of city and develop different projects in both top-down and bottom-up approaches following the guidelines of a long-term strategic plan. The use of these different mechanisms could be the best strategy to overcome those several urban issues and to start a new cycle of wealth creation.

Despite this framework suggests that the governance dimension should lead this process of transformation, we highlight that the other dimensions are also very important. As mentioned before, it is necessary to understand a smart city as an integrated model.

6.2.2 Knowledge and Human Capital

From the literature review and the empirical evidences, it is possible to affirm that there is no smart city without knowledge. It means that a city should create a "local" innovation ecosystem, in which knowledge production, diffusion and applications flows easily (Leydesdorff and Deakin, 2011; Zygiaris, 2013). This innovation ecosystem allows the collaboration among actors in a quadruple helix configuration (Carayannis and Campbell, 2009), in which it is possible to develop smart solutions using creativity and knowledge to deal with several urban issues more efficiently. The increase of local knowledge base also fosters the creation of new knowledge intensive and high-tech ventures (Hajkova and Hajek, 2014; Shutters et al., 2016), which create jobs that require highly talented people (Florida, 2002; 2009).

Therefore, cities should also elaborate strategies to attract, retain and bring together high-skilled people, knowledge intensive firms and knowledge institutions in order to compete in the global knowledge economy.

6.2.3 Urban Design, Mobility, Utilities, Amenities and Facilities

To attract and retain people, the city has to offer high living conditions. It is important to provide good and efficient public services, such as health, education, security, but also offer good options for leisure and fun, such as bars, restaurants, museums, parks, gyms and so on. These public services, amenities and facilities should offer alternatives for a safer, greener, happier and healthier city. Cities should also deploy some digital-green technologies (i.e. cameras, sensors, smart grids, solar panels, and smart meters and big data) in their infrastructures in order to reduce criminality, pollution, waste and so on.

In order to enhance their innovation ecosystem, cities can change and improve some other elements related to the environ-urban dimension.

As highlighted in different cases, cities should develop multimodal mobility solutions depending on their size and density where technology could have a crucial role in costs savings and in decreasing commuting time. As matter of fact, there are a lot of solutions and possibilities that would deliver value for the citizens, according to the evaluation of risk and return.

6.2.4 Business-Friendly Environment, Economic Activities, Research, Education and Technology, and Collaborative Spaces

A business-friendly environment can attract and retain people, firms and investments, which are fundamental for economic development. It depends on not only a flexible normative-legal framework, but also on a strong network among the different stakeholders in this ecosystem. Moreover, cities should foster the formation of clusters, startups, venture capitals based on knowledge in order to raise up firms' productivity, workers' salaries, and, consequently, the city's gross domestic product.

The S&T institutions, such as universities, schools, research centers, are even more important for the knowledge economy. These institutions produce basic, intermediate and advanced research, which results in publications, patents, spin-offs and spinouts. They also train high-skilled people to work in those firms or stimulate them to become entrepreneurs.

In addition, cities can stimulate creativity and innovation through the creation of some collaborative spaces, such as fab labs, coworking, incubators, accelerators and so on. A smart city must have different kinds of knowledge sources and spaces to foster innovation.

6.2.5 Innovation Districts

As highlighted by Angelidou (2014), most of smart cities projects present a mix of local strategy for industrial cities (i.e. existing cities) that can focus on hard and soft infrastructure-oriented strategies or on the development of economic activities for entire cities or geographically-based in districts.

Therefore, cities should start implementing their strategies, plans and initiatives in a specific district, because small-scale projects are more viable and likely to succeed (Caragliu and Del Bo, 2016). Emphasis should be placed on regenerating degraded urban areas (Angelidou, 2014), which are characterized as abandoned industrial districts. These areas show an already existing infrastructure that does not require huge investments.

The creation of an innovation district[1] should be a very important stage for every city that wants to be smart. The innovation district can be the location where startups,

[1] Innovation districts can be defined as small pockets in a town or city (Cosgrave et al., 2013) where firms

creative and high-tech firms, universities, research and technological centers should establish their activities in order to develop solutions for global consumers' needs. This process can begin in a point that can sprawl for other city's districts gradually, transforming a city in a cozy place for living, working and entertaining.

6.2.6 Smart Citizens and Spirit of Community

As already mentioned before, it seems clear that a city will only start this transition process, if many citizens (i.e. community) have the willingness to participate actively in public affairs. This should occur when the "smart citizen" must feel being part of city and build together with other citizens solutions to improve the city as a whole. There are different mechanisms that can stimulate this public engagement, such as open data, e-governance and so on.

* * *

In sum, a smart city is a complex ecosystem with an enviro-urban configuration, a socio-institutional structure and a techno-economic dynamic that are governed by interconnected stakeholders in order to create wealth through a comprehensive innovation process.

7. CONCLUDING REMARKS

In the present paper, we identified the driving elements of a smart city, based on the literature, interviews with experts from existing projects related to smart cities and on the proposed conceptual framework, we assume that:

a. Every dimension of a smart city is comprised by different elements.

b. The 'smartness of a city" relies on its elements' specific features.

c. Cities can become smarter through the implementation of smart city projects in order to integrate these specific features into their elements.

In this sense, we conclude that to transform a traditional city into a smart city requires more than willing – good practices are necessary for building, nurturing and

and institutions share common infrastructure and labor market pooling, to take advantages of locally-embedded technologies, production processes, and to reduce transportation and transaction costs (Fujita et al., 1999).

improving those elements. Actually, the challenge to make a city smarter lies on defining how to articulate these driving elements in each dimension properly in order to build up and develop its urban innovation ecosystem.

As presented before in the framework (Figure 2), we argue that the governance dimension takes the lead of transformation process, because it seems clear a city with structured plans can take the reins of its trajectory.

Besides that, some important drivers and values of the 21st century, as collaboration, participation, sustainability, knowledge, creativity and connectivity must be considered in this urban development process to reach a successful smart city plan. The dimensions of a smart city should rely on the integration of technology and processes, which, in turn, help to promote such integration towards a continuous smart growth. By doing so, maintaining a city based on traditional industries is no longer justifiable: the costs of becoming smart are smaller than those related to conserving a traditional city configuration.

Our findings, especially the identification on what make a city smarter, may be of significant practical utility to government entities, policymakers, as well as to business owners. Identifying the driving elements of a smart city could allow cities around the world to evolve towards a sustainable development, by structuring feasible and realistic projects, considering their idiosyncrasies. Thus, the integrated framework proposed here allow as to suggest two major managerial implications. First, the practitioners must have in mind that the city of the future everything is integrated. It is enabled not only because digital technologies, but also because the collaboration among different stakeholders is crucial to develop solutions for the different urban issues. Second, to become smart, cities should have a long-term mindset. The two major steps presented in the framework will only have a real impact in the process of urban transformation, if all stakeholders understand that it takes time for a city to become smarter.

We understand that this study presents limitations. The analysis of European experiences shows some results that could not appear in other experiences around the world. Furthermore, the definition of the smart city concept remains a complex issue within the literature. Although advancing in this definition, our framework needs to be validated with a greater number of examples from different contexts in order to identify if other elements than those identified here may appear.

To help clarify this fuzzy smart city world, we identify the need to, in future studies, set indicators considering the dimensions and elements of a smart city in order to

allow measurement and comparison of the “smartness of cities”. Besides that, we understand that it is necessary to make a deepen analysis of the different smart city projects in a longitudinal approach in order to capture how in fact is occurring the transition process of cities towards a smarter level.

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APPENDIX I - Interview Guide

About the Project

1. When did this project start? Is there any deadline for conclusion?
2. What is/was the main objective of this project?
3. What are/were the solutions that this project is/intends to offer?
4. Is this project linked to a strategic plan?
5. How is/was this project (being) funded?
6. How was the structure of this project to set up?
7. Who are/were the actors that participate(d) in this project?
8. What are/were the results obtained so far? (For actors, for stakeholders and for city)
9. What are/were the main difficulties in implementing this project?

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PAPER 2

THE ROLE OF DEDICATED ORGANIZATIONS IN THE GOVERNANCE OF SMART CITY DEVELOPMENT: A MULTIPLE CASE STUDY[2]

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ABSTRACT

Even before this global pandemic, many cities around the world have been looking for implementation of strategies and projects focused on smart cities development to overcome complex urban issues and move on towards smartness. However, it does not happen instantly and without conflicts of interest. In fact, the main difficulties of a strategy emerge during the implementation phase, because cities present several limitations of governance, capabilities, financing tools and so on. An alternative to solve these issues refers to the creation of a dedicated organizational structure to lead the collaboration between stakeholders in this process of urban transformation. Despite their relevance, there are few studies addressing how these smart city dedicated organizations are constituted and structured, what tools and mechanisms they use and what is their role in the development of different urban innovation ecosystems. The literature is still scarce, especially with evidence from developing countries. Therefore, this paper aims to (1) analyze the structure, tools, and mechanisms of smart city dedicated organizations around the world and (2) to characterize their role in the governance of smart city development. Multiple case studies were conducted based on the documental analysis of websites, reports and official documents and interviews with directors of six smart city dedicated organizations from European and South American cities. From this study, we expect to contribute with propositions and insights on how to structure a new governance model for smart cities development in different contexts.

Keywords: governance, dedicated organization, smart city, development, case studies

1. INTRODUCTION

Cities are renowned for being spaces where human activity meets companies, institutions, and governments that act together to achieve the best solutions for the quality of life and sustainable development of the region (Glaeser, 2011). However, cities have been dealing with a series of challenges that are related to environmental sustainability, mobility, security, education, health issues, and so on (Angelidou, 2015). These challenges are being reinforced by this pandemic, which calls into question the places where we live, work, and entertain (UN, 2020).

It is important to highlight that, even before this global crisis, many cities around the world were already looking for solutions to mitigate urban problems through the implementation of strategies and projects focused on smart cities development (Lim et al., 2019; Mora et al., 2017). Now, with the fast-growing emergence of new technologies, new business models, new patterns of production and consumption, the dynamics of cities are becoming increasingly complex and, therefore, demanding non-trivial solutions capable of guaranteeing a higher quality of life for citizens (Caragliu et al., 2011; Mora et al., 2017; Neirotti et al., 2014). One should ask then: are cities prepared for this inevitable transformation?

As a matter of fact, these technological, economic, social, and environmental factors challenge urban planning and management (Komninos et al., 2019). These smart city initiatives claim that government should foster collaboration among other stakeholders, integrate departments and their activities, increase transparency, and adopt a policy experimentation approach in order to enhance its responsiveness to those complex issues (Bolívar, 2018; Dameri & Benevolo, 2016; Meijer & Bolívar, 2016). There is no doubt that this collaborative process brings a set of advantages for smart city projects to succeed such as reducing costs, sharing risks, enabling complementary assets, enhancing the knowledge base and so forth (Alderete, 2020; Ferraris et al., 2019).

However, it does not happen instantly and without conflicts of interest. In fact, “the main difficulties of a strategy emerge during the implementation phase” (Siokas et al., 2021, p. 3), because “many of the challenges for cities to become or to be smart exceed the scope and capabilities of their current organizations, institutional arrangements, and governance structures” (Ruhlandt, 2018, p. 1). Indeed, the lack of appropriate structural and organizational formations does not foster the involvement of local stakeholders and

makes it difficult to organize and coordinate the different activities needed to achieve sustainable urban development (Coletta et al., 2019).

In this sense, the literature sheds light on the need to discuss alternative governance models to overcome those challenges by combining political and social support with strategic planning and creative thinking (Siokas et al., 2021) in order to deal with smart city complexity (Boykova et al., 2016; Nesti, 2020). The transition from a top-down to a bottom-up approach, the formation of coalitions based on collaboration and the myriad of smart projects under development demand new structures and organizations that will be responsible to coordinate and organize these processes over time (Ooms et al., 2020; Ruhlandt, 2018; Viale Pereira et al., 2017).

Considering different experiences around the world, there is some evidence that a part of the strategy to make a city smarter involves reorganizing existing government structures and introducing new organizational arrangements to provide the smart city with a better governance system (Nesti, 2020). Some authors point out that it is necessary to create a dedicated organizational structure to lead the collaboration between those stakeholders in this process of urban transformation (Gianoli & Henkes, 2020; Lee et al., 2014; Ruhlandt, 2018). These organizational arrangements, the so-called ‘smart city dedicated organizations’ (Camboim et al., 2019), are created to overcome fragmentation and lack of coordination among municipal units and foster collaboration with other agents (Coletta et al., 2019). They can be created in the initiation phase of smart city development, but some authors pointed out that they might play a more relevant role in the implementation phase (or growth phase) (Ooms et al., 2020).

Despite their relevance, studies addressing how these smart cities dedicated organizations are constituted and structured, what tools and mechanisms they use, and what is their role in the development of different urban innovation ecosystems are still scarce, especially evidence from developing countries (Ciasullo et al., 2020; Coletta et al., 2019; Nesti, 2020; Noori et al., 2020; Ooms et al., 2020). It is important to analyze how contextual factors influence the way cities from different countries/continents structure and organize the process of smart city development (Dameri et al., 2019).

In addition, those few studies focus mainly on a single case of a city and use different frameworks for analysis, which may hinder the comparison among different contexts and the identification of what characteristics and capabilities can make a relevant impact on smart city governance. Then, one should ask: Which are the characteristics of

smart city dedicated organizations in different contexts? What is their role in smart city development?

To answer these questions, this paper aims to (1) analyze the characteristics of smart city dedicated organizations and (2) to identify their role in the governance of smart city development. Multiple case studies were conducted based on the documental analysis of websites, reports, and official documents and interviews with directors of 6 smart city dedicated organizations from European and Brazilian cities.

Preliminary results show that these dedicated organizations can be responsible for the promotion of smart city initiatives, coordination and articulation of stakeholders at different scales and levels, the attraction of investments, integration of projects, and so on. They present different organizational structures, play specific roles, have different responsibilities, use different tools and mechanisms, and perform a set of activities that vary depending on the local context. In this sense, these new structures can be categorized along a spectrum, as a continuum of network governance, which encompasses the steering, boundary, alignment, dependency, role of local government and governance models dimensions. From this study, we expect to contribute with propositions and insights on how to structure a new governance model for smart cities development in different contexts.

After this introduction, the main concepts related to smart city development and smart governance are presented. In the third section, the method is described, detailing how the cases were selected and how data were collected and analyzed. In the fourth section, the results are presented, illustrating with empirical evidence how cities are transforming their governance structures for the development of a smarter city. In the fifth section, the role of dedicated organizations in smart cities development are discussed. In the last section, the theoretical and empirical contributions of the studies are presented as well as the limitations and suggestions of future studies.

2. SMART CITY DEVELOPMENT: FROM STRATEGY TO IMPLEMENTATION

For the last decades, many cities in different countries have been undertaking several initiatives towards smart city development (Angelidou, 2015, 2017; Caragliu et al., 2011; Lee et al., 2014). However, there is still no consensus on how this

transformation process should be done, because the nature of smart city development is per se dichotomous, complex and therefore uncertain – which makes each experience context-dependent (ben Letaifa, 2015; Mora, Deakin, & Reid, 2019a; Mora, Deakin, Reid, et al., 2019).

There is a growing body of evidence that these smart city initiatives have been shifting their strategies from a technocentric to a more holistic approach and embracing an integrated intervention logic in their projects (Mora, Deakin, & Reid, 2019b; Mora et al., 2017). Moreover, the literature highlights that it is necessary to bring together different stakeholders to design specific strategies and implement them through projects in order to address local challenges (Fernandez-Anez et al., 2018; Yigitcanlar et al., 2018). The mix of top-down and bottom-up initiatives do not only satisfy the demands of local society for greater participation in public affairs, but also it helps to prioritize and legitimize the smart city projects that must be done (Marsal-Llacuna & Segal, 2016).

To overcome these challenges, it is necessary to combine political and social support with strategic planning and creative thinking in order to govern smart city development (Siokas et al., 2021). Given the high level of uncertainty and complexity of smart city strategies, cities should adopt innovative governance approaches to respond to the changing environment (Gianoli & Palazzolo Henkes, 2020). In other words, for smart city development to succeed, it is necessary to establish a flexible-integrated and inclusive governance model in order to boost this process of urban transformation at different scales (Ciasullo et al., 2020).

2.1. SMART CITY GOVERNANCE: DEFINITIONS AND ELEMENTS

‘Smart city governance’, or just ‘smart governance’, has different definitions depending on the theoretical approach (Ciasullo et al., 2020; Dameri & Benevolo, 2016; Homsy & Warner, 2015; Noori et al., 2020; van Winden, 2008). In a broad sense, the literature highlights that the term ‘smart governance’ refers to an integrated structure of coordination that enables different types of leadership, collaborative decision-making processes, and flexible organizational arrangements in order to foster smart city development (Bolívar, 2018; Castelnovo et al., 2016; de Guimarães et al., 2020; Meijer et al., 2016; Ruhlandt, 2018; Scholl & AlAwadhi, 2016).

For a better understanding of smart city governance, Ruhlandt (2018) performed a systematic literature review, in which the author identified seven components (or elements), namely: 1) Stakeholders; 2) Structures & organizations; 3) Processes; 4) Roles & responsibilities; 5) Technology & data; 6) Legislation & policies; 7) Exchange arrangements.

In that framework, the governance dimension encompasses both formal (rules, laws, municipal laws and territorial policies, etc.) and informal institutions (partnerships, negotiations, networks) that are organized to solve problems, impose rules or allocate resources (Sokolov et al., 2019). This dimension considers the different mechanisms, instruments and processes (Dameri & Benevolo, 2016) that are used to change traditional government functions (Meijer & Bolívar, 2016) to adapt city structures to the new paradigm (Gil-Garcia et al., 2016).

Governance elements have also an impact upon different territorial planning issues (i.e., density strategies, type of planning, government attitude and approaches, etc.), but, in the case of smart cities, connectedness and ICT-based city planning are among the most important (Sokolov et al., 2019). In fact, the use of digital technologies in government (e-government) is important in this process, because the adoption and implementation in different areas may help improving city planning and management, its public services, and making it more open, transparent and democratic through open data platforms (Bolívar & Meijer, 2016; Cruickshank, 2011; Lee et al., 2013; Stratigea et al., 2015)

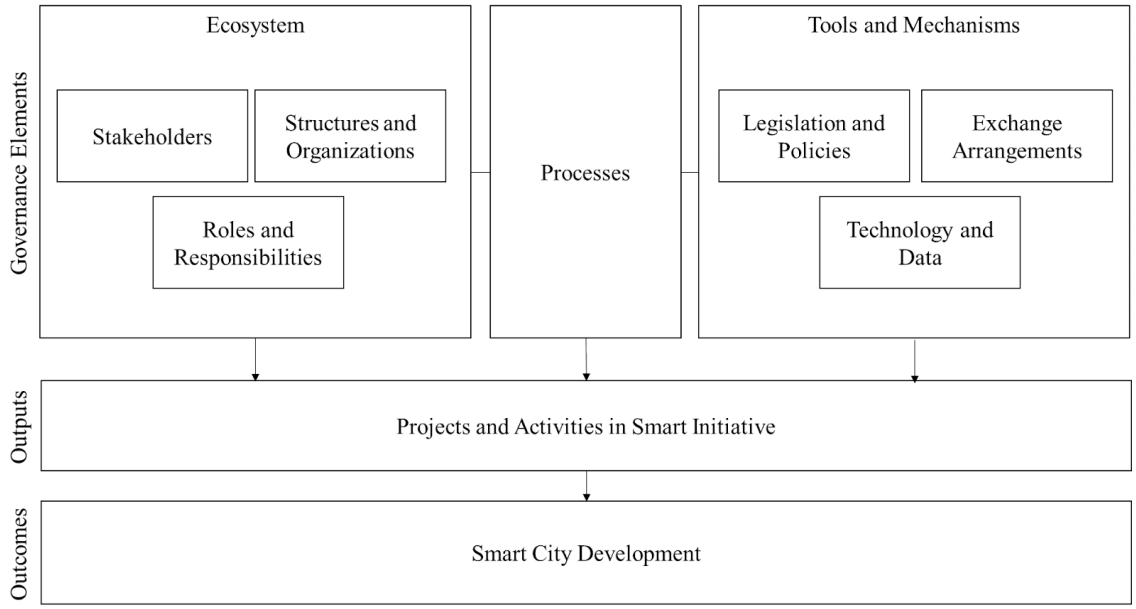
Beyond these technological and legal aspects, it is widespread in literature that smart city governance has a central focus on collaboration among different stakeholders (i.e., government, firms, universities and civil society) who actively participate in a collective decision-making process to design or implement policies or manage programs and assets through smart city projects (Castelnovo et al., 2016; Gil-Garcia et al., 2015). Indeed, these collaborative networks are crucial to define a shared vision of the future and are responsible for developing solutions for different domains of intervention through projects (ben Yahia et al., 2019; Mora, Deakin, Reid, et al., 2019).

In the case of stakeholders and their roles and responsibilities, for example, it is known that each agent plays an important role in smart city development, but it is not known exactly when they have to be part of or how they get involved in this process (Axelsson & Granath, 2018). In fact, the lack of integration between stakeholders and the absence of leadership tend to promote piecemeal initiatives rather than a holistic strategy

implementation (Dowling et al., 2019). In some cases, even when these small-scale initiatives succeed, it is difficult to replicate and upscale the developed solutions in the rest of the city or globally (van Winden & van den Buuse, 2017).

In this sense, governance in smart cities can be viewed as a process that requires collaboration among stakeholders in both strategizing and implementing phases (Fernandez-Anez et al., 2018). It means that those specific governance elements will vary "across the phases of evolution of the smart city ecosystem" (Ooms et al., 2020, p. 1). Consequently, the dynamics of governance challenges may appear throughout the process of smart city development, which is summarized in Figure 1.

Figure 1 – The Dynamics of Governance and Smart City Development



Source: Adapted from Ruthlandt (2018) and Ooms et al. (2020).

In this study, we focus on the micro-level of the urban innovation ecosystem by analyzing the organizations and structures constituted and their roles and responsibilities to foster smart city development through different tools and mechanisms. Regardless of the strategy adopted, the government plays an important role for smart city projects to succeed because it deals with the power of law and has enough legitimacy to change current practices and implement new solutions (Camboim et al., 2019).

In that way, it has been highlighted that the government needs to be engaged with smart city development, be open to collaborate with other stakeholders, and establish a

set of routines, procedures, and institutional arrangements to support these processes (Bolívar, 2018; Meijer & Bolívar, 2016; Tomor et al., 2019). The question that arises is, how can the government deal with this kind of complexity?

2.2. DEVELOPING A SMART CITY: THE NEED OF NEW STRUCTURES AND ORGANIZATIONS

As mentioned before, a part of the strategy to make a city smarter involves reorganizing existing government structures and introducing new organizational arrangements to provide the smart city with a better governance system (Nesti, 2020). These organizational arrangements are created to overcome fragmentation and lack of coordination among municipal units and foster collaboration with other agents (Coletta et al., 2019).

In general, these new organizational arrangements are crystalized in smart city dedicated organizations' (Camboim et al., 2019). These dedicated organizations are responsible for the promotion of smart city initiative, coordination, and articulation of stakeholders at different scales and levels, the attraction of investments, integration of projects and so on (Coletta et al., 2019; Gianoli & Palazzolo Henkes, 2020; Putra & van der Knaap, 2018).

The fact is that these dedicated organizations may present different organizational structures, play specific roles, have different responsibilities, use different tools and mechanisms, and perform a set of activities that vary depending on the local context (Lee, Hancock, & Hu, 2014; Meijer, Gil-Garcia, & Bolívar, 2016). In this sense, these new structures can be categorized along a spectrum, as a continuum of network governance, which encompasses the steering, boundary, alignment, dependency, role of local government and governance models dimensions (Bolívar, 2018). These characteristics and categories are summarized in Table 1.

Table 1 - Governance Structure: Characteristics and Categories

Sub-Dimensions	**Description**	**Categories**
Steering	Steering mechanism refers to how priorities and defining goals are set, which can be performed directly by the local government, jointly with the other stakeholders involved	(1) Local government; (2) Joint steering; (3) Self steering

	into the smart city or self-steering by the stakeholders outside the local government.	
Boundary	The boundary is about determining the scope (i.e., conditions such as mission, resources, capability, responsibility and accountability of the task to be performed) in which the different actors of the network work. It can be set by the government, participatively or exclusively by the other stakeholders	(1) Fixed Boundaries by Local Governments; (2) Jointly set Boundaries; (3) Boundaries set by the parties
Alignment	Alignment refers to how the smart city strategic plan is designed and who is responsible to lead that process. The strategic approach can be top-down, hybrid or bottom-up.	(1) Strategic Planning of Local Governments; (2) Joint alignment; (3) Alignment by the parties
Dependency	Dependency refers to the degree of formality established in relationships among the stakeholders involved in collective action. It characterizes the power dependence of the network.	(1) Formal Dependency; (2) Informal dependency
Roles	The role of local government varies depending on what urban governance approach (i.e., top-down, bottom-up, or hybrid) is adopted and which is the level of engagement in the smart city development. The government can lead the process by promoting initiatives, but also can bring together all actors to collaborate and implement the strategic plan. It also can act as a facilitator through the establishment of rules and access to resources in order to ease the implementation of projects led by different stakeholders.	(1) Commissioner or Executer; (2) Co-producer; (3) Facilitator
Governance model	A governance model can be seen as the way that a smart city development network is managed in terms of decision-making and interventions. The governance models can vary from a more centralized and hierarchical structure to a more collaborative, participative and independent structure.	(1) Bureaucratic Model; (2) Collaborative Model; (3) Participative Model; (4) Self- Governance Model

Source: Based on Bolívar (2018) Bolívar & Meijer (2016) and Meijer et al. (2016)

Despite its great importance for smart city development, these new organizational arrangements have been overlooked in the literature. Few studies shed light on how these smart cities dedicated organizations are constituted and structured, what are their tools and mechanisms and their role in smart city development (Coletta et al., 2019; Gianoli & Palazzolo Henkes, 2020; Michelucci et al., 2016; Ooms et al., 2020). These studies show important findings; however, they focus on single case studies from European cities and

use different methods and levels of analysis that may restrain further comparison and generalizable implications.

In order to fulfill this gap, we analyzed smart city dedicated organizations from different cities around the world through the use of a common framework (Figure 1) and method.

3. METHODOLOGICAL PROCEDURES

In order to analyze the role of dedicated organizations and how they are structured, exploratory descriptive research was conducted. Considering the complexity of the object of this research and the fact that we are discussing a recent theme, we chose the qualitative method of multiple case studies, in order to analyze dedicated organizations from six (6) cities located on different continents. The multi-case study design is adequate to capture contextual factors and can be rapidly adapted to detect changes in the observed phenomena and in the environment (Yin, 2009).

The selection of cities and their smart city organizations was based on international rankings and done through document analysis. Then, some interviews were conducted based on a semi-structured questionnaire with managers of these organizations. After that, data were analyzed in order to understand the role of these organizations in the development of smarter cities. These phases are detailed in the subsections below.

3.1. CASE SELECTION

Case selection was based on three main criteria:

a) continents – we selected two continents namely Europe and South America. Europe was selected because it was one of the first continents that established programs to foster the implementation of smart city solutions through several multi-sectoral projects. South America was chosen because it represents a different approach to smart city development and has different challenges considering some contextual factors (e.g., governance, legislation, culture, investments, etc.) and its own development stage. It is interesting to analyze a country in South America, because initiatives are happening more recently, in order to compare one reality with

another. In South America, Brazil plays a key economic role in the continent and gathers a heterogeneous urban configuration, with diverse problems, management structures and solutions related to smart cities.

b) cities - a document analysis was conducted to identify big cities (more than 1 million habitants) that are developing smart city projects/initiatives across Europe and America. Three (3) European cities (Amsterdam, Barcelona and Vienna) figuring in the top positions of the smart city ranking in a report called "Mapping Smart Cities in the EU" (Manville et al., 2014) and three (3) Brazilian cities (Campinas, Curitiba, and Recife) figuring in the top positions of the smart city national ranking called "Connected Smart Cities 2020" (Urban Systems, 2020) were then chosen. These rankings used different indicators and methodologies that aim to capture the local specificities and other contextual factors that influence the local urban development, which is an adequate criterion for multiple case study design.

c) dedicated organizations - the six cities actually have their dedicated organizations; each one of them was chosen considering its centrality in the urban development process. The websites of these organizations, their organizational structures, institutional reports, and actively participating plans and projects were researched and analyzed. Following this prior review, key members (e.g., coordinators or managers) were contacted for an interview.

3.2. DATA COLLECTION

In the second phase, a total of six (6) managers and/or practitioners working in these dedicated organizations, one for each of these cities, were interviewed between the months of January and March of 2022 (Table 2). Interviews were based on a semi-structured questionnaire (see Appendix A) with questions related to the current literature about governance elements and characteristics of these dedicated organizations.

Table 2 - Analyzed Dedicated Organizations

Region	**City (Country)**	**Dedicated Organization (Website)**	**Established in**	**Interviewees' position**	**Interview Duration**
Europe	Amsterdam (Netherlands)	Smart City Amsterdam (amsterdamsmartcity.com/)	2009	Program Director	52 minutes

Europe	Barcelona (Spain)	Barcelona Activa (www.barcelonactiva.cat/en/home)	1986	Project Manager for Economic Development	51 minutes
Europe	Vienna (Austria)	Smart City Wien Agency (urbaninnovation.at/en/Smart-City-Agency)	2013	Senior Expert Smart City	57 minutes
South America	Campinas (Brazil)	Campinas Municipal Development Company (www.emdec.com.br/)	2021	Director of strategic projects and smart city	40 minutes
South America	Curitiba (Brazil)	Curitiba Agency for Development and Innovation (www.agenciacuritiba.com.br)	2007	President	44 minutes
South America	Recife (Brazil)	Recife Agency for Innovation and Strategy – ARIES (www.aries.org.br)	2014	President	65 minutes

Interviews were carried out in Portuguese (South American cities) and English (European cities) totalizing 309 minutes of primary data. All interviews were recorded and transcribed to allow further analysis.

3.3. DATA ANALYSIS

A qualitative analysis of each interview was conducted, highlighting important statements related to each question in an Excel spreadsheet. Each statement was allocated to the related governance structure characteristics and then compared to the results of the document analysis. This final phase aimed to show what is the role of those dedicated organizations in smart city development considering the opinion of their coordinators or managers. After that, all results were triangulated to establish a relationship between governance elements, characteristics, and capabilities. This step provided a rich analysis of how they could be integrated in order to increase the smartness of a city.

4. DISCLOSING THE CHARACTERISTICS OF DEDICATED ORGANIZATIONS

Considering the results of all interviews and document analysis, it is possible to state that the governance models of cities are organized in different structures and can perform different roles in a smart city ecosystem. These dedicated organizations involve different numbers of stakeholders and have different approaches because structures may or may not be independent of the government. Each case is described below.

4.1. EUROPEAN CITIES

As mentioned before, Europe is a global reference on the topic of smart cities with several examples of well-established initiatives that can provide important insights on how smart city dedicated organizations were structured and developed over time.

4.1.1. Amsterdam

In Europe as well as worldwide, Amsterdam is at the forefront of smart city projects. The city has a long tradition of innovation that makes Amsterdam one of the most prominent ecosystems to launch new projects. In 2009, the Amsterdam Smart City Program was formally initiated by some public and private organizations. It focused in the very beginning in the energy field trying to understand how smart technology and innovation could be used to inspire and engage people in order to speed up the sustainable transition process. It was quite revolutionary that time, since most of the smart city initiatives were totally technology push, which needed to be open and transparent in a citizen-centric way and to empower citizens.

Then, after some years, it started to shift from one project to a couple of projects in different areas, to include more than only two partners and to widen the scope going beyond the city of Amsterdam. It was needed to expand the relationships along the innovation ecosystem. So gradually other themes came like mobility, circular economy and the intervention spatial scale was defined as the Amsterdam region, because it was not possible to solve urban issues only within the boundaries of the city of Amsterdam. Moreover, this program has always been part of an international movement since its very first days enabling many projects to upscale globally.

However, this project-oriented structure increased the level of complexity and required more skills and resources that could jeopardize the achievement of the smart city objectives and goals. Then, around 2017, the ASC shifted from a project management structure to an open multi-stakeholder platform in order to foster a wide-range of projects developed in the ecosystem.

This platform was created to address urban challenges through collaboration between diverse stakeholders in order to speed up and facilitate different projects that would benefit the quality of life and sustainability in the metropolitan region (Gil-Garcia et al., 2016; Tomor et al., 2019). The platform takes a broader perspective of smart city projects by also including projects without a strong technology approach.

The ASC platform has strategic and project partners that have different functions and responsibilities. Some of them are involved in different projects in order to develop innovative urban solutions. The founders compose the board during a minimum three-year with renewable commitment to discuss the latest concepts, questions, and calls for urban issues and pay an annual fee to maintain the staff of the ASC organization.

Actually, the ASC organization acts as an enabler and facilitator in this process through the community website "www.amsterdamsmartcity.com", which serves as a connector between urban stakeholders that want to start a smart city project with experts that can help its development (Gil-Garcia et al., 2016; Tomor et al., 2019). Besides that, the strategic partners, such as Amsterdam University of Applied Sciences (AUAS) and Waag Society, have been developing projects and initiatives in order to make Amsterdam an even more innovative, inclusive, and sustainable place.

4.1.2. Barcelona

Among the different smart city projects being carried out in Barcelona, the most emblematic concerns the creation of the innovation district – 22@ Barcelona. The 22@ Barcelona project involves the transformation of an old industrial district (Poblenou District) into an innovation district, which aims to perform a massive urban refurbishment and achieve an outstanding social and economic revitalization (Pareja-Eastaway, 2015). These three different axes (i.e., urban, social and economic) encompass some strategies that shaped the implementation of several projects. The implementation of the plan has

been coordinated and carried out by the “Barcelona Activa”, since 2000, which is an urban development agency linked to City Hall.

In 1986, Barcelona City Council established Barcelona Activa to respond to the economic crisis at that time. Barcelona Activa started to develop technical and vocational education and training programs for people who were unemployed and helped them to find jobs. In the course of time, companies were not absorbing unemployed people anymore, then the agency realized the need to capacitate these people to become entrepreneurs. With the emergence of digital technologies, Barcelona Activa stands as a public training operator with IT Academy for programs that, in 12 weeks, people can get expertise in this sector.

Actually, the agency focuses on offering a set of services and facilities to support local businesses, new companies and startups, and promoting entrepreneurial activities and training programs for workers in order to foster a more diversified economy (Barcelona Activa, 2017). It represents a substantial change on the objectives and how public administration acts in the ecosystem. Now, it focuses on enhancing not only individual digital competence, but also fostering the digital transformation of businesses, which indicates that government may change its role during this process of transformation.

Working towards greater coordination of the public-private-community ecosystem, Barcelona Activa develops and implements various plans to ensure the city's competitiveness and achieve sustainable socio-economic development. The agency also works to strengthen the city's brand on the global scenario in order to bring investments and businesses to Barcelona.

4.1.3. Vienna

Urban Innovation Vienna is a subsidiary of Wien Holding and the group's innovation hub. With its approximately 75 companies, Wien Holding works to promote the city of Vienna as a center of innovative services and expertise. The Urban Innovation Vienna agency is structured as a limited company but owned by the city of Vienna. So, they are a hybrid solution. Their scope of action in the marketplace is somehow limited not to skew the competition, so about 2/3 of their revenues come from assignments, entities, public sector, or entities of the city of Vienna and 1/3 is acquired or generated in

certain specific B2B, B2C marketplaces. Besides that, the agency has important partners in the city of Vienna.

The Urban Innovation Vienna agency evaluates the development of international cities in the competition of metropolises. Trend scouting allows them to explore what cities and their inhabitants, their economies and mobility might look like in the near future and what are the respective consequences for politics and planning. As a think tank, they search for and find innovative solutions to the key challenges of modern cities.

The main activities involve integration and collaboration between different stakeholders, innovation brokerage, looking for technological future trends, stakeholder communication, running and supporting innovation pipelines, and research projects. Strategic decisions regarding the design and implementation of projects are made by looking into the use case. According to them, a truly smart use case has to understand the true social impact of the technology in the medium and long term. It involves having the right ecological and economical calculations, considering the carbon footprint, collaboration with other cities, developing a management structure, mechanisms and concepts to get it done. In order to get to the decision-making, the organization focuses on having the appropriate data, which highlights the importance of having a monitoring scheme.

They have developed their own Smart City monitoring methodology. Now, a city-wide process for approximately 100-250 stakeholders works together. They gather quantitative and qualitative on Smart City progress in Vienna. The agency highlights the importance of defining indicators, developing a method, aggregating the findings, and making it comparable. In the city of Vienna, that draws on the Vienna Smart City framework strategy, which defines the reduction of carbon emissions or carbon equivalents as of the primary goal. Therefore, the organization considers that their primary indicator.

In order to develop innovative projects and solutions, the agency deals with different types of capital. For the bigger part, the organization works as an intermediary and facilitator. They apply for third-party funding in terms of getting research funding, while also dealing with other funding actors. They closely collaborate with sister organizations, like the Vienna Business Agency.

They have Innovation Labs where they try pre-fund projects and generate impact measurements. For example, they work with a platform for innovative procurement where they try to design processes to bring together the procurement side and innovations - these

are innovative partnerships, where the private sector and stakeholders have some type of guarantee.

In terms of public engagement, the agency perceives that since 2005, the awareness of the general public has risen about urban development and sustainable transformation. While decisions are made based on data, the organization mentions that public awareness and support are important in forming attitudes and conducting political will.

Next steps for the agency involve getting a review of the Smart City Strategy in the short term, since the new government coalition will define even stricter goals, climate neutrality by 2040. Thus, the organization seeks to develop a climate budget process with a participatory budget scheme. According to them, the most pending questions in Vienna encompass: how to provide key infrastructures, like smart grids, park-and-ride infrastructure, mobility as a service platform in order to facilitate all the other innovations. To do so, they argue that monitoring has to be even more developed and done on a regular basis in order to convince investors on the one hand and convince politicians on the other hand.

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Considering the European cases, it is possible to comprehend that each agency was establish to deal with a local issue and to promote activities related to a broader vision of future. It is important to say that over time, these agencies changed their role from executors to facilitators and used their experience and capabilities to improve programs and projects in different areas developed from other stakeholders. These agencies can perform different activities like project management, training and capacity building, research and data analytics, fundraising and networking.

4.2. SOUTH AMERICAN CITIES

Considering the lack of studies in cities from developing countries about governance and dedicated organizations, it was chosen examples from Brazil that have already started initiatives on smart city development and present cities with similar demographic and territorial characteristics to European cases.

4.2.1. Campinas

The city of Campinas, located in the State of São Paulo, was elected in 2020 as the fourth smartest city in Brazil (Ranking Connected Smart Cities, 2020). The City Hall, together with other important actors in the city, has been carrying out some initiatives to revitalize degraded areas, improve infrastructure and public services and invest in technologies, guided by the strategic master plan for smart cities prepared at the end of 2019 (Campinas, 2019). This plan includes the importance of defining an alternative governance model so that in 10 years the city can improve its quality of life and reach a higher level of socioeconomic development. Therefore, the City Hall appointed a management committee that would be responsible for all initiatives to implement solutions aimed at transforming Campinas into a smart city.

Created in 1972, Campinas Municipal Development Company (EMDEC) is a mixed-capital company that was responsible for carrying out official press services in the municipality and promoting the city's socioeconomic, physical-territorial, and administrative planning. However, at the end of the 1980s, it became responsible for executing, directly or indirectly, the services, activities, and functions of the Municipal Transport Department of Campinas-SP.

Currently, the agency carries out the planning and management of traffic and its municipal public transport system. EMDEC’s resources come from transfers from the Municipal Budget; public prices charged for services provided, such as the tariffs for the Municipal Courtyard and Zona Azul; and traffic and transport fines, the revenues of which are applied in accordance with the legislation.

Considering its previous experience and based on the need to implement the strategic plan, the EMDEC, through its Strategic Projects and Smart City Directorate, was created in 2021 and became responsible for working on the design of proposals and projects for smart cities such as the requalification of the rail yard and downtown areas, the implementation of new technologies in the urban environment and in public services and the creation of a Real Estate Fund. The emergence of this Directorate is the first step so that, in the future, Campinas moves towards the implementation of a Development Agency in the municipality, with attributions related to economic, urban, and scientific-technological development.

4.2.2. Curitiba

The city of Curitiba, capital of the State of Paraná, has a long tradition in urban planning and stands out worldwide for its urban mobility initiatives. The City Hall has an intense agenda to support the economic, digital, and sociocultural transformation to consolidate Curitiba as the smartest city in the country and a global reference. At the end of 2021, the capital won the title of smartest city in Latin America. Curitiba's smart city initiatives have mobilized the Curitiba Agency for Development and Innovation, which has, among different attributions, the articulation and promotion of the local entrepreneurship and innovation ecosystem called Vale do Pinhão.

Created at the end of 2007, Curitiba Agency is a mixed capital company linked to the city of Curitiba, which aims to promote, through the execution and support of strategic projects and programs, the sustainable development of economic activities in the city. The agency had signed a contract agreement with the city hall to manage some services and spaces that composes its revenue stream. It also receives funds from private companies to foster open innovation initiatives and to organize events related to smart city development.

Since 2017, the Agency has been strengthening territorial development and innovation actions such as the Vale do Pinhão movement, in which it seeks to qualify the urban environment, make the legislation more flexible and provide tax incentives, improve education with a focus on entrepreneurship, accelerate the digital transformation of the municipality preparing for the new economy and articulating the innovation ecosystem itself. In 2020, it established four work groups with other stakeholders to improve the governance mechanisms, to support innovation activities of companies, to qualify the communication among stakeholders and to establish metrics and monitoring processes.

4.2.3. Recife

In recent years, the city of Recife, home to one of the main technology parks and innovation environments in the country, Porto Digital, has been drawing up together with the population a proposal for a strategy for the future through the Recife Agency for

Innovation and Strategy (ARIES). The Recife 500 Years Plan establishes objectives and goals to be achieved by 2037 and defines 17 strategic paths in the face of the challenges and opportunities identified to achieve better quality of life and social inclusion, qualified urban spaces, and a dynamic economy.

Created in 2014, ARIES is a non-profit social organization that has a management contract with the city hall with the purpose of strategically thinking about the long-term development of Recife, contributing to social inclusion, to reducing inequalities, to the environmental resilience of the city in the face of climate change. The organization has a board of directors made up of 11 people, three from the city hall, one from the State Government and the other seven from civil society, and has a team of 15 people who are allocated per project.

The Recife 500 Years Plan began with the definition of reference parameters and identification of city indicators on the current moment and the desired future for Recife. For this, qualitative research was carried out with interviews with focus groups, quantitative research with questionnaires answered by people throughout the city, and internet research in which more than 5 thousand people participated in the process.

ARIES was responsible for coordinating the participation process and preparing the plan that was delivered in 2019 and currently acts as a "guardian", monitoring and following up on its implementation, carrying out the dialogue with other plans (e.g., land use planning, mobility, early childhood, climate change, etc.), elaborating studies on the city and implementing some priority projects (e.g., Parque Linear Capibaribe, filter gardens nature-based solutions).

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Considering the Brazilian experience, the agencies are much more focused on planning and executing projects, which demonstrates that cities are still starting their "smartization" process. Much of that is leaded or fostered by the government that have to find an organization with more flexibility and autonomy to develop and implement projects. However, when interacting with other stakeholders, these agencies have to overcome some cultural and organizational barriers like lack of trust and reputation, excessive bureaucracy and lack of legal frameworks for urban innovation that may restrain smart city development.

5. THE ROLE OF DEDICATED ORGANIZATIONS IN SMART CITIES DEVELOPMENT

Based on the results, we argue that no project towards smartness in a city will advance unless the city improves its governance. As shown earlier, all cities have begun to bring together the most relevant stakeholders and create dedicated organizations to discuss the city's future and to develop different projects following both bottom-up and top-down approaches based on guidelines of a long-term strategic plan or focusing on one theme or area for development (e.g., economy, energy, mobility, etc.). Table 3 shows the governance elements, dimensions and categories applied to each dedicated organization.

It is important to mention that each organization sets its objectives depending on the needs of the context and is linked to what was the purpose of its creation. Some of them have shifted their strategic focus and, consequently, the activities that they perform because the ecosystem evolved and became more complex over time. For example, Barcelona Activa and Amsterdam Smart City started focusing on projects and initiatives in one sector (i.e., employment and electric energy, respectively) and after some years got involved in projects of different areas.

However, despite being independent in most of the cases, the structure of these organizations is linked in some way to the government structure through a management contract, by being a department of the municipality or a state-owned company, or by participating in the board management of the organization. They are also funded partially or totally by the government through subsidies and public calls, but they are always looking for alternative sources of revenue in order to cover the expenses with the structure and team by doing consultancy services and technical studies, and participating in consortiums of research and applied projects.

Table 3 - Governance Structure Characteristics, and Categories of Dedicated Organizations

Characteristics	Categories	Amsterdam	Barcelona	Vienna	Campinas	Curitiba	Recife
Steering	(1) Local government; (2) Joint steering; (3) Self steering	(2) and (3) Independent Platform organization that connects stakeholders to make Amsterdam better to live	(1) and (2) It is the economic development agency of Barcelona City	(1) and (2): It is a Wien Holding Group owned by the city of Vienna.	(1) It is a municipal state-owned company	(1) e (2) Curitiba Agency is a mixed capital company linked to the city of Curitiba.	(1) and (2): ARIES is a non-profit social organization that has a management contract with the city hall with the purpose of strategically thinking about the long-term development of Recife
Boundary	(1) Fixed Boundaries by Local Governments; (2) Jointly set Boundaries; (3) Boundaries set by the parties	(2) and (3): They are free to develop their program, but discuss with the board members the strategies.	(1) to promote economic development (2022, city approved the amount of 55 million Euros)	(2): Integration and collaboration between different stakeholders, innovation brokerage, looking for technological future trends, stakeholder communication, to run and support innovation pipelines, research projects, limited company.	(1) The government set the boundaries of what should be done and give the subsidies for operation	(2) The government set some boundaries in terms of mission and activities, but the constant interaction with companies is important to gain relevance and secure alternative revenue streams	(2) The agency is independent but has established a management contract with the government. So, they have to accomplish some tasks following the government agenda.
Alignment	(1) Strategic Planning of Local Governments; (2) Joint alignment; (3) Alignment by the parties	(2) and (3) The city doesn't have a unique strategic plan. The vision and development paths are shared and aligned with the stakeholders	(1) and (2) Strategic plan is designed by Barcelona City and implemented by Barcelona Activa	(1) and (2): The city of Vienna draws on the Vienna Smart City framework strategy and that is the primary indicator. For the bigger part, the agency works as intermediaries and facilitators, constantly interacting with stakeholders	(1) and (2) The plan was developed by the government and the agency discuss with other departments what projects should be implemented	(2) The plan for territorial innovation development was elaborated with the participation of several stakeholders that defined strategic areas to boost the innovation ecosystem.	(1), (2) and (3) The agency responded to the demand of the government to think about the future of the city, and organized several workshops and discussions with the society to elaborate a strategic plan with a shared vision.
Dependency	(1) Formal Dependency; (2) Informal dependency	(1) Formal interaction with stakeholders to develop or support projects.	(1) Formal interaction with stakeholders to develop or support projects.	(1) Formal interaction with stakeholders to develop or support projects.	(1) Formal interaction with stakeholders to develop or support projects.	(1) Formal interaction with stakeholders to develop or support projects.	(1) Formal interaction with stakeholders to develop or support projects.

		(2) Informal interaction to foster engagement and promote awareness	(2) Informal interaction to foster engagement and promote awareness	(2) Informal interaction to foster engagement and promote awareness	(2) Informal interaction to foster engagement and promote awareness	(2) Informal interaction to foster engagement and promote awareness	(2) Informal interaction to foster engagement and promote awareness
Roles	(1) Commissioner or Executer; (2) Co-producer; (3) Facilitator	(3) but sometimes (2): The shift from a project-driven to a platform organization, enhanced their role as intermediaries and facilitators. Sometimes they participate in consortiums for research and applied projects.	(1) but also (2) and (3) - Barcelona city defines the budget and the strategies; Barcelona Activa promotes the strategies by defining and implementing the projects.	(3) but also (1) and (2): Mostly, intermediaries and facilitators. The agency also applies for third-party funding in terms of getting research funding, to projects by themselves. They are in the early stage of the innovation pipeline. Innovation Labs. Innovative partnerships. Where the private sector and stakeholder has some type of guarantee. Close collaboration with sister organizations, like the Vienna business agency.	(2) but sometimes (1): Within the scope of projects and execution of short-term activities. Seeking resources, bringing solutions to other departments. Project guidelines follow the master plan.	(1) and (2) but sometimes (3): They articulate within public management all the actions that make sense for one of these pillars, both economic development, urban development and sustainability. They are part of working groups. They manage these coworking spaces, manage the city's entrepreneurial spaces to serve MEIs and small businesses; and manage programs to bring startups closer to investors.	(1) e (2): ARIES is an important actor that is leading the development, but it cannot execute everything. So they are deciding to focus on a specific area and coordinate the projects in other areas with other partners.
Governance model	(1) Bureaucratic Model; (2) Collaborative Model; (3) Participative Model; (4) Self-Governance Model	(4) They are independent, but make part of Amsterdam Economic Board	(3) The most strategic decision-making is hierarchical (approved by the Board), but interventions are more participative.	(2)/(4): Decisions are made looking at the use case and impact indicators. Smart City monitoring. People vote on certain decisions, but factual decisions are mainly carried out by the agency based on data.	(1) and (2:) Hierarchical for Strategic Decision-making and collaborative with other secretaries (public agents)	(2) It is a flexible and autonomous organization that interacts with government and other stakeholders to validate their activities and projects.	(2) It is a flexible organization that has autonomy to decide what to focus on, but the strategic decisions depend on political approval. It is regulated by the Municipal Law for Social Organizations.

The results show that the role of dedicated organizations vary depending on their context and degree of maturity of the process of smart city development. The organizations from Europe already have overcome the barriers of legitimacy and relevance in the ecosystem. They act much more as facilitators and co-producers delegating the tasks of design and implementation to other partners. In contrast, the organizations from Brazil are still testing and validating their role in the local ecosystem by focusing much more on executing projects and studies to start the process of urban transformation. It means that the coordination structure itself also demonstrates an evolutionary process.

All organizations reported that they establish formal relationships with strategic partners and have informal interactions through participation in specific groups and matchmaking potential partners. The use of these different mechanisms may be the best strategy to overcome the most varied urban problems and enable the beginning of a wealth creation cycle.

The governance model in Europe has a more bottom-up approach when compared to the more top-down approach in Brazil, which ends up influencing the predominant role played by the agency. Therefore, it is important that the smart city agency finds a balance depending on its context aiming to achieve an integrated governance model and supportive structures to lead this urban transformation process.

6. CONCLUDING REMARKS

In the present paper, based on the results of interviews and document analysis, it was possible to identify different roles of dedicated organizations in smart cities development. Transforming the traditional city into a smart city requires more than willingness - good practices and structures are crucial to building, nurturing and enhancing the different elements that can drive the urban ecosystem of urban innovation.

Considering the degree of smartness of each city, dedicated organizations from Europe have a different strategic focus and play different roles when compared with those from Brazil. The government and its dedicated organization are important in both contexts, but they decrease their central role as executors and became facilitators or co-producers as the city becomes smarter. In developing countries such as Brazil that still present major inequalities, the government still has a preponderant role in the ecosystem

and has to spend a great number of resources to solve different kinds of (basic) problems ("middle-income trap"). It is important to highlight that dedicated organizations in Brazilian cities still are in their infancy. However, analyzing from an evolutionary perspective, if we consider how it happened in other more advanced countries, it is possible to infer that they will reach a higher stage following some similar strategies and changing their role over time.

Our findings may be of significant practical utility to government entities and policy makers. Identifying the role of dedicated organizations and understanding how they interact with other actors will assist in structuring a local governance model that considers the idiosyncrasies of each experience. In all cases these organizations have a high level of integration and seek to foster collaboration between different agents for the construction of plans and projects as well as their implementation. This collaboration is enabled by digital technologies, which facilitate the development of solutions to different urban problems. In addition, these organizations allow long-term planning because they have greater legitimacy and some autonomy to think about the city of the future.

This study also presents some limitations. The analysis of European and Brazilian experiences shows some results that could not appear in other parts of the world. In addition, this study focuses on the micro-level of the urban innovation ecosystem, dealing with local governance, but it does not consider the national mode of governance. Therefore, there is a need to replicate this study in different contexts in order to identify whether the role of dedicated organizations is similar and to identify the main barriers to their establishment.

In future studies, therefore, it is necessary to carry out more interviews with organizations in other countries in Latin America, as well as in other continents. It would also be interesting to conduct an in-depth analysis of different organizations linked to smart city initiatives in a longitudinal approach, in order to capture how the city governance transition process is taking place. To address this limitation, it could be conducted a comparative study between local governance and integrating the more global framework of each country.

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APPENDIX A

General Information and Governance Model

1. When and how did this organization start?
2. What are the organization's objectives?
3. What are the main activities performed by the organization?
4. How is the organization funded and administered?
5. How are strategic decisions made regarding the design and implementation of projects?
6. Which are the main tools (i.e. (digital) technology) and mechanisms (i.e., legislation and policies, exchange arrangements) used by this organization to plan and manage smart city development? Does the organization have autonomy to use/implement that?

Roles and Responsibilities

1. Which is the level of involvement of this organization in the design of smart city strategic plan?
2. How do you interact with the stakeholders that participate in this initiative? Are these relationships formal (or informal)?
3. Who is leading the implementation of smart city projects? How much is the organization involved in this process?
4. How has the community been engaged and responded to the smart city initiative?
5. What are/were the main difficulties through this implementation process faced by the organization?

Impact on the Smart City Development

1. What are/were the results obtained so far?
2. How do you measure it?
3. Which are the next steps?

PAPER 3

TOWARDS AN EVOLUTIONARY FRAMEWORK FOR THE ANALYSIS OF SMART CITY DEVELOPMENT

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ABSTRACT

The ‘smart city’ model has gained prominence in the urban development agenda as an alternative for tackling the challenges of the twenty-first century. However, there is no consensus yet on how this transformation process should be done because cities are inherently different and in different stages of development, implying different issues that must be solved in a particular way. In fact, the nature of smart city development is per se dichotomous, complex and, thus, uncertain, which makes each experience context-dependent and systemically different. It poses several challenges in defining what theories and concepts can help comprehend this complex urban transformation process. To bridge this gap, the evolutionary approach has started penetrating smart city literature to analyze the relationship between sustainable urban planning and development. The evolutionary approach provides some concepts to shed light on the interaction between elements, contextual factors, systems, and especially their change over time in a given territory. Given this context, this paper aimed to build an evolutionary framework for analyzing smart city development. We intertwined the building blocks of evolutionary urban economics with the processes of smart city development, expecting to help cities design more assertive strategies and projects that may lead them to achieve sustainable development.

Keywords: smart city; urban development; evolutionary approach; assessment; framework.

1. INTRODUCTION

This paper sought to build an evolutionary framework to analyze smart city development; the ‘smart city’ model has gained prominence in the urban development agenda in recent decades (Mora et al., 2019b). Despite this growing interest, there is no consensus yet about what a smart city is and how it is possible to make cities smarter (Komninos & Mora, 2018; Lim et al., 2019). The term ‘smart city’ is often linked with the use of digital technologies to solve urban challenges because this idea’s main promotors and diffusers were giant IT enterprises (Hollands, 2015).

Since Giffinger’s et al. (2007) work, there has been a current of thought proposing that a smart city can be understood as an integrated model divided into different dimensions with several elements that can be enhanced over time in order to dynamize the innovation ecosystem (Appio et al., 2019; Camboim et al., 2019). We define a smart city as an urban innovation ecosystem that aims to ease the knowledge flux through the collaboration of different stakeholders to co-create smart solutions for the city dimensions and, consequently, ensure a higher quality of life and a prosperous environment for creativity and innovation in the most sustainable way.

For that, “cities have begun to propose strategic responses whose objective is to reorganize the functioning and evolutionary processes” (Mora et al., 2020, p. 2) of their urban (eco)systems (Mora et al., 2020, p. 2). It is important to establish ‘drivers of evolution’ for the technical, social, economic, urban, institutional, and environmental dimensions in order to achieve a sustainable development (Ahvenniemi et al., 2017; Albino et al., 2015; Gil-Garcia et al., 2015; Leydesdorff & Deakin, 2011; Markkula & Kune, 2015; Zubizarreta et al., 2016).

Nevertheless, it is not an easy task and does not follow a linear path. Smart city initiatives present many idiosyncrasies because cities are inherently different, both in characteristics and stages, and have different issues that must be solved in a particular way (Dameri et al., 2019; Pancholi et al., 2017; Yigitcanlar et al., 2018). It does not mean that smart city experiences worldwide will not have similarities, but each city will certainly follow different development paths at some level (Komninos et al., 2019; Mora et al., 2019b). Hence, the question is how to analyze this dynamic, context-dependent, long-term urban development process so that a city becomes smarter?

Despite the exponential growth of publications in the field of smart cities (Janik et al., 2020), a few academic studies have attempted to establish a comprehensive

analytical framework that seeks to explain how smart city development happens (Appio et al., 2019; Fernandez-Anez et al., 2018; Yigitcanlar et al., 2018). The problem is that these research efforts "tend to rely on an excessive level of abstraction and sometimes neglect widely accepted theoretical assertions incorporated into broader academic debates related to system innovation" (Mora et al., 2020, p. 4).

The literature is still scarce on offering an overall understanding of the smart city development process based on a robust theoretical basis. It still requires a more comprehensive framework grounded on multidimensional contextual dimensions such as territory, the different levels of the innovation ecosystem, and the notion of time to explain where, why, when, how, and by whom a smart city is developed.

To better grasp this complex urban transformation process, the evolutionary approach has started penetrating smart city literature to analyze sustainable urban planning and development (Caird & Hallet, 2019; Komninos et al., 2019; Mora et al., 2020). As an evolutionary approach, we consider theories and concepts devoted to explaining the transformation processes of urban (eco)systems over time from a holistic perspective.

In theoretical terms, two main research streams have been adopted to understand how it is possible to rearrange and transform urban agglomerations in a smarter way to address the critical global challenges of our time, namely sustainability transition studies and evolutionary economic geography (EEG). It is important to highlight that these research streams are not exclusionary, although they frame smart city development from different assumptions by proposing different ways to assess these transformation processes.

Sustainability transition research assumes that smart cities "must be interpreted as urban environments engaged in a context-dependent, multidimensional, and systemic transformation process through which the sustainability of their socio-technical systems for urban service provision is enhanced by adopting smart city technologies" (Mora et al., 2020, p. 2). It emphasizes explaining how landscape, regime, and experimentation niches interact, foster socio-technical change, and introduce new technologies in society (Carvalho, 2015). Thus, smart city development can be considered the outcome of a socio-technical transition process.

Evolutionary economic geography takes an explicit dynamic perspective, in which organizations' capabilities become central and their co-evolution with institutions involved in a certain territory (Boschma & Frenken, 2006). This co-evolution occurs

systemically and relies on contextual factors, determining the uneven development among territories (Boschma & Martin, 2013; Martin & Sunley, 2006). When applied to the smart city context, this perspective can be useful to explain "the complexity of smart city development processes and the multi-disciplinary character of smart city technologies" (Komninos et al., 2019, p. 2), considering the uniqueness of each city trajectory.

In summary, both research streams underline the importance of shedding light on smart city development as a context-dependent, multidimensional, and systemic transformation process while providing more focus on the strategic level of urban planning and management (i.e., EEG) and the operational level of urban planning and management (i.e., sustainability transitions research).

Given this theoretical gap, the EEG approach can add value to the discussion by providing concepts, principles, and ideas that can be useful to explain the processes and mechanisms behind smart city evolution. By better understanding smart city development as a dynamic long-term process, which relies on contextual factors and history as well as on the dynamicity and systematicity of the city, it is possible to frame the evolutionary building blocks for spatial development analysis.

Indeed, the inherent specificities of each city impact its evolution process; its characteristics and stages suggest different paths. Cities must build new assets and capabilities in order to thrive and achieve sustainable development.

Therefore, it is possible to analyze the dynamics of urban transformation processes in the different levels of intervention and scale over time when adopting the evolutionary approach. By assessing the current stage of development, it is possible then to define smart strategies, projects, and solutions, which will focus on environmental sustainability, quality of life and economic prosperity are to be jeopardized, becoming difficult to imagine how the urban innovation ecosystem can be in fact performing.

In this sense, this paper proposes an evolutionary framework that intertwine the evolutionary concepts with smart city development in order to enable a space-time contextual analysis of this urban transformation process.

2. THE DEVELOPMENT PATHS OF SMART CITY

Numerous cities from different countries have taken various initiatives and projects toward smart city development (Angelidou, 2015, 2017; Caragliu et al., 2011; Lee et al., 2014). Nonetheless, there is no consensus on how this process of transformation should be done because the nature of smart city development is dichotomous and complex and therefore uncertain, making each experience context-dependent and systemically different (ben Letaifa, 2015; Mora et al., 2019a; Mora et al., 2019). It is dichotomous because these initiatives may differ in their main strategic principles of development and are complex because many factors should be considered, from urban morphology to local socioeconomic systems (Mora et al., 2019b). Which strategic approach will be adopted? Who will lead this process? What will be the focus of the intervention? What will the interaction between stakeholders be like?

Given the above, the challenge to becoming a smart city lies in determining the potential development paths considering its contextual factors and the innovation system; hence, it is necessary to bridge some theoretical gaps to support the implementation of this new model (Lim et al., 2019).

2.1.The Urban Innovation Ecosystem and the Smart city

Some authors have reported that a smart city can be viewed as a complex and adaptative ecosystem that needs to constantly face ‘wicked problems’ that demand breakthrough innovations (Kroh, 2021). In the twenty-first century, “the combination of global urban sustainability challenges and strong transformative potential of digital technologies has opened up a window of opportunity” for cities to adapt their urban innovation ecosystem toward a smarter level (Mora et al., 2020, p. 11; Angelidou, 2015; Yigitcanlar et al., 2018).

In the new techno-economic paradigm (Teece, 2008), value creation is related to developing innovative solutions that require an ever-increasing level of connected knowledge and creativity (Ketonen-Oksi and Valkokari, 2019), the complementarity of capabilities, institutional support, and advanced infrastructure, which makes ‘entrepreneurial innovation’ feasible only on urban agglomerations (Autio et al., 2018; Woolley, 2014). This is why research is shifting from highlighting simple

entrepreneurship and innovative ventures and relations toward shedding more and more light upon ‘urban (entrepreneurial) innovation ecosystems (Nylund and Cohen, 2017).

From this perspective, it is possible to analyze innovation on a more disaggregated level as an ‘urban event’ in which social, economic, environmental, and institutional factors are more intense (Bruns et al., 2017; Bosma & Sternberg, 2014; Acs et al., 2018; Audretsch & Belitski, 2017). The urban systems and their contexts influence how local stakeholders can create and shape opportunities for innovation.

In this sense, a smart city can be seen as an innovation ecosystem that uses digital technologies and collective intelligence to solve different urban issues and achieve sustainable development (Camboim et al., 2019; Zheng et al., 2020). However, this does not happen by chance, as smart city development is a long-term process that requires the deliberate action of stakeholders to change and improve the elements of the ecosystem (Appio et al., 2019).

2.2. Smart City Development: From strategy to implementation

Many scholars have attempted to ‘simplify’ this complex model to better grasp how a city can achieve ‘smart characteristics’ (Angelidou, 2017). Some authors have suggested that the city must follow some steps to begin this process of transformation to foster the interplay among the different dimensions and enhance their elements (Appio et al., 2019; Fernandez-Anez et al., 2018; Mora et al., 2019; Stratigea et al., 2015; Yigitcanlar et al., 2018).

Considering the existence of different approaches, Camboim et al (2019) propose a logic sequence for urban transformation based on two major steps: (1) the establishment of a governance model; and (2) the implementation of a strategy and concrete projects to engender an actual process towards smartness and higher performance.

The establishment of a governance structure is the moment that the city must bring together different stakeholders. They ought to be aware and, especially, understand the urban ecosystem existing conditions in order to build a vision of the future enabling the design of strategies with concrete objective and feasible goals in order to develop a smart city (Axelsson & Granath, 2018; Fernandez-Anez et al., 2018).

Only then, somehow, the process of implementation can start. The implementation of these strategies through projects that aim to develop solutions with different scale and scope for the several urban issues (Camboim et al., 2019; van Winden & van den Buuse,

2017). Depending on their objectives and goals, these projects will focus on different dimensions and, consequently, will have different effects in the smart city development.

As a matter of fact, designing strategies and their implementation are crucial for smart city development (Fernandez-Anez et al., 2018). These strategies and projects aim to improve the elements from each city dimension (i.e., governance, environmental-urban, technological-economic, and socio-institutional dimensions) and, consequently, foster local sustainable development (Camboim et al., 2019).

A ‘smart city strategy’ is a long-term integrated plan that establishes a shared vision of the future and defines place-based policies and goals for local sustainable development (Siokas et al., 2021). It is generally materialized in a document created and implemented by the local governance structure and considers the contextual factors and the city’s development stage (Ahvenniemi & Huovila, 2020; Caragliu & Del Bo, 2019).

A ‘smart strategy’ is different from the traditional one because it avoids the ‘one size fits all’ approach and adopts a more holistic and evidence-based approach to address the local urban issues (Clement & Crutzen, 2021). It is important to highlight that “the long-term success of a strategy is directly linked to the quality of assumptions about the future” (Sokolov et al., 2019, p. 1). In this sense, these initiatives may follow different development paths regarding their main strategic principles, such as (1) a technology-led or holistic strategy; 2) a double or quadruple-helix model of collaboration; (3) a top-down or bottom-up approach; (4) a mono-dimensional or integrated intervention logic (Mora et al., 2019b).

After planning and designing the strategies, it is necessary to get off the paper and go beyond the discourse to put the plan into practice effectively. Indeed, “smart city implementation requires lowering the scale from the strategy to the project level” (Fernandez-Anez et al., 2018, p. 4). The main assumption is that smart projects can enhance urban smartness by creating, improving, or changing the elements from the different city dimensions in an integrated manner.

A smart city project is an instrument to foster major changes in the hard and soft assets, called ‘elements of a city’ (Camboim et al., 2019). A smart city project can focus on different areas of intervention (i.e., energy, mobility, security, education, and so on), happens at different lengths of time, and their ‘smart solutions’ may have different upscaling potential (van Winden & van den Buuse, 2017).

They are customized holistic practical solutions (i.e., technological and non-technological) that should, at same time, allow more efficiency and provide new value

for its final users and society (Meijer & Thaens, 2018; Schiavone, Paolone, & Mancini, 2019). Cities can follow different development paths, but to be successful, projects need to be consistent with the strategies and motivated by the 'concrete' demands of stakeholders, all duly supported by a governance structure that catalyzes the process of urban transformation. It is also useless to make specific efforts without prioritization and defined steps, because the impact of these initiatives will only appear in the long term.

Conversely, smart city development can also bring negative outcomes as this process does not guarantee improvement. The mainstream discourse assumes that applying information communication technologies is crucial for urban development and growth (Kitchin, 2015; Vanolo, 2014).

Nevertheless, this view neglects the fact that cities are made by people and rely on different socio-spatial processes of governance and techno-economic systems, in which urban life and its issues "will not be ameliorated solely by simple technological solutions or more sophisticated data gathering" (Hollands, 2015, p. 74). Without an evolutionary and holistic view, smart city initiatives can make cities 'less smart' by further perpetuating issues that include urban splintering, participation inequality, digital divide, and information insecurity, among other concerns (Angelidou, 2014; Lam and Ma, 2019).

In this sense, despite the efforts made to analyze smart city development, most studies have disregarded the processes behind this 'new' urban development paradigm, especially the importance of longitudinal analysis, neglecting the different levels of spatial analysis that must be integrated into the same framework (Sharifi, 2019). This urges the creation and validation of new frameworks encompassing the different levels of intervention and scales of smart city development and its inherent evolutionary process (Caird, 2018).

Caird and Hallet (2019) and Komninos et al. (2019) suggested that adopting an evolutionary approach can help determine a more accurate scope for planning and evaluating smart city development. It is pivotal to analyze smart city dynamics through an evolutionary approach by defining "spatial and temporal system boundaries to control extraneous influences" (Arnold, 2004 apud Caird & Hallett, 2019, p. 206). Assuming that any development process is evolutionary, it is necessary to understand how it occurs from a space-time perspective.

3. THE EVOLUTIONARY APPROACH

Since the ‘90s, there has been a significant increase in the use of terminologies, concepts, and evolutionary metaphors in economic geography to better understand different objects of study at different scales of analysis (Zhu et al., 2019). This new theoretical approach has allowed the integration with other areas of knowledge that led to the emergence of the EEG perspective (Boschma & Frenken, 2006). When adopting this perspective, it is important to clarify that the term ‘evolution’ presupposes ‘change’, meanwhile, ‘economic’ deals with the optimal allocation of resources. Thus, in a changing environment, one should expect innovation to perform the optimal allocation of resources. However, the real novelty here is the ‘geography’ itself. By incorporating it, innovation may be perceived through time and space. In this context, with EEG, the phenomenon of smart city development is broadly understood.

The EEG provides a multiscale perspective through the notion of capabilities (i.e., micro level) and institutions (i.e., meso level) that interplay in a certain spatial innovation system (i.e., macro level) in order to explain the uneven development among territories (Boschma & Martin, 2007). This current of thought considers the feedback mechanisms at different levels of analysis and supports the use of mixed methods, which might help in experimenting with non-trivial techniques (Boschma & Frenken, 2011).

3.1 EVOLUTIONARY CONCEPTS

Comprehensively, EEG is based on three theoretical frameworks, namely: generalized Darwinism, complex adaptative systems and path-dependence. All frameworks provide a set of ideas that can be interchangeably used for understanding evolutionary change in complex systems (e.g., cities) over time (Boschma & Martin, 2010).

Despite the overlaps among the above-mentioned frameworks, some authors argue that ‘generalized Darwinism’ is more consistent and ‘generalizable’ than the other approaches (Aldrich et al., 2008). This framework demands a better understanding of what the key principles of variation, selection, retention, and so forth “might represent in the economy (Boschma & Martin, 2013), how those concepts are put into motion or embedded within a dynamic system of economic competition, and how they are

influenced by other mechanisms specific to that system" (Essletzbichler & Rigby, 2007, pp. 551–552).

As Nelson and Winter (2002) pointed out, any evolutionary system may be characterized by variation, selection, and retention principles. These mechanisms can be synchronous, albeit they will follow a sequential logic that "is essentially directed and irreversibly locked in" (Dopfer, 2005). It means that cities will experience general patterns of evolution, but they may occur at different paces and follow different paths due to their previous particularities and smartness levels (Komninos et al., 2019).

The variation must result from endogenous mechanisms that generate novelty and new development paths (Gluckler, 2007). These endogenous mechanisms refer to innovative processes that change entities' frequency, type, characteristics, and behaviors within an environment and determine the rate and direction of evolutionary change (Metcalfe, 2001). Essential to this view is that variation depends on entities' characteristics and the environment's specificities, which select the pattern of change and its replication, meaning that without variation, there can be no selection and retention.

Selection should be conceived as an instance that determines the future existence and future non-existence of an actualized entity (or a new variety). In fact, selection mechanisms are often attributed to the environment. While in biology, the natural environment selects biological fitness (natural selection), in evolutionary economics, market competition selects, in our case, cities (competitive selection).

Cities are considered selection environments composed of institutions, markets, and spatial structures, which drive the choice of alternative development paths for the city and its dimensions (Lambooy, 2002). In this sense, "the local environment acts as a kind of selection mechanism that may (or may not) provide conditions favorable to meet the new requirements of change" (Lambooy, 2002, p. 1029). It reinforces the importance of contextual factors (e.g., political, economic, and sociocultural) as determinants for the success or failure of an innovation system (Boschma et al., 2017; Johnson, 2008; Martin & Simmie, 2008). Selection thereby alters the environment within which future decisions are made individually or collectively.

Cities compete to attract and retain people and investments by providing better public services, jobs, living, and entertainment conditions. However, structural changes in the selection environments (i.e., the cities) rely on the actions of individual economic agents, broader coalitions and institutions, and the characteristics of such spaces.

For selection operations, even in a globalized and highly wired world that constantly changes — and sometimes abruptly due to natural or anthropogenic shocks — a certain level of stability, or inertia, in city characteristics is required. It is then necessary to create and implement retention mechanisms to maintain and reproduce the selected variant over time.

Retention (or continuity) refers to a principle that describes the continuation of the outcomes from variation and selection processes. To ensure the continuity of the new pattern, the retention mechanisms such as rules, routines, and habits must be established to enable their transmission (i.e., heredity) and replication at all system levels. They reinforce a system's existing structures and elements over time until a new process of variation and selection occurs, meaning retention mechanisms may condition and even determine future decisions regarding creating and selecting 'new' development paths.

3.2 THE BUILDING BLOCKS OF AN EVOLUTIONARY ANALYSIS

As mentioned herein, the general concept of EEG connects the notions of time and space with the processes that occur in certain territories over time. In this transformation of cities towards smartness, it is important to first consider their contextuality and historicity, and then dynamicity and systematicity as building blocks for the evolutionary analysis.

As a matter of fact, this open-ended process of accumulation of causes and consequences occurs during a certain time in a specific territory (Simmie & Martin, 2010). The true is that this change process influence the development path of a territory systems in different ways and at same time is conditioned by the development itself (Martin & Sunley, 2006).

3.2.1 Space: Systematicity and Contextuality

In this sense, "the local environment acts as a kind of selection mechanism that may (or may not) provide conditions favorable to meet the new requirements of change" (Lambooy, 2002, p. 1029). It reinforces the importance of contextual factors, such institutions, and other urban elements, as determinants for the success or failure of an innovation system (Boschma et al., 2017; Johnson, 2008; Martin & Simmie, 2008).

Conversely, in a globalized world where everything is interconnected, one should think that these contextual factors could lose their influence on the adaptative process, but the exactly opposite is happening. The fact is that “not all territories have the same capacity” (Rodriguez-Pose & Crescenzi, 2008, p. 372) to meet those requirements related to the new paradigm.

This occurs because each territory present specific elements that evolve in different pace due to contextual factors and how its heterogenous entities interact and learn from each other (i.e., networks) over time. It means that each territory has its own dynamics of development that affect and is affected by what composes and how works its innovation system.

In this new techno-economic paradigm, the pace of this change occurs faster and faster. This faster pace is due to the fact that the different agents that influence this process are even more interconnected and perform a greater number of interactions (Metcalfe, 2001). The interactions between them alter the natural condition of the ecosystem they are inserted into and, at the same time, they are influenced by these changes (Martin & Sunley, 2006). The series of positive and negative outcomes denote the complex systemic nature of the change process (Martin & Sunley, 2007).

In this sense, based on seminal works (Cooke, 1992; Cooke et al., 1997; Freeman, 1995; Lundvall, 1992; Nelson, 1993), EEG studies have focused on deepening how the innovation systems could foster regional and national development (Coenen et al., 2017). This systemic approach has been applied in different scales of analysis to respond to the ‘one size fits all’ mentality by emphasizing that territories have different drivers of evolution that depend on how the local heterogeneous entities combine their capabilities to alter these elements.

For this reason, there is a consensus that networks play a critical role in understanding the differences between these innovation systems. These networks are shaped and transformed over time and affected by evolutionary mechanisms such as variation, selection, retention, and replication (Boschma & Martin, 2013).

3.2.2 Time: Historicity and Dynamicity

“To understand geographically uneven development, in all of its manifestations, it is necessary to create a space for history” (Martin & Sunley, 2010, p. 62). This open-ended process of accumulation of causes and consequences occurs during a certain time

in a specific territory. This changing process influences the development path of territory in different ways and is conditioned by the development itself (Martin and Sunley, 2006).

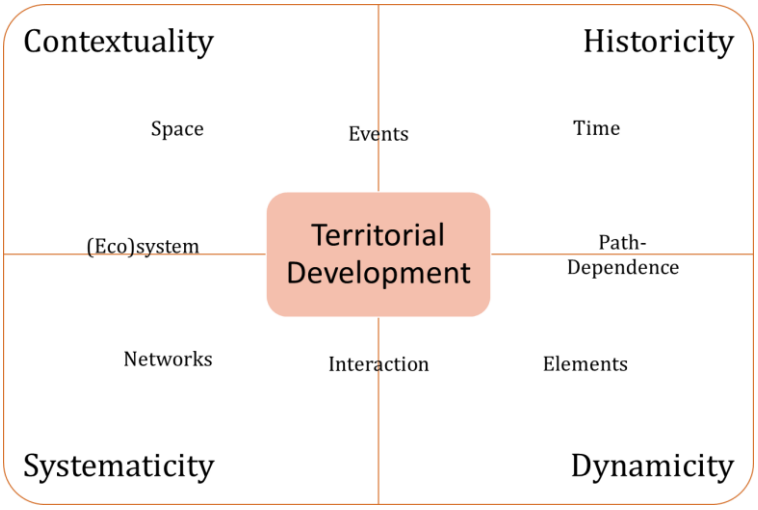
Given this evolutionary approach, it is possible to affirm that the dynamic of spatial development is path-dependent and context-dependent, albeit it is crucial to highlight that this development process does not happen randomly. There is a strong hypothesis that it is conditioned by the new combination of existing capabilities and elements in the local system (Boschma, 2017).

This means that the innovation system will often evolve into a similar configuration to the previous one, which characterizes the high level of relatedness in the development process (Boschma et al., 2015). In other words, territory adaptation over time is directly linked with the development processes and is determined and shaped by past events (i.e., history).

Nonetheless, adaptation only driven by related variety may lead to several issues because continuing to just combine existing capabilities can lock in the local development into one path (Hassink, 2010). This path-dependence lock-in may hinder the region (or city) from adapting to changes and shocks (i.e., its resiliency) (Martin, 2009). As a consequence, the long-term success of an innovation system relies on the agents' ability to adapt their structures and elements to the new paradigm (Boschma, 2015; Simmie & Martin, 2010).

In sum, the main assumption of EEG is that the dynamicity and systematicity of development are geographically uneven because history and context greatly influence this process. In a broad sense, territorial development dynamics are triggered by systematic interactions among elements that form a set of networks and occur in a delimited space. The sequences of these events shape and are shaped by the (eco)system over time, which means that decisions and actions (i.e., interactions) made in the past will determine the paths of territorial development (i.e., path-dependence); Figure 1 illustrates these relationships.

Figure 1 - The Evolutionary Building Blocks of Territorial Development



Considering these building blocks for territorial development, it is possible to identify the main pillars of the transformation process and how to change them to facilitate territorial development, in our case, smart city development.

4. INTERTWINING SMART CITY WITH THE EVOLUTIONARY APPROACH

When analyzing smart city development through the lens of EEG, one must consider that the process of spatial transformation occurs systemically and relies on the complex interactions of multi-stakeholder networks, contextual factors, and historical facts that determine and shape territorial development over time (Boschma & Frenken, 2006, 2011; Martin & Sunley, 2006; Simmie & Martin, 2010).

In the case of urban innovation ecosystems such as smart cities, this sequential logic has feedback loops that are related to the two major dynamic, context-based, and 'never-ending' processes that any city has to do in order to become smart(er), which are: (1) the design of 'smart city strategies' and (2) their implementation of solutions through 'smart city projects' (Camboim et al., 2019). They result from a mix of elements in the ecosystem that can be seen as pre-conditions to start and sustain this new development path (Caragliu & Del Bo, 2016).

It is noted that these evolutionary processes (i.e., design and implementation) do not occur in the 'vacuum' and without the interaction of 'heterogeneous entities.' They

involve human agency represented by different local stakeholders of the quadruple-helix, forming different collaborative networks (Axelsson & Granath, 2018; Johnston & Huggins, 2016).

However, cities have limitations in governance, funding, financing tools, infrastructure, institutions, and technical capabilities to implement such solutions (Ardito et al., 2019; Ferraris et al., 2019). Sometimes, the stakeholders and, consequently, the system, are unable to adapt their structures and elements, which are necessary conditions to start this process of urban transformation.

Hence, one must ask: what mechanisms trigger and enable this long-term adaptative process of urban transformation? Considering the above-mentioned principles (i.e., 'variation,' 'selection,' 'retention,' and 'replication') of an ecosystem, it is possible to unfold the evolutionary mechanisms underlying the processes of smart city development.

Variation results from innovative processes (i.e., endogenous mechanisms) that change ecosystem elements; in smart cities, it is mainly triggered by the 'sense of urgency' of different stakeholders on mitigating global and local urban issues and the need for the city to adapt to the principles and values of the twenty-first century. Creating an 'urban innovation' (or 'smart city solution') is the primary mechanism that fosters territory variation. Moreover, creating solutions (i.e., new variations) for urban problems happens through collaborative projects based on city strategies that will be selected for implementation (Mora et al., 2019b, 2019a).

Selection is the result of mechanisms that determine whether this new variety will be tested and validated by the environment. From this perspective, cities can be considered as 'selection environments' in constant change (Lambooy, 2002) that "guide the actions from an existing situation to an envisaged future" (Komninos et al., 2019, p. 2). These selection environments comprise 'heterogeneous entities' and relations among them, which are all embedded within institutional frameworks.

In smart city development, the selection mechanisms can be 'natural filters' to implement strategies through projects, such as the idiosyncratic characteristics of a city (i.e., morphology, demography, location, and so on), socio-economic factors (i.e., a culture of collaboration, knowledge base, investment capacity, etc.), or governance elements (i.e., structures and organizations, legislation and policies, technology and data, exchange arrangements, among others).

After finding and selecting the most fitting solution for the context, the challenge is to ensure the continuity (i.e., retention) of the new pattern. Retention will depend on the specificities of each project (i.e., scale, scope, objectives, and desired outcomes) and mechanisms such as the institutional framework and capabilities (or habits of thought) of those 'heterogeneous entities.' These mechanisms, when established, can enable the survival, transmission (i.e., heredity), and replication of solutions at all urban scales and city dimensions. Successfully implementing these solutions will lead to changes in the urban innovation ecosystem and produce outcomes that will reflect the development path for the upcoming years.

As the evolutionary approach highlights, this transformation process does not occur randomly. In fact, cities 'reinvent' themselves based on their existing assets and capabilities, although they must also build new ones to seize new opportunities and trends and avoid lock-in effects. This means that the ecosystem and its elements will co-evolve towards a smarter level based on pre-conditions that will determine the possible paths of development of solutions and enable (or not) rapid adaptation to a constantly changing environment (Carvalho, 2015).

5. TOWARDS AN EVOLUTIONARY FRAMEWORK FOR THE ANALYSIS OF SMART CITY DEVELOPMENT

In this study, the space-time boundary of this complex dynamic ecosystem is the urban environment and, more specifically, the longitudinal development processes of smart cities. Given this context, it is necessary to identify when the smart city development was started to analyze the previous development path of the city and to understand to what extent the 'new' path creation process differs from that. In this way, we propose to define the boundaries of spatial development analysis in two timeframes:

1) before Smart City Strategy (SCS) launch (t_{-1}); and

2) after SCS launch (t_0) until the present (t_1).

The launch of SCS refers to the exactly moment that one stakeholder or more established a long-term strategic plan or started to develop smart city projects, which can be funded or recognized by prestigious international organizations (e.g., intergovernmental agencies, standardization entities, financial institutions and so on). Indeed, in the period before SCS launch, there were plans and projects that were not

labeled as ‘smart’, but they had ‘smart characteristics’ like mobility, connectivity, sustainability and so on. They should be taken into account to describe the previous development path and to understand in what extent the ‘new’ path creation process differs from that one.

In addition, in order to propose an evolutionary framework for UIEs, it is also pivotal to define the different levels of analysis to better understand how the urban innovation ecosystem behaves and evolves and how these smart cities’ evolutionary processes unfold over time.

5.1. Analyzing the Urban Innovation Ecosystem from a multi-level evolutionary perspective

From the analysis of how stakeholders behave individually and collectively to transform the local ecosystem, it will be possible to understand the dynamics of smart city development through the years. By defining the space-time boundaries of an urban innovation ecosystem, an evolutionary framework should be capable of linking micro-behavior to macro-processes that occur in a given territory over time.

At the **micro-level**, the main unit of analysis of smart city development is **the stakeholder** and its capabilities. It is from the sum of the (bounded) capabilities of different stakeholders that the interfaces of complementarity emerge, materializing the several collaborative networks of an innovation ecosystem.

Each stakeholder involved in those collaborative projects has different abilities, knowledge bases and resources (i.e., capabilities) that can be used to explore or exploit ‘urban innovations’ (Meijer & Thaens, 2018; Nilssen, 2019). This comprehensive collaborative process of urban entrepreneurship and innovation requires these stakeholders to quickly adapt their routines by creating new processes, products, or business models that may bring positive returns for themselves and the target audience.

Nevertheless, this may also lead to several issues, including how to engage the stakeholders and make them more ‘open’ to collaborating (Ferraris et al., 2018), how to balance the exploration of new ideas and the exploitation of already established solutions (van den Buuse et al., 2020), how to build capabilities to achieve innovation, and how to create a sustainable business model (Kuk & Janssen, 2011; Schiavone et al., 2019).

Therefore, smart city development can be analyzed at the micro level by considering the innovativeness of each stakeholder in developing, producing, and

delivering smart city solutions. To deliver innovative solutions, it is necessary to analyze how the specific characteristics, innovation strategies, and capabilities may enhance the innovativeness of an individual (i.e., stakeholder) over time. It can be used a mix of quantitative and qualitative methods and techniques (e.g., case studies, surveys, action research, etc.) to analyze the innovativeness of an individual involved in a specific project, the stakeholders of one project (or all projects) based on the lens of dynamic capabilities, innovation capabilities, ambidexterity theory, open innovation and so on (Ferraris, Santoro, & Pellicelli, 2020; Linde, Sjödin, Parida, & Wincent, 2021; van den Buuse et al., 2020).

At **meso level**, the main unit of analysis of smart city development is the **collaborative networks**. As a matter of fact, the collection of collaborative networks among the different stakeholders will give rise to the level and performance of the ecosystem itself. Both designing and implementing strategies through projects rely on multi-stakeholders' partnerships that combine their capabilities and share resources to create solutions for the different dimensions of the urban innovation ecosystem (Axelsson & Granath, 2018; Sandulli et al., 2017). The literature highlights that each stakeholder has an important role in leading, coordinating, or supporting smart city development (Ruhlandt, 2018). It is a consensus that the government cannot solve complex urban issues (Meijer & Thaens, 2018). Consequently, forming collaborative networks to develop, test, and replicate smart city solutions is fundamental to achieving those desired outcomes (Ferraris et al., 2018).

Thus, smart city development can be analyzed at the meso level by considering how the governance structures and interactions among stakeholders contribute to collective connectedness (i.e., network) over time (Ben Yahia et al., 2019). Connectedness refers not only to the number of existing interactions among those stakeholders but also to the proportion of possible relationships (i.e., density), which provides the continuity (or not) of the smart city development process.

Additionally, the definition of the smart city development period (t-1 and t0) enables the city to map both finished and under implementation smart city projects and the innovative solutions that lead (or not) to the transformation of different city dimensions and elements (i.e., systematicity). It is possible to apply the pilot method proposed by Mora et al. (2019), which collects data from the internet about the smart projects of a city and uses social network techniques to identify the structure of

collaborative networks and stakeholders from each project and how they have evolved over time (i.e., dynamicity).

Finally, at the **macro-level**, the main unit of analysis of smart city development is the **innovation ecosystem** *per se*. It encompasses the city dimensions and respective elements and their interaction in the aggregate-level, which enables the measurement of the direct and indirect effects of the smart city development processes.

In this sense, smart city development can be analyzed at the macro level by considering the different degrees of smartness of the urban innovation ecosystem (Alderete, 2020; Manitiu & Pedrini, 2016; Nicolas et al., 2020). As mentioned herein, the development of an ecosystem relies on 'systemic' interactions among elements from different dimensions, including governance, economy, socio-institutional, and environ-urban. However, the dynamics and pace of this development will vary among territories because each ecosystem has a particular way of organization conditioned by contextual factors and its formation history (i.e., path-dependence).

Therefore, in order to design assertive strategies, it is necessary to analyze how elements from different dimensions compose and contribute to the smartness of urban territory and impacts urban performance over time. For this, one must gather indicators before SCS (t-1) to represent the initial conditions of the ecosystem and during the smart city development period (from t-1 until t0) to assess the impacts of smart city strategies implementation by modeling it and comparing the results with itself and other cities.

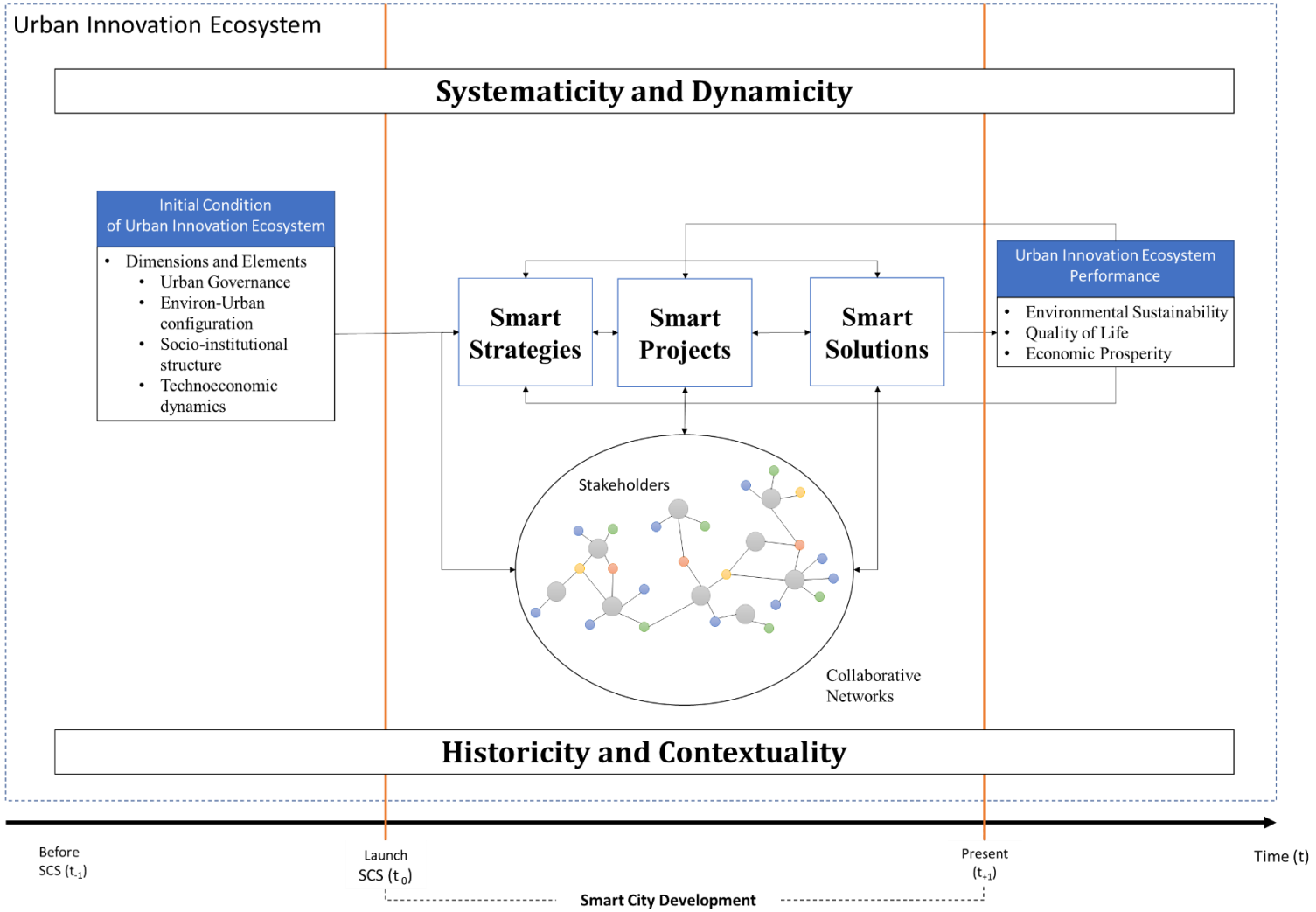
5.2. The Evolutionary Framework

When analyzing smart city development through an evolutionary approach, it is necessary to consider that this process involves stakeholders (i.e., micro level) that interact amongst themselves to combine their capabilities and share resources, forming collaborative networks (i.e., meso level) to solve the different urban issues (i.e., macro level).

As discussed earlier, the key drivers of evolution in smart city development are the design and implementation of strategies through projects that aims to create customized solutions for the local urban issues. The dynamics of this urban transformation process relies on the agency of a bunch of individuals interested in create those solutions (i.e., stakeholders) that need to establish collaborative networks in order to combine their capabilities and share resources.

It is expected that the solutions developed in the different projects based on customized strategies contribute to the city achieving greater quality of life, improving sustainability and increasing economic prosperity. However, as mentioned before, this process of adaptation is not a guarantee of improvement, because the strategic choices made by each city should consider contextual factors, history and its systems, which may cause negative outcomes. This is the rationale behind the proposed evolutionary framework illustrated in the Figure 2.

Figure 2 - The Evolutionary Framework for the Analysis of Smart City Development



From an evolutionary approach, the analysis of smart city development should consider what has been done so far and how contextual factors (i.e., contextuality and historicity) promote or restrain this transformation process. The framework sheds light on the importance of how the different levels of analysis interplay (i.e., innovation ecosystem, collaborative networks, stakeholders), by considering the feedback loops that can enhance or buffer changes in the ecosystem itself and its elements.

In addition, this approach proposes when and how the key evolutionary concepts and mechanisms (i.e., variation, selection, retention, path-dependence, and co-evolution) are related to the main processes of smart city development over time (i.e., designing and implementing strategies, projects, and solutions). Notably, it is important to highlight that these mechanisms operate at different levels with different intensities in the urban innovation ecosystem.

Hence, the impacts of the development processes on the city's performance may take time to appear, requiring the creation of metrics and assessment schemes that will enable the city' stakeholders to monitor and control the smart city evolution and guide what development path is more adequate.

6. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

In the last decade, the smart city model emerged as a solution to tackle different urban issues. Many initiatives and projects are being implemented around the world, although there are some concerns if they are delivering what they promise. For this, it is necessary to evaluate how this model is contributing (or not) to urban development.

In this sense, a growing awareness of smart city assessment has proliferated in recent years (Sharifi, 2019, 2020). Countless models, indices, rankings, toolkits, and benchmarking have been created to assess the impacts of smart city interventions, which are important support systems for decision makers (Caird & Hallett, 2019).

Despite their interesting results, development processes have been overlooked in these assessment schemes, revealing a misalignment between the dynamics of smart city development and the metrics and methods used. This misalignment indicates the lack of an adequate theoretical basis that should provide concepts and new ways to analyze and measure the studied object.

Therefore, we proposed incorporating the evolutionary approach to overcome limitations of current assessment schemes, highlighting the importance of time, space, and context for analyzing spatial transformation processes. Within this perspective, smart city development must be measured considering the different scales and units of analysis related to implementing strategies through projects over time.

Incorporating the evolutionary mechanisms into the analysis may identify why and how some solutions are retained and upscaled and others are not. In addition, it enables us to explain why cities start this process of change and select some strategies and projects that should consider the local context and the previous development paths.

By using this framework and data analysis, the cities can determine the strategies that must be implemented more assertively, prioritize and scale the projects to be carried out, and facilitate matchmaking among stakeholders depending on their potential for innovation in order to start or improve their smart city development process. These changes will help transform the smart city model into an effective 'enabling tool' to deal with traditional city social, economic, environmental, and governance challenges.

In this study, we proposed that smart city development as an aggregate input-output of longitudinal processes should be analyzed from different and respective units of analysis. At the macro level, the measurement of urban smartness can help the city identify the elements from each dimension that should be improved and compare itself and with other cities. This analysis will enable the city to define strategies and projects based on evidence like indicators, parameters, and real-time information and not on wishful thinking. At the meso level, the analysis of projects and their collaborative networks can help the city identify how implementation of smart city strategies occurs over time. It will enable the city to (re)define the scale and scope of projects and (re)design its governance structure to foster a more integrated, holistic, and sustainable development.

At the micro level, the analysis of stakeholders' characteristics, capabilities, and strategies can help the city identify its potential for creating innovative solutions not only for its own urban ecosystem but also for other cities worldwide. Moreover, it will enable the city to find suitable partners for new endeavors and better understand how stakeholders can improve their innovativeness and, consequently, the impact on the ecosystem's performance.

Despite the promising contributions of this study, the framework needs to be validated, which requires in-depth research; nonetheless, this opens up an exciting research avenue that includes the following topics but is not limited to:

- Measuring the smartness of a city still requires a better conceptualization and operationalization of the indicators and modelling techniques considering the evolutionary approach.
- Assessing how smart city collaborative networks are structured and evolve over time is still scarce, especially in initiatives of cities from developing countries.
- Assessing what stakeholders should have and improve internally in terms of innovativeness over time to create and deliver smart solutions is still incipient, especially in public and non-profit organizations.

Thus, for this proposition's theoretical and empirical advancement, it is necessary to test this framework by conducting empirical research with suitable methods and techniques to avoid the static, timeless, non-contextual, non-spatial, and non-integrated assessments from previous studies. It is necessary to analyze to what extent these key evolutionary concepts can be applied to the smart city context.

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No potential competing interest was reported by the authors.

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PAPER 4

MEASURING THE SMARTNESS OF AN URBAN INNOVATION ECOSYSTEM

ABSTRACT

Even before this global pandemic crisis, many cities around the world were already looking for solutions to mitigate urban problems through the implementation of strategies and projects focused on smart city development. Cities have begun to establish ‘drivers of evolution’ for the technical, social, economic, urban, institutional and environmental dimensions in order to achieve a sustainable development. From this perspective, smart cities as urban innovation ecosystems will evolve by selecting elements, features and capabilities that should be created, replaced or improved in order to reach a smarter level. Consequently, the pace of development relies on the ability of urban ecosystem (i.e., smartness) to adapt its dimensions into the current socio-techno economic paradigm in order to ease the collaborative process of value creation and, consequently, enhance quality of life through wealth and prosperity in the most sustainable way. In other words, smartness is a precondition for urban performance in the 21st century.

Keywords: measurement; smartness; urban; innovation; ecosystem.

1. INTRODUCTION

Cities have always been places where agglomeration economies attained their highest yields, producing cultural, economic, and social benefits. They are hubs of knowledge and creativity that provide a set of advantages and opportunities for different stakeholders to sustain their activities and thrive (Belitski & Desai, 2016; Florida et al., 2017; Levenda & Tretter, 2019). Cities are the main locus of entrepreneurship and innovation (Glaeser, 2011).

However, many of cities are struggling to ensure better quality of life for their citizens and to sustain economic growth and innovation due to rapid (unplanned) urbanization, which brought many problems such as inequality, pollution, diseases, insecurity and so on, that end up restrain the dynamic of value creation in 21st century (Caragliu et al., 2011; Komninos et al., 2019; Neirotti et al., 2014). This is challenging 'industrial cities' to rethink and to reshape their structures to overcome these issues (Boykova et al., 2016; Lim et al., 2019).

To solve (or mitigate) these issues, cities from around the world are designing strategies and implementing them through initiatives and projects towards smart city development (Angelidou, 2017). It is important to highlight that these development processes are both context and path-dependent, because each city has specific needs and its systems have different dynamics (Dameri, Benevolo, Veglianti, & Li, 2019).

In this sense, we assume that it is necessary to achieve a minimum stage of development to start disruptive changes in the different urban dimensions, denoting different degrees of smartness (Ben Letaifa, 2015). We define smartness as the ability of an urban innovation ecosystem to adapt, combine and catalyze its elements of innovation from each specific city dimension (i.e., governance, techno-economic, environ-urban and socio-institutional) towards a smarter level.

The degree of smartness conditions the possibilities of path creation and the pace of development of cities. Consequently, smart city development is more likely to occur (first) "in cities that are already endowed with smart characteristics" (Caragliu & Del Bo, 2016, p. 667).

In this sense, "smartness should be seen as a continuum" (Gil-Garcia et al., 2015, p. 79), in which stakeholders may implement initiatives to create, improve or alter smart city elements across those different city dimensions (Bibri & Krogstie, 2017b). The notion of smartness may help cities to understand how this process of urban

transformation affects their dimensions and their performance (Gil-Garcia et al., 2016; Manitiu & Pedrini, 2016).

Then, it is important that cities, especially those with less 'smart characteristics', assess their current stage of development in terms of smartness. The assessment of smart city development may bring multiple benefits for different stakeholders such as identification of city strengths and weakness, comparison among cities, monitoring and tracking projects implementation, increasing transparency on investments, enabling to make policies based on evidences, enhancing citizen awareness, and so on (Sharifi, 2019). Under this assumption, the question that arises is: how to measure the smartness of a city?

Many scholars, organizations and companies have developed indexes, toolkits and benchmarking to measure and rank smart cities (Caragliu & Del Bo, 2012; Hara, Nagao, Hannoe, & Nakamura, 2016; Kourtit, Nijkamp, & Arribas, 2012; Lazaroiu & Roscia, 2012; Lombardi, Giordano, Farouh, & Yousef, 2012; Marsal-Llacuna, Colomer-Llinàs, & Meléndez-Frigola, 2015). These assessments schemes provide a good overview about city's characteristics and its strengths and weakness, being used to showcase the competitive positions of cities (Sharifi, 2020).

However, most of them, by adopting a summative approach, neglects the current stage of development of the targeted city as well as the processes related to smart city development (Sharifi, 2020). In fact, these approaches present some limitations that do not properly capture the smartness of a city (Caird & Hallett, 2019; Castelnovo et al., 2016; Sharifi, 2019).

First, few of them consider that a smart city will 'not be built in a day' or, in other words, a time perspective (Angelidou, 2014; Fernández-Güell et al., 2016). Second, many of them focus on what the city has in terms of resources and assets without considering their interplay (Huovila et al., 2019). Third, metrics are based in an input-output logic, which does not allow us to comprehend the dynamics and outcomes of the urban interventions (Ahvenniemi et al., 2017; Huovila et al., 2019). Fourth, it is still not clear what are the elements that compose smartness considering that most of definitions focus exclusively on the technology dimension of this construct and end up neglecting the social, environmental and economic dimensions (Ahvenniemi et al., 2017). Last but not least, there are few assessment schemes adopting a modelling approach, which could enable cities to analyze their system complexities and provide alternative development paths (Sharifi, 2020).

The fact is that, despite the recent advances in the field of smart city assessment, it is still not clear what are the elements that compose smartness and how it affects urban performance over time (Ahvenniemi & Huovila, 2020). Some definitions focus exclusively on the technology dimension of this construct and end up neglecting the social, environmental and economic dimensions (Ahvenniemi et al., 2017).

In addition, there are few assessment schemes adopting a modelling approach, which could enable cities to seize and analyze their system complexities in order to provide alternative development paths (Sharifi, 2020). It is not possible to capture the evolution of smartness without considering that smart city development processes and outcomes occur in a certain space during a certain period of time.

In this sense, this paper aims to build a model to assess the impact of smartness on the urban innovation ecosystem performance. For that, we performed a PCA to define the constructs of smartness and tested the impact on urban performance through a structural equation modelling by using data from 115 European cities. The results show that urban attractiveness (PC1) and smart business and citizens (PC3) have a significant impact on economic prosperity (PC5), but social inclusion (PC4) policies may have a negative impact. It means that not necessarily all dimensions will enhance urban performance, due to the fact that some actions may represent opposite interests and lead to trade-off situations.

Conversely, all of these smartness dimensions (exception to collaborative mindset) have a positive impact on quality of life, which stress the importance of holistic strategies and interventions in the city environment and its socioeconomic dynamics. When focusing on the environmental sustainability, it is important to bring together the different stakeholders to discuss about issues that require a collaborative mindset (PC2) and diverse perspectives including the different segments of the society. It is also important to maintain a balance between economic development and sustainability policies, because it can cause negative effects on the environment.

To achieve that, we presented a literature review on smart city assessment and how smartness has been conceptualized and measured. Then, we discussed the interconnection between the different perspectives, which resulted in a multidimensional construct that was tested through PCA technique and validated through a structural equation modelling. Lastly, we discuss the results and further policy implications as well as the limitations and opportunities for future studies.

2. SMART CITY ASSESSMENT

There has been a growing interest from different sectors (i.e., academia, firms, governments) in developing and implementing frameworks for assessing smartness at various levels ranging from projects to different territorial scales (Sharifi, 2019). There is a wide range of relevant schemes available with different objectives and indicators that cities use for monitoring and evaluating their progress and impacts on smart city development (Sharifi, 2020).

The assessment of the smartness of city may enable the identification of the driving elements' effects on this urban transformation process. It helps cities to monitor what has been done so far, but also understand the consequences of these initiatives in their territory. Consequently, it can provide evidence that may help practitioners to design and implement proper strategies and projects to tackle the local urban issues.

Considering the amount of complex urban data generated along this process of transformation, this nascent field, called as Smart City Assessment (SCA), has a great potential for future development (Sharifi, 2019). However, the lack of adequate assessment (i.e., a clear scheme for evaluation of smart strategies, projects and performance) may restrain cities to exploit value of data (Huovila et al., 2019) and, consequently, to achieve those desired outcomes.

In a recent study, Sharifi (2019) evaluated the structure and content of 34 assessment schemes considering some criteria such comprehensiveness, context-sensitivity, interlinkages and interoperability, feasibility, presentation and communication, and so on. The results show that most of these schemes report the strengths and weaknesses of cities, but few of them consider locally-specific conditions, temporal changes, interrelationship among variables and do not appropriately use modelling and scenario-making approaches.

In other study, though, Caird and Hallett (2019) discuss about the importance of developing 'standardized smart city indicator frameworks' and analyze how some cities are evaluating their smart development. The authors point out that the "cities were at the early stages of developing plans to evaluate the city-level impacts of smart city developments" (Caird & Hallett, 2019, p. 204).

Caragliu and Del Bo (2012) used a composite indicator to capture the multi-faceted nature of urban smartness, by considering the role of efficiency in exploiting urban amenities, the contribution of transport infrastructure to urban competitiveness and

the e-government side of the concept. It identified four clusters considering the impacts of smartness on urban performance, which revealed that cities that are "smarter tend also to outperform those with lower scores in the same indicator" (Caragliu & Del Bo, 2012, p. 108).

Hadjuk (2019) examined the smartness of a bunch of European cities that possesses the ISO 37120 through the application of Hellwig's synthetic indicator of development. It concluded that these cities also vary strongly in terms of their level of smartness, which means that it still necessary to analyze the differentiation and dynamics of changes of their urban development.

Ramirez et al. (2021) propose a methodology to assess the smartness of cities at neighborhood level, especially those one from developing countries, given the great heterogeneity of different regions in a same city. They integrate different indicators in terms of efficiency with the citizen perception that live in the specific district in order to compare them in a ranking.

In this sense, assessment frameworks should consider that the relationship between smartness of a city and its performance do not follow a linear function, because smart city development is a complex iterative process of urban transformation. Despite their interesting findings, our study advances the literature by testing a multidimensional framework through an evolutionary approach. It incorporates the notion of time and assumes that elements of those latent construct are influenced by contextual factors, being crucial to understand the uneven development of smart cities. However, before modelling this interaction, it is necessary to better define what is smartness and urban performance.

3. MULTIDIMENSIONAL CONSTRUCT OF SMARTNESS AND RELATIONSHIP WITH SMART CITY PERFORMANCE

Considering that, smartness of a city refers to the ability of an urban innovation ecosystem to combine, recombine and catalyze the elements from each specific dimension (i.e., governance, techno-economic, environ-urban and socio-institutional) towards a smarter level. The smartness is influenced by city dynamics, its system configuration, its development trajectory and local contextual factors. The elements from each dimension were highlighted and detailed below, which enabled to define representative indicators

3.1. Conceptualizing the Smartness of a City Defining the Dimensions and Elements of Smartness

As a result of an evolutionary process, it is reasonable to assume that cities are in different stages of development towards a smarter level. We suggested that cities are in different "degrees of smartness", not only because the stage perspective, but also because the local specificities should be considered to design and implement feasible strategies (Camboim et al., 2019).

3.1.1. Techno-economic dimension

From this perspective, smart cities as urban innovation ecosystems will evolve by selecting what elements, features and capabilities should be created, replaced or improved in order to reach a smarter level (Angelidou, 2017; Camboim et al., 2019; Komninos et al., 2019). Consequently, the pace of development relies on the ability of urban ecosystem (i.e., smartness) to adapt its dimensions into the current socio-techno economic paradigm in order to ease the collaborative process of value creation and, consequently, generate wealth (Angelidou, 2017; Camboim et al., 2019; Komninos et al., 2019). In other words, smartness is a precondition for urban performance in the 21st century (Caragliu & del Bo, 2012, 2016).

To measure the smartness of an urban innovation ecosystem, we used the framework proposed by Camboim et al. (2019). Based on a systematic literature review and empirical cases, this framework provides a holistic perspective that can be useful to explain whether and how the four proposed dimensions (governance, techno-economic, environ-urban and socio-institutional) and their elements are intertwined to process of urban transformation and impact on city performance.

In the case of smart cities, as highlighted by Komninos et al. (2019, p. 2), "the uniqueness of each city trajectory, is based on rapidly changing digital technologies, and is ready to value opportunities offered over time". However, digital technology is a mean and not an end. It is true that smart cities are digital, but "a mere technological advance in itself is therefore insufficient to ensure a city's smartness" (Nilssen, 2019, p. 103).

The fact is that there is no smartness 135ithoutt knowl'dge. Knowledge is "increasingly perceived as the main source of economic growth" (Lambooy, 2002, p. 1019), because its application enables the creation of new technologies to solve different problems, which is the very nature of innovation. Knowledge plays a vital role on

enabling cities to design and successfully implement strategies to solve the different urban problems (Ardito et al., 2019). It is necessary then to foster the knowledge generation in order to achieve a higher level of development. But, how is it possible to do this?

Knowledge is embedded in individuals that can "greatly augmented by social processes" (Metcalfe, 2001, p. 568), which reinforces the importance of interaction to raise the local **knowledge base** (Leydesdorff & Deakin, 2011; Markkula & Kune, 2015).

Actually, a smart city must have different sources of knowledge and financing to engender entrepreneurial opportunities and, consequently, create innovative solutions (Kraus et al., 2015). The presence of **S&T institutions** and **collaborative spaces** (i.e. universities, research centers, science parks, incubators, living labs, fab labs, makerspaces, coworking), qualified **human capital**, diverse set of companies (large, high growth, new technology-based firms) and risk financing agents (i.e. accelerators, venture capital) in the city is essential to raise up the local knowledge base and to drive local **entrepreneurial activity** (Hájková & Hájek, 2014; Johnston & Huggins, 2016; Lai & Vonortas, 2019; Richter et al., 2015).

Besides that, the economic activities in a smart city have to show a higher degree of relatedness, being at same time specialized and diversified, but also following the path-dependence of the local knowledge base and the labor market (Boschma, 2015; Markkula & Kune, 2015). It necessary to transform the city into a global provider of valuable solutions, by leveraging the local business into **internationalization** (Anthopoulos & Fitsilis, 2014; Kumar et al., 2018; Kumar et al., 2016; Richter et al., 2015). This process may ensure its economic resilience over time (Boschma, 2015; Boschma et al., 2017)

However, only raising the knowledge base, increasing the availability of capital (i.e., both financial and human) and becoming a global innovation hub will not per se make a city smarter. It is important to consider how in fact the knowledge flows to make a real impact in the city development (Leydesdorff & Deakin, 2011).

3.1.2. Governance dimension

The recent literature stands out that this process should not happen in a disconnected way, from isolated **initiatives and projects** without a shared vision of the future formalized in a long-term **strategic plan** (Axelsson & Granath, 2018). Ben Letaifa (2015) suggests that smartness emerges when a city adopt a new governance model based on the quadruple helix approach by integrating and synchronizing formal leadership and

endogenous democratic participation in **dedicated organization** (Lee et al., 2014; Mora, Deakin, & Reid, 2019b).

Axelsson & Granath (2018) affirm that the involvement of stakeholders contributes to (or impede) smartness in the planning and outcomes. It is necessary, then, that these **partnerships** among stakeholders become more open, engaged and proactive to participate and collaborate in the smart city development (Boukhris et al., 2016; Capdevila & Zarlenga, 2015; Cortés-Cediel et al., 2019; Vanolo, 2016).

The literature highlights the smartness of a city can be enhanced by adopting **e-government** practices that will enable participation and collaboration between stakeholders and, consequently, improve **public services and utilities** and **decision-making** assertiveness (Angelidou, 2017; Gil-Garcia et al., 2016; Nam & Pardo, 2014). Another important topic is that smart city development requires new sources for **funding and investments** (Tomor et al., 2019), because those smart projects cannot be financed exclusively with the municipal budget (Caragliu & del Bo, 2016).

Besides that, the interactive process of knowledge creation, learning, innovation is facilitated in cities, because they provide a set of economic advantages that attract and approximate these different stakeholders into the same location engendering face-to-face interactions (Boschma, 2005; Glaeser, 2011). As a consequence, an important subset of urban economies, which some authors have labelled as 'buzz', emerges (Storper & Venables, 2004).

'Urban buzz' does not refer to individuals, but "mainly to the positive externalities created by the interface of various actions and behaviors in a given urban space" (Arribas-Bel et al., 2016, p. 190). The nature of buzz is spontaneous and fluid, because the "co-presence [of different actors] within the same economic and social context generates manifold opportunities for personal meetings and communication" (Bathelt et al., 2004, p. 38). Nowadays, with the widespread of digital technologies, this phenomenon occurs in real-time (Arribas-Bel et al., 2016).

This clustering process catalyzes the formation of 'communities of practice' that share a particular institutional structure, which stimulates the generation of local buzz and its rapid diffusion (Bathelt et al., 2004). The physical environment, thus, is crucial to foster these social processes and the urban development itself (Hillier, 2007).

3.1.3. Environ-urban dimension

The literature posits that the interaction among individuals can also be facilitated and stimulated through the provision of **advanced technological infrastructure** (Neirotti et al., 2014; Schaffers et al., 2011), **integrated mobility** (Battarra et al., 2018; Docherty et al., 2018; Li et al., 2019; Yigitcanlar & Kamruzzaman, 2019) and the existence of **diversified amenities and facilities** that make urban areas more conducive to entrepreneurship and more attractive to live, work and have fun (Belitski & Desai, 2016; Betz et al., 2016; Shapiro, 2006; Winters, 2011).

Besides that, a pleasant and functional **urban design** is important to stimulate connections and also to attract and retain highly educated and skilled human capital (Chiodi, 2016; Pancholi et al., 2019; Yigitcanlar et al., 2007), which are the 'very porters of knowledge and creativity' (Florida, 2012; Miguélez & Moreno, 2014). It means that smartness also relies on the ability of the city to provide high quality services, functional and beautiful spaces, consumer goods and digital infrastructure for its inhabitants (Gil-Garcia et al., 2015; Lee & Lee, 2014).

As a matter of fact, this process of urban transformation will not occur in the entire city and at same time, because it is not feasible in terms of investment and each neighborhood requires specific solutions (Caragliu & del Bo, 2016; Muñoz & Cohen, 2016). Actually, smart city projects are implemented at different territorial levels such as districts, neighborhoods, blocks or streets (Angelidou, 2014; Leon, 2008; Nielsen et al., 2019). In that way, cities around the world have focused on regenerating 'brownfield' sites and degraded urban areas (e.g., former industrial districts, abandoned waterfronts or ports) into **living labs** or even **innovation districts,** because small scale projects are more feasible and likely to succeed (Angelidou, 2014; Chang et al., 2018; Leon, 2008).

However, simply offering these assets is neither a necessary nor a sufficient condition to enhance smartness, because it can endanger the sustainable development of the city. The creation of sustainable business models "that includes multiple applications, agents, and technological and social innovations" (Anand & Navío-Marco, 2018, p. 797) are crucial to leverage the smart city development (Kuk & Janssen, 2011; Schiavone et al., 2019; Timeus et al., 2020).

Besides that, the wise management of **natural resources** is imperative to sustain economic growth, environmental protection and a high quality of life over time (Belanche et al., 2016; Caragliu et al., 2011; Herrschel, 2013). It means that 'smart management and investments' should create benefits for a maximum of citizens in order to improve their living conditions (Glasmeier & Nebiolo, 2016).

Depending on the smartness of a city, it is possible to reach high levels of efficiency and effectiveness (Caragliu & del Bo, 2012; Gil-Garcia et al., 2016), because solutions are locally adapted (Angelidou, 2017), which reduce costs and the possibility of failure (Cruickshank, 2011). Moreover, it enables the city to deliver higher value for different stakeholders, because the creation of these solutions is based on evidences (i.e. local data and information) and democratically constructed, which increase the level of customization, transparency and, consequently, legitimacy (Anthopoulos et al., 2016; Kuk & Janssen, 2011). In other words, as pointed by Manitiu and Pedrini (2016), the notion of 'urban smartness' is associated with a model of a technologically advanced, green and economically attractive city that remains competitive over time.

3.1.4. Environ-urban dimension

However, it is important to highlight that all of these improvements will not happen 'from day to night' and without resistance of different stakeholders (Appio et al., 2019; Boykova et al., 2016). Engelbert, van Zoonen & Hirzalla (2019) stress that the inclusion and participation of '**smart citizens**' in the center of decision-making processes may grant smartness. This '**spirit of community**' is vital for identifying priorities and also for solving urban issues (Boukhris et al., 2016; Lee & Lee, 2014; Vanolo, 2016)

This new dynamic should be followed by an institutional change (Dameri & Benevolo, 2016; Nam & Pardo, 2011). The fact is that smart cities are conditioned by their **'institutional capital'** (Dameri & Ricciardi, 2015), which shapes the choices and, at some level, the outcomes of this urban innovation process (Bibri & Krogstie, 2017b).

One of the main discussions is how **land use** policies can promote a more sustainable socioeconomic development (Sokolov et al., 2019; Yigitcanlar et al., 2019), by preserving the historical heritage and cultural identity of a territory, making districts more vibrant and attractive for business and people, and even, guaranteeing the access to affordable housing and infrastructure (Lara et al., 2016).

Nonetheless, as any path-dependent process is necessary to be aware of positive and negative lock-in. The 'change of mindset' is important to embrace **socio-cultural diversity** without neglecting the local history and traditions in order to reinforce city attachment (Belanche et al., 2016; Kourtit et al., 2012).

The fact is that in a knowledge-based economy embedded in a digital revolution, cities should be institutionally arranged to facilitate the growth, accumulation and

application of knowledge by merging physical and digital environments in order to achieve a sustainable socioeconomic development (Yigitcanlar et al., 2018). In other words, smart city development relies not only on the change of **formal and informal rules**, but also on sociocultural aspects, such as trust to ease (or not) knowledge production and creativity in cities (Camboim et al., 2019).

In sum, smartness of a city refers to the ability of an urban innovation ecosystem to combine and catalyze the above-mentioned elements from each specific dimension (i.e., governance, techno-economic, environ-urban and socio-institutional) towards a smarter level by considering city dynamics, its system configuration, its development trajectory and local contextual factors.

Then, 'smartness of a city' can be viewed as an integrated multidimensional construct comprised by a set of elements that interact and, consequently, influence the urban performance in terms of quality of life, innovation and environmental sustainability. This multidimensional construct is summarized in Chart 1.

Chart 1 - Dimensions and Elements of Smartness

Dimension	Element	Description
Techno-economic	Knowledge Base	Refers to the different types of knowledge (analytic, synthetic and symbolic) produced by S&T institutions, industries and other local organizations.
	Economic Activities	Refers to existence of businesses from different sectors that use digital technologies to create and deliver value.
	Entrepreneurial Activity	Refers to the creation of new firms (tech or non-tech based).
	Human Capital	Refers to the presence of high-skilled people living in the city.
	Collaborative Spaces	Refers to the existence of spaces that provide shared facilities, practices and tools in order to foster networking, collaboration, knowledge transfer, co-creation.
	Internationalization	Refers to the provision of high-added valuable solutions for the global market through established international business networks.

Governance	Strategic Plan	Refers to existence of a plan with a long-term vision, strategies and desired objectives to achieve a sustainable socioeconomic development.
	Initiatives and Projects	Refers to the implementation of projects and a set of action that aim to make a city smarter.
	Dedicated Organization	Refers to the existence of an autonomous organization steered by main local stakeholders, which coordinates and boost smart city development.
	Public Services and Utilities	Refers to the provision of ICT-based services that are essential for citizens and city administration.
	E-government	Refers to digital tools and practices related to open governance, which are implemented by the government in order to ensure transparency, inclusiveness and participation.
	Partnerships	Refers to the establishment of alliances, cooperation agreements and collaborative networks to solve different urban issues.
	Funding and Investments	Refers to the amount spent for financing smart city projects and activities.
Environ-Urban	Diversified Amenities and Facilities	Refers to the existence of a wide range of entertainment, culture, and catering venues and green public spaces for leisure.
	Urban Design	Refers to the aesthetic of urban realm (buildings, streets, public spaces, districts, etc.) and its functionality, which make urban areas more attractive and sustainable.
	Advanced Technological Infrastructure	Refers to the deployment of digital and green technologies in infrastructures, which provides a huge amount of data that can be analyzed in order to make cities more efficient and connected
	Integrated Mobility	Refers to the mix of walkable streets and multimodal transportation in order to reduce commuting time and make cities more environmentally-friendly.
	Living Labs/Innovation Districts	Refers to delimited urban areas (street or district) used to test ideas and technologies, to implement industrial cluster policies, to revitalize public spaces in order to achieve economic growth and social development

Socio-Institutional	Smart Citizens	Refers to the presence of citizens actively involved in public affairs that propose and co-create solutions to deal with different urban issues.
	Spirit of Community	Refers to the existence of individuals or groups that share similar values and resources, which are committed and engaged into activities that benefit their community.
	Socio-Cultural Diversity	Refers to the balance between preservation of local identity and tolerance to differences on cultural, ethnic, religious and gender orientation aspects.
	Formal and Informal Rules	Refers to a flexible and trust-based institutional framework that encompass different interests on win-win situations.
	Land Use	Refers to pro-development policies that stimulate mix use of areas and implement high-density strategies.

Source: Adapted from Camboim et al. (2019)

In that way, the creation or adaptation of indicators is crucial to better capture smartness of city (Sharifi, 2019). These indicators have to consider not only the input-output logic, but also which will be the main outcomes of this process in a multidimensional and integrated approach (Mora, Deakin, Reid, et al., 2019).

3.2. Defining Smart City Performance

The literature highlights that a city should address social, economic, technological and environmental issues to become smarter (Lim et al., 2019; Mora et al., 2017). As mentioned before, the smart city solutions designed and implemented in smart projects may help "to increase the competitiveness of local communities through innovation while increasing the quality of life for its citizens through better public services and a cleaner environment" (Appio et al., 2019, p. 1).

This process of urban transformation should enable any city to achieve some common desired outcomes such as quality of life, environmental sustainability, innovation that are linked to the Sustainable Development Goals (SDG's) defined by UN Agenda (United Nations, 2015). Each of these outcomes reflects how a city is performing and advancing (or not) towards a smarter level (Camboim et al., 2019).

Then, we define ‘smart performance’ as the outcome of the process of transformation of the different elements of city dimensions that occurs in a balanced way. It is smart because the growth in some indicators in one dimension should lead to development in others. If the projects may enhance the smartness of city and, consequently, its performance must be measured in terms of quality of life, economic prosperity and environmental sustainability. It means that the ‘smart performance’ of a city is direct and indirectly affected by changes in city dimensions and its smartness (Camboim et al., 2019).

In 21st century, the utmost goal of any city is to provide high quality of life (QoL) for its inhabitants (Caragliu et al., 2011; de Guimarães et al., 2020; Shapiro, 2006). Better utilities, social inclusion, existence of good amenities and facilities, work-life balance are crucial to guarantee high levels of well-being and livability conditions and, consequently, to attract and retain talented people and companies (Florida, 2012; Shapiro, 2006; Winters, 2011).

This new dynamic of wealth creation relies on the local innovation economy (Yigitcanlar et al., 2018). Considering that innovation is the engine for economic growth and development, all those stakeholders must constantly seek to create, produce and deliver high added value solutions to generate benefits and gains for the urban innovation ecosystem itself (Camboim et al., 2019; Nicolas et al., 2020; Zygiaris, 2013). For example, an increase in GPD per capita should be followed by a reduction in inequality meanwhile preserving natural resources.

Thus, this cannot be done at any cost. A city that values the quality of life of its citizens must also be concerned with environmental sustainability (Bibri & Krogstie, 2017; Ciasullo et al., 2020; Marsal-Llacuna et al., 2015). The efficient use of natural resources, reduction of air pollution and real commitment to deal with climate change are the main objectives of any ‘smart sustainable city’ (Ahvenniemi et al., 2017; Akande et al., 2019; de Jong et al., 2015; Herrschel, 2013).

The challenge is to deliver all these desired outcomes at the same time without incurring in traditional trade-off situations. As a matter of fact, the effective impact of the smart city development occurs when these solutions contribute to achieving the strategic objectives defined by the local governance.

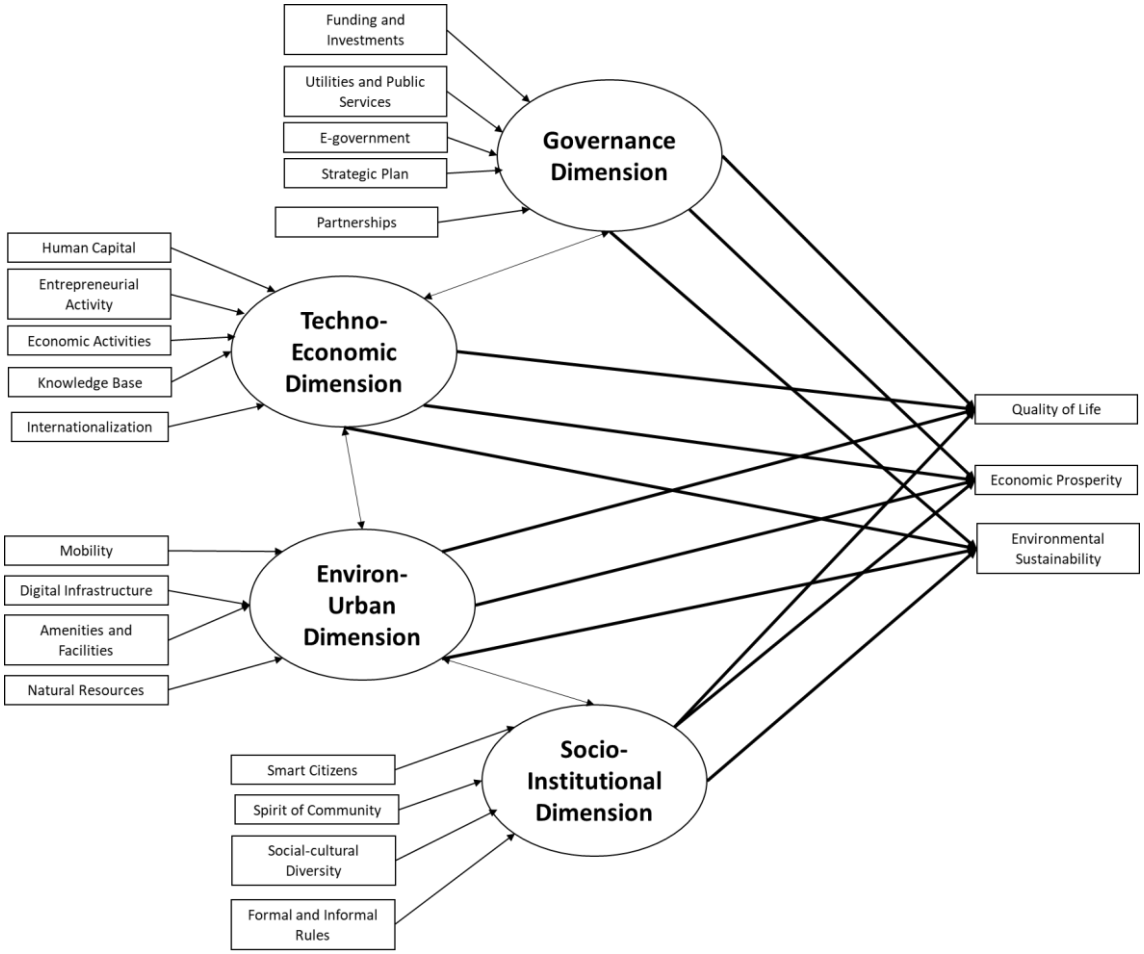
For example, cities have been focusing on renewable energy, electric mobility solutions and so on, to become carbon neutral, and, consequently, more sustainable. The development of new products fostered by the creation of a municipal investment fund for

research and development or startups incubators can contribute to achieve economic prosperity. The building of affordable houses to receive immigrants and offering training programs for professional relocation can enhance social cohesion and quality of life.

Considering the lack of data availability on city or even regional level of all these indicators, it was used some questions from the perception survey to compose the urban performance in terms of quality of life, economic prosperity and innovation.

In sum, each city can improve its performance by making their elements smarter through a holistic approach. For that, the city should consider its 'degree of smartness' to design and implement smart city strategies and projects that will change the elements of innovation ecosystem and, consequently achieve a smart sustainable development. These relationships are represented in Figure 1.

Figure 1 – Smartness model and its impact on performance.



From an evolutionary approach, the assessment at macro-level also has to reveal if the territory has the ability to adapt their structures and elements to the new paradigm

and sustain growth over time (Huovila et al., 2019). Therefore, our main hypotheses are that:

I. ***All dimensions of smartness are positively correlated;***
   a. *Governance Techno-Economic dimensions are positively correlated*
   b. *Governance and Environ-Urban dimensions are positively correlated*
   c. *Governance and Socio-institutional dimensions are positively correlated*
   d. *Environ-Urban and Techno-Economic Dimension are positively correlated*
   e. *Socio-Institutional and Techno-Economic dimensions are positively correlated*
   f. *Socio-Institutional and Environ-Urban dimensions are positively correlated*

II. ***All dimensions of smartness have a positive impact on smart city performance; and,***
   a. *Governance has a positive impact on smart city performance*
   b. *Techno-Economic Dimension has a positive impact on smart city performance*
   c. *Environ-Urban dimensions has a positive impact on smart city performance*
   d. *Socio-Institutional has a positive impact on smart city performance*

For testing these hypotheses, it is necessary to develop a model composed by those smart indicators, to analyze the causal relationships among them and with the smart city performance over time. This assessment model will provide information and insights to guide which governance efforts should be carried out to transform a city into a smart city. In that way, the creation or adaptation of indicators is crucial to better capture smartness of city and its performance. These indicators have to consider not only the input-output logic, but also which will be the main outcomes of this process in a multidimensional and integrated approach (Mora, Deakin, Reid, et al., 2019). This multidimensional and integrative approach for smart city development imposes some challenges for measuring

city performance, because the identification of latent variables and the establishment of possible causal paths among them is complex (Nicolas et al., 2020). The lack of appropriate indicators for capturing the smartness of a city and models that provide more than descriptive information should be addressed to ease smart city development.

4. METHODOLOGICAL PROCEDURES

In order to achieve our main objective that is to measure the smartness of urban innovation ecosystem, it is necessary to operationalize the elements from each construct presented in the Table 2 into measurable indicators and test them through quantitative methods and techniques. In this sense, this research adopted a descriptive approach to assess the relationships and impacts between the smartness of city and its performance. Descriptive approach is useful to describe a situation through the measurement of an event or activity (Hair et al., 2005).

4.1. Data Collection

Considering that smart city initiatives started mainly in Europe and after 2006, we chose the Eurostat Statistical Database (Eurostat, 2019b, 2019a) as the main data source for this study. More specifically, we gather perception surveys data, Urban Audit data and Metropolitan Regions Data during 2006–2015 period. This database is an adequate source, because it provides a mix of objective and subjective indicators at urban-level, which enables longitudinal data analysis and comparison among cities.

However, it is big challenge to directly measure these outputs given the lack of available longitudinal urban data. To overcome this issue, Liguori et al. (2019) and Audretsch and Belitski (2017) suggest to utilize citizens perception surveys in order to allow longitudinal comparisons between the cities by capturing their subjective performance. It is important to highlight that individuals are the micro-agents of the processes of value co-creation in any urban ecosystem.

Thus, it is possible to infer that citizens perception about the quality of life in ‘‘their’’ city and the systemic conditions of urban ecosystem can be useful to assess its smartness (Audretsch & Belitski, 2017; Liguori et al., 2019). In this sense, EU conduct a survey with more than five hundred citizens from different European cities every three years since 2006, where they asked in 1-5 Likert Scale how satisfied citizens were about

a determined indicator. We used just the percentage of citizens that were very satisfied with the correspondent indicator.

Moreover, to contextualize our data with the process of urban transformation, we integrated in our main database the list of cities that shows EU initiatives related to smart city development since 2006 until 2015. This information was retrieved from Smart Cities Information System (Eurostat, 2019a). Other international databases will be considered for indicators that are only available at country or regional-level, such as World Bank, UN, Global Data Lab and so on.

After preparation, in which we integrated above-mentioned data sources and cleaned missing data, the final sample were left with 115 cities from 30 different countries. The list of cities included in this study were summarized in Table 3.

Table 3 - List of Cities

City Name	Country		City Name	Country
Wien	Austria		Reykjavík	Iceland
Graz	Austria		Dublin	Ireland
Bruxelles / Brussel	Belgium		Roma	Italy
Antwerpen	Belgium		Napoli	Italy
Liège	Belgium		Torino	Italy
Sofia	Bulgaria		Palermo	Italy
Burgas	Bulgaria		Bologna	Italy
Zagreb	Croatia		Verona	Italy
Lefkosia	Cyprus		Rīga	Latvia
Praha	Czechia		Liepāja	Latvia
Ostrava	Czechia		Jelgava	Latvia
København	Denmark		Daugavpils	Latvia
Aalborg	Denmark		Jurmala	Latvia
Tallinn	Estonia		Ventspils	Latvia
Helsinki / Helsingfors	Finland		Rezekne	Latvia
Oulu / Uleåborg	Finland		Valmiera	Latvia
Paris	France		Jekabpils	Latvia
Paris	France		Vilnius	Lithuania
Strasbourg	France		Luxembourg	Luxembourg
Bordeaux	France		Valletta	Malta
Lille	France		Amsterdam	Netherlands
Rennes	France		Rotterdam	Netherlands

Marseille	France		Groningen	Netherlands
Berlin	Germany		Oslo	Norway
Hamburg	Germany		Warszawa	Poland
München	Germany		Kraków	Poland
Frankfurt am Main	Germany		Gdańsk	Poland
Essen	Germany		Białystok	Poland
Stuttgart	Germany		Lisboa	Portugal
Leipzig	Germany		Lisboa	Portugal
Dresden	Germany		Braga	Portugal
Dortmund	Germany		Bucureşti	Romania
Düsseldorf	Germany		Cluj-Napoca	Romania
Nürnberg	Germany		Piatra Neamţ	Romania
Darmstadt	Germany		Bratislava	Slovakia
Freiburg im Breisgau	Germany		Košice	Slovakia
Frankfurt (Oder)	Germany		Ljubljana	Slovenia
Augsburg	Germany		Madrid	Spain
Karlsruhe	Germany		Barcelona	Spain
Saarbrücken	Germany		Málaga	Spain
Koblenz	Germany		Oviedo	Spain
Rostock	Germany		Stockholm	Sweden
Kaiserslautern	Germany		Malmö	Sweden
Konstanz	Germany		Zürich	Switzerland
Mannheim	Germany		Genève	Switzerland
Münster	Germany		Ankara	Turkey
Braunschweig	Germany		Antalya	Turkey
Oberhausen	Germany		Diyarbakır	Turkey
Kassel	Germany		İstanbul	Turkey
Osnabrück	Germany		London	United Kingdom
Wolfsburg	Germany		Glasgow	United Kingdom
Fürth	Germany		Manchester	United Kingdom
Zwickau	Germany		Greater Manchester	United Kingdom
Athina	Greece		Cardiff	United Kingdom
Athina	Greece		Belfast	United Kingdom

Irakleio	Greece		Newcastle upon Tyne	United Kingdom
Budapest	Hungary		Tyneside conurbation	United Kingdom
Miskolc	Hungary			

4.2. Data Processing

To define the constructs and items that will compose measurement model, it was considered the four dimensions (i.e., governance, techno-economic, environ-urban and socio-institutional) and their elements as proposed by Camboim et al. (2019), that affects the city performance. In this study, the item generation was based on indicators available Eurostat database. These indicators were classified into the correspondent elements represented in the Table 2.

Table 2 – Dimensions, Elements and their smart indicators

Dimensions	Element	Indicator	Indicator Description	Unit	Coverage	Sources
Technoeconomic	Economic Activities	E_ESELL	Percentage of Business' that have at least 1% of turnover from e-commerce, without financial sector (10 persons employed or more)	Percentage of firms	National-level	(Eurostat, 2019b)
		E_ERP1	Business with integration of internal processes	Percentage of firms	National-level	(Eurostat, 2019a)
		PS2012V	In this city it is easy to find a good job (strongly agree)	Percentage of individuals	City-level	(Eurostat, 2019a)
	Human Capital	EC2009I	Prop. of employment in industries (NACE Rev.1.1 C-E)	Percentage of total employees	City-level	(Eurostat, 2019a)
		TE1026V	Students in higher education (ISCED level 5-6)	Number of Students	City-level	(Eurostat, 2019b)
		TE2031V	Persons aged 25-64 with ISCED level 5, 6, 7 or 8 as the highest level of education	Percentage of population	City-level	(Eurostat, 2019b)
	Entrepreneurial Activity	BUS_DEN	New business density	New registrations per 1,000 people ages 15-64	National-level	(World Bank, 2019)

Governance	Funding and Investments	PS2082V	This city spends its resources in a responsible way: (strongly agree)	Percentage of individuals	City-level	(Eurostat, 2019b)
	Strategic Plan	SCI01	City involved in EU initiatives related to smart cities development (yes/no)	Date of the first initiative	City-level	(Eurostat, 2019b)
	E-government	PS2042V	When you contact administrative services of this city, they help you efficiently (strongly agree)	Percentage of individuals	City-level	(Eurostat, 2019b)
	Public Services and Utilities	PS3042V	Health care services offered by doctors and hospitals in this city (very satisfied)	Percentage of individuals	City-level	(Eurostat, 2019a)
		PS1022V	Schools in the city (very satisfied)	Percentage of individuals	City-level	(Eurostat, 2019b)
Environ-Urban	Advanced Digital Infrastructure	HH_DEG1	Households located in cities with internet access	Percentage of households	National-level	(Eurostat, 2019b)
	Urban Space	PS3062V	Public spaces in this city such as markets, squares, pedestrian areas: very satisfied	Percentage of individuals	City-level	(Eurostat, 2019b)
		PS3072V	Outdoor recreation outside / around this city, such as walking, cycling or picnicking (very satisfied)	Percentage of individuals	City-level	(Eurostat, 2019b)
	Mobility	PS1012V	Public transport in the city, for example bus, tram or metro (very satisfied)	Percentage of individuals	City-level	(Eurostat, 2019b)
	Innovation Districts	INNO_DIST	Existence of at least one innovation district	Date of the first initiative	City-level	(GIID, 2019)
	Amenities and Facilities	PS1052V	Green spaces such as public parcs or gardens (very satisfied)	Percentage of individuals	City-level	(Eurostat, 2019b)
		PS1082V	Cultural facilities such as concert halls, theatres, museums and libraries in the city (very satisfied)	Percentage of individuals	City-level	(Eurostat, 2019b)
		PS3250V	Availability of retail shops (very satisfied)	Percentage of individuals	City-level	(Eurostat, 2019b)
	Natural Resources	PS2072V	This city is a clean city (strongly agree)	Percentage of individuals	City-level	(Eurostat, 2019b)
		PS3260V	The quality of the air in the city (very satisfied)	Percentage of individuals	City-level	(Eurostat, 2019b)
Socio-Institutional	Smart Citizens	PS3310V	Most people in my neighborhood can be trusted (strongly agree)	Percentage of individuals	City-level	(Eurostat, 2019b)
	Socio-cultural Diversity and Inclusion	PS2022V	Foreigners who live in this city are well	Percentage of individuals	City-level	(Eurostat, 2019b)

			integrated (strongly agree)			
		PS2032V	In this city, it is easy to find good housing at a reasonable price (strongly agree)	Percentage of individuals	City-level	(Eurostat, 2019b)
		PS3082V	The presence of foreigners is good for this city: strongly agree	Percentage of individuals	City-level	(Eurostat, 2019b)
	Spirit of Community	PS3092V	Generally speaking, most people in this city can be trusted (strongly agree)	Percentage of individuals	City-level	(Eurostat, 2019b)
	Formal and Informal Rules	PS3320V	The public administration of the city can be trusted (strongly agree)	Percentage of individuals	City-level	(Eurostat, 2019b)
Urban Performance	Quality of Life	PS2092V	You are satisfied to live in this city: strongly agree	Percentage of individuals	City-level	(Eurostat, 2019b)
		PS3290V	You feel safe in this city: strongly agree	Percentage of individuals	City-level	(Eurostat, 2019b)
	Economic Prosperity	PS3330V	Your personal job situation: very satisfied	Percentage of individuals	City-level	(Eurostat, 2019b)
		PS3340V	The financial situation of your household: very satisfied	Percentage of individuals	City-level	(Eurostat, 2019b)
	Environmental Sustainability	PS3122V	This city is committed to the fight against climate change	Percentage of individuals	City-level	(Eurostat, 2019b)

The fourth step is related to the specification of a measurement model that captures the expected relationships between the indicators and the focal construct and sub-dimension they are intended to represent. The raw data was prepared for the Cluster and Structural Equation Modelling (SEM) analysis such as missing value, standardization and so on.

4.3. Data Analysis

The data screening process enabled to run the descriptive analysis and the validation of proposed model. To create a consistent metric for assessing the smartness of a city and its relationship with urban performance, we used quantitative methods and techniques by considering a longitudinal perspective.

After gathering and preparing data, it is important to split the database in different samples to test, refine and validate the metric. Then, we performed feature scaling procedure considering that our features have different units of measure. After that, we applied principal component analysis (PCA) technique in order to reduce the

dimensionality of our unique database. The chosen indicators for elements that compose each construct were tested in an exploratory factor analysis (EFA) to evaluate their adequacy and correlations (e.g., KMO and Bartlett's Test), which resulted in four constructs.

In order to test how this model impacts on urban performance, the relationships among constructs were tested through the statistical method of multiple regression and Structural Equation Modelling (SEM).

This method is well suited to investigate complex relationships among multiple constructs that are represented by several variables in an integrated model (Malhotra, 2011). SEM consist of two sub-models: the measurement model and the structural model. The former is to test the links between item (or measurement variables) and their corresponding constructs (or latent variables). The latter one is to quantify the cause-effect relationships between the latent variables (i.e., exogenous and endogenous).

Considering that measuring the smartness of a city is complex, the SEM will help explain how dimensions are intertwined and which elements are most important for smart city development. Sharifi (2019) highlighted that a major shortcoming in smart city assessment is “the limited use of modelling and scenario-making techniques for dealing with future uncertainties”. Few studies used SEM in the context of smart cities with the exception of Nicolas et al. (2020) and Guimarães et al. (2020).

Considering our approach, it is necessary to define a suitable SEM strategy to assess these complex relationships of the hypothesized model and perform confirmatory analysis. The two most prevalent SEM based analytical methods are covariance-based SEM (CB-SEM) and variance-based SEM (PLS-SEM) (Hair et al., 2014). In this study, it will be used the CB-SEM, because it enables to specify the multiple relations among exogenous variables (e.g., non-recursive models) and their conjoint effect on endogenous variable.

The properties of the scale were examined, and evaluated its convergent, discriminant, and nomological validity through a pre-test by running the PLS-SEM algorithm. The sample was chosen randomly through the use of oversampling techniques (i.e., bootstrapping) to ensure the stability of results.

After that, it is evaluated the goodness of fit of the measurement model (e.g., Chi-square, GFI, RMSEA, SRMR) and assessed the validity (e.g., AVE) and reliability (e.g., Cronbach’s alpha, Fornell and Larcker’s index) of indicators at the construct level. These preceding analyses can be used to begin to identify problematic indicators (i.e., low

validity, low reliability, strong and significant measurement error covariances, and/or non-hypothesized cross-loadings that are strong and significant) that should be replaced or dropped. Multicollinearity problems also should be examined using the variance inflation factor (VIF).

5. RESULTS AND DISCUSSION

In order to build smartness model, we forced the dimensional reduction of our bunch of features to settle upon a single factor solution for each of factors (or dimension). Features that did not fit its respective dimension (i.e., loadings of less than .5) were then eliminated. We verified the degree of intercorrelations among features and the statistical probability of significant correlations among them through the Measurement of Sampling Adequacy (KMO) and Bartlett's sphericity tests (0.736 and p-value<0.001, respectively). After this validation, this process yielded a set of 19 features that formed the four dimensions of smartness accumulating 61% of explained variance. Table 3 illustrates summary statistics built in the PCA.

Table 3 - Principal Components of Smartness Construct

Indicator	Indicator Description	PC1	PC2	PC3	PC4
PS1012V	Public transport in the city	0.622212	0.035368	0.331186	-0.04738
PS1022V	Schools in the city	0.732679	0.200366	0.04971	0.172007
PS1052V	Green spaces	0.848197	0.091387	0.062857	0.000659
PS1082V	Cultural facilities	0.73733	0.218124	0.393639	-0.23396
PS2022V	Foreigners who live in this city are well integrated	0.077909	0.126205	0.047025	0.652894
PS2032V	In this city, it is easy to find good housing at a reasonable price	-0.07875	0.149387	-0.16845	0.697886
PS2042V	When you contact administrative services of this city, they help you efficiently	0.537219	-0.059	0.185331	0.546118
PS3042V	Health care services	0.585688	-0.08567	0.590282	0.081661
PS3062V	Public spaces	0.738889	0.005181	0.130537	0.215726
PS3082V	The presence of foreigners is good for this city	0.070982	0.825502	-0.0597	0.285006
PS3092V	Generally speaking, most people in this city can be trusted	0.449963	0.164459	0.606226	0.310451

PS3250V	Availability of retail shops	0.622407	0.166498	-0.27364	-0.14148
PS3260V	The quality of the air in the city	0.56357	-0.16598	0.218305	0.318769
PS3310V	Most people in my neighborhood can be trusted	0.315905	0.846899	0.146851	0.196188
PS3320V	The public administration of the city can be trusted: strongly agree	0.428566	0.708364	-0.03895	0.21791
EC2009I	Prop. of employment in industries (NACE Rev.1.1 C-E)	0.064697	-0.53674	0.279733	-0.01912
E_ESELL	Percentage of Business' that have at least 1% of turnover from e-commerce, without financial sector (10 persons employed or more)	0.155326	0.035916	0.702626	-0.11991
E_ERP1	Business with integration of internal processes	-0.08503	-0.46768	0.658716	-0.03675
INNO_DIST	Existence of at least one innovation district	-0.12222	0.553705	0.104904	-0.28492
SS Loadings		4.623374	2.943901	2.235003	1.833821
Proportion Var		0.243335	0.154942	0.117632	0.096517
Cumulative Var		0.243335	0.398278	0.515909	0.612426

Rotation: Varimax and Interval Confidence: 95%.

It is important to highlight that the proposed model by Camboim et al. (2019) suffered some changes, since some elements from governance dimension were coupled with elements present in the environ-urban dimension. As well as, the socio-institutional dimension was divided in two factors.

The first factor (PC1) shows a strong positive correlation between elements related to the availability of diversified amenities like retail shops and cultural facilities, the importance of the quality of urban spaces and the provision of good utilities like public transportation, education, health. The relationship between these elements has a broader mean of **urban attractiveness and utilities**.

The second factor (PC2) is characterized by elements that reflects how stakeholders perceive each other in terms of trust and how they deal with diversity. It demonstrates that some cities may have a precondition to civic engagement and participation considering high levels of trust between city neighbors and with the local public administration. Interestingly that, depending on the proportion of people employed

in a determined sector, they tend to have less trust in each other. This factor is related to the **collaborative mindset.**

The third factor (PC3) shed light on the digital and operational capability of business and the level of trust among the citizens, which may reflect on how they made deals in the local economy. This factor can be summarized as **smart businesses and citizens**, which characterizes what they are (e.g., digital-based), how they work (e.g., integrated) and what they expect as stakeholders (e.g., good management of natural and financial resources).

The fourth factor (PC4) refers to the integration of vulnerable groups into the society and the efficiency of public administrative services. PCA4 highlights the importance of public initiative on promoting **social inclusion** in order to give opportunities and better living conditions for foreigners and fulfilling citizen's needs. It means that reducing inequalities and making public administrative services more efficient may have a positive impact on smartness.

These four dimensions reveal what differentiates the smartness of urban innovation ecosystems of cities. In fact, this multidimensional construct puts the stakeholders in the center of the process of urban transformation. It also orientates which policies and mechanisms can be formulated to improve the elements that have a greater influence in the urban ecosystem.

It is important to highlight that some elements, given their low factor loadings, were removed from the smartness dimensions such as entrepreneurial activity, strategic planning, and digital infrastructure. This could have at least two explanations: a) the indicators are not appropriate to capture variability, because they are not available at city-level and, consequently, do not represent the reality; b) another possibility is that these elements are "preconditions" to make the urban innovation ecosystem smarter and, consequently, should be treated as antecedents and not as features of smart city development.

In order to measure the urban performance, we considered the features that represent in the perception survey the quality of life, the economic prosperity and environmental sustainability. Then, we tested the statistical probability of significant correlations among them through the Measurement of Sampling Adequacy (KMO) and Bartlett's sphericity tests (0.701 and p-value<0.001, respectively). After this validation, this process yielded a set of 5 features that formed the three dimensions of urban

performance accumulating 77% of explained variance. Table 4 illustrates summary statistics built in the PCA.

Table 4 - Principal Components of Urban Performance

Indicator	Indicator Description	PC5	PC6	PC7
PS2092V	You are satisfied to live in this city: strongly agree	0.418617	0.770741	0.369374
PS3122V	This city is committed to the fight against climate change	-0.111791	0.149192	0.640961
PS3290V	You feel safe in this city: strongly agree	0.455913	0.755920	0.142062
PS3330V	Your personal job situation: very satisfied	0.814369	0.379972	-0.329193
PS3340V	The financial situation of your household: very satisfied	0.810418	0.387122	-0.038390
SS Loadings		1.715567	1.481957	0.677292
Proportion Var		0.343113	0.296391	0.135458
Cumulative Var		0.343113	0.639505	0.774963

Each construct is related to the desired outcomes of a smart city, which focus on, economic prosperity (PC5), quality of life (PC6) and environmental sustainability (PC7).

In order to analyze how smart is an urban ecosystem, we argue that creating a ranking could not suffice to guide the different actors of an ecosystem for designing appropriate policies. It is necessary to compare urban ecosystems considering its different dimensions and which stage of development they are in relation with others.

To overcome this issue, we used the factors created in the EFA to perform then a confirmatory analysis (CFA) through CB-SEM. Both EFA and CFA are applied when you want to estimate the dimensionality of a model and to measure some of the elements. Coupling these techniques enabled us to measure the impact of smartness on the dimensions of urban performance.

Then, we tested the fit indices to estimate how plausible the model was by comparing with cutoff point recommend by the literature (Brown, 2015; Mair, 2018). Almost none of indices reached these cutoff points (Table 5), which may be related to the small sample for a great number interrelationship or even the indicators for each one of the constructs.

Table 5 – Fit indices from CB-SEM

Fit Indices	Value	Recommended
DoF	234.000000	-
DoF Baseline	276.000000	-
chi2	843.359665	-
chi2 p-value	0.000000	>0.05
chi2 Baseline	2011.270378	-

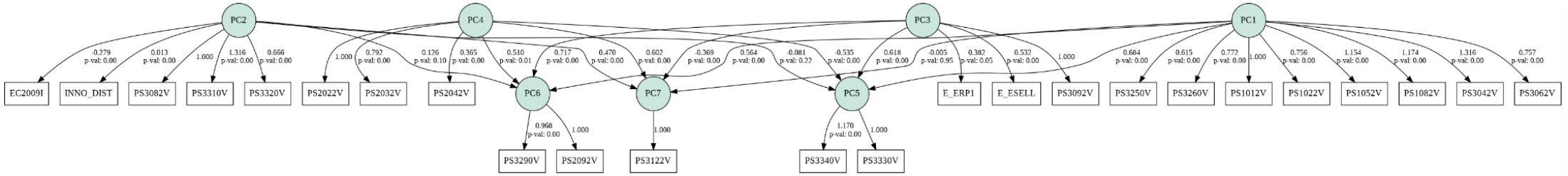
CFI	0.648839	>0.95
GFI	0.580683	>0.95
AGFI	0.505421	>0.90
NFI	0.580683	>0.95
TLI	0.585810	>0.95
RMSEA	0.181558	<0.05
AIC	110.916008	-
BIC	268.129766	-
LogLik	10.541996	-

Despite the not well-fitted model, there are some findings that can help to disclose how cities can improve its smartness and urban performance (see Appendix A). The model shows that urban attractiveness (PC1) and smart business and citizens (PC3) have a significant impact on economic prosperity (PC5), but social inclusion (PC4) policies may have a negative impact. It means that not necessarily all dimensions will enhance urban performance, because some actions may represent opposite interests and lead to trade-off situations.

Conversely, all smartness dimensions (exception to collaborative mindset) have a positive impact on quality of life, which stress the importance of holistic strategies and interventions in the city environment and its socioeconomic dynamics. When focusing on the environmental sustainability, it is important to bring together the different stakeholders to discuss about issues that require a collaborative mindset (PC2) and diverse perspectives including the different segments of the society. It is also important to maintain a balance between economic development, interventions in urban realm and sustainability policies, because it can cause negative effects on the environment. These relationships are represented in the Figure 2.

The model validates some of our hypothesis when considering the positive impact on urban performance (See Appendix A). Urban attractiveness and Utilities dimension (PC1) has a positive and significant impact on Economic Prosperity (PC5) and Quality of Life (PC6), but it has not a significant impact on Environmental Sustainability (PC7). Collaboration mindset (PC2) has a positive and significant impact on Quality of Life (PC6) and Environmental Sustainability (PC7), but it has not a significant impact on Economic Prosperity (PC5). Smart business and citizens (PC3) dimension has a positive and significant impact on Economic Prosperity (PC5) and Quality of Life (PC6), but it has a negative impact on Environmental Sustainability (PC7). Social inclusion (PC4) dimension has a positive and significant impact on Environmental Sustainability (PC7) and Quality of Life (PC6), but it has a negative impact on Economic Prosperity (PC5).

Figure 2 – CB-SEM model for the smartness and urban performance.



Therefore, it is necessary to design strategies and develop projects that foster economic activities and improve the quality of infrastructure and services in a more direct way without neglecting the importance of people and its interactive networks. The policies related to the social dimension are important, but it will not have an impact in the short-term.

6. CONCLUDING REMARKS

In the last decade, smart city model emerged as solution to tackle different urban issues. There are many initiatives and projects being implemented around the world, but there are some concerns if they are delivering what they promise. For this, it is necessary to evaluate how this model is contributing (or not) to urban development.

In this sense, a growing awareness about smart city assessment has proliferated (Sharifi, 2019, 2020). Assessment schemes can be useful to monitor the impacts of smart city interventions, being important support systems for decision makers (Caird & Hallett, 2019). A great number of models, indexes, rankings, toolkits and benchmarking were created for that purpose.

However, despite the recent advances in the field of smart city assessment, it is still not clear what are the elements that compose smartness and how it affects urban performance over time. Some definitions focus exclusively on the technology dimension of this construct and end up neglecting the social, environmental and economic dimensions (Ahvenniemi et al., 2017).

In this study, we presented a multidimensional and integrative approach to define the smartness concept and establish a measurement model to assess the impact of smartness on urban performance. As highlighted in the previous section, smartness will vary depending on the combination of elements from each city dimension that can be changed and improved through smart city projects over time.

The focus on the economic, governance, environ-urban dimensions may have a significant impact on urban performance. While in the social dimension, it could be important to adopt a more integrative and holistic perspective due to the fact that it does not show a linear and direct impact on performance.

In practical terms, when analyzing cities from Europe through the use of database from 2015, the elements that generate the dynamics of smart city development, in that

time frame, are related to the environ-urban and governance dimension, represented by urban attractiveness and utilities and the techno-economic dimension related to smart business. The design of strategies and projects to improve the amenities and facilities and the quality of services provided to citizens may enhance the city smartness, as well as, stimulating business to become more digital and efficient.

It is expected that these results provide insights for decision-makers about what should be done first and will have a greater impact on city performance. By identifying the smartness of a city, it will be possible to effectively design and implement strategies to enhance the city smartness.

Despite the interesting results, this study has some limitations. The structural model has not reached satisfactory parameters. It happened maybe, because the selected indicators that do not represent elements related to smartness. So, it should be interesting to develop a research instrument capable to capture particularities of this concept.

Moreover, this study focused only in European cities in a cross-sectional analysis. So, it should be interesting to focus on other continents and make comparisons among cities around the world and analyze if the elements and constructs remains the same along over time.

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APPENDIX A - RELATIONSHIPS AMONG CONSTRUCTS

index	Lval	op	rval	Estimate	Std. Err	z-value	p-value
0	PC5	~	PC1	0.6840564534990217	0.13735400523193386	4.980243949486625	6.350417227629634e-7
1	PC5	~	PC2	-0.08095359581434383	0.065894019086609836	-1.228542391796436	0.21924342601288194
2	PC5	~	PC3	0.6181842687862279	0.11524536111436043	5.364070733983178	8.136701623584486e-8
3	PC5	~	PC4	-0.5348400878393272	0.16881831725974836	-3.168140143307079	0.001534175467293730 2
4	PC6	~	PC1	0.5644312352835721	0.14405990135836821	3.918031526868508	0.00008927503208933096
5	PC6	~	PC2	0.12572098814702173	0.07595654585069173	1.655169896647 1846	0.09789003974718469
6	PC6	~	PC3	0.7173559477057672	0.13328138276754944	5.382266696253413	7.355367759309672e-8
7	PC6	~	PC4	0.510037343718621	0.18956559949017307	2.690558545894 6644	0.007133251749964264 5
8	PC7	~	PC1	-0.005104186625712898	0.07557319515162 46	-0.067539643062 65849	0.9461521034580829
9	PC7	~	PC2	0.4703927024653762	0.06329101806449178	7.432218928420885	1.0680345496894006e-13
10	PC7	~	PC3	-0.36938061615709356	0.07720769575057 12	-4.784246085333748	0.000001716303072107 9053
11	PC7	~	PC4	0.6024954153813844	0.13043847163036834	4.619000880998 47	0.000003855922204420992
12	PS1012V	~	PC1	1.0	-	-	-
13	PS1022V	~	PC1	0.7559224276136357	0.12236540515247946	6.177582844313747	6.509042194124959e-10
14	PS1052V	~	PC1	1.1536284816714728	0.16655499168526142	6.926411931529 23	4.316547119742609e-12
15	PS1082V	~	PC1	1.1735581221147326	0.16672614967875835	7.038836585435826	1.9384494009955233e-12
16	PS3042V	~	PC1	1.315730651539286	0.21111367178816 05	6.232332754144449	4.59539961639166e-10
17	PS3062V	~	PC1	0.7574796030827464	0.11754179826050055	6.444342474645039	1.1610268302320037e-10
18	PS3250V	~	PC1	0.6149822066417777	0.14096330879839172	4.362711203927354	0.000012846047103387548
19	PS3260V	~	PC1	0.7716643792415799	0.15204684380599845	5.075175254680699	3.8713901351350444e-7
20	PS3082V	~	PC2	1.0	-	-	-
21	PS3310V	~	PC2	1.3163402313188128	0.14609256530170464	9.010316360667 28	0
22	PS3320V	~	PC2	0.6664599605737944	0.07602331872152746	8.766520217385708	0
23	EC2009I	~	PC2	-0.278746796837558	0.07294797065880 01	-3.821172738821 2147	0.000132818578250537 56
24	INNO_DIST	~	PC2	0.013311038140477887	0.00429422279713 8796	3.099754895402065	0.001936808459717998
25	PS3092V	~	PC3	1.0	-	-	-
26	E_ESELL	~	PC3	0.5315670419201382	0.08180214844648631	6.498203922619255	8.128453465872099e-11
27	E_ERP1	~	PC3	0.3820369399744532 6	0.19688188855862293	1.940437196988 5827	0.052326579711044374

index	Lval	op	rval	Estimate	Std. Err	z-value	p-value
28	PS2022V	~	PC4	1.0	-	-	-
29	PS2032V	~	PC4	0.7923057729157091	0.14809181030013166	5.350098505141	8.7906370183077 34e-8
30	PS2042V	~	PC4	0.3647320232695407	0.11326250776419192	3.220236161693313	0.00128085032949964 98
31	PS3330V	~	PC5	1.0	-	-	-
32	PS3340V	~	PC5	1.169863587511542	0.09294093463578677	12.587172617570175	0
33	PS2092V	~	PC6	1.0	-	-	-
34	PS3290V	~	PC6	0.9680605457413748	0.07555009195092623	12.813492620993335	0
35	PS3122V	~	PC7	1.0	-	-	-
36	PC1	~~	PC2	52.1389183825904	17.554097046274222	2.9701851508023696	0.00297620311982749 2
37	PC1	~~	PC3	60.5435672354275	14.640112340750 06	4.1354578316249 13	0.00003542476630791 214
38	PC1	~~	PC4	8.939083440062682	7.6234699966263 21	1.1725740960504072	0.24096664233228315
39	PC1	~~	PC1	91.07687869845712	25.456231792632508	3.5777832100355 42	0.00034652066886731 17
40	PC2	~~	PC3	46.32284982745904 5	16.112137316903105	2.8750282421475686	0.00403991360124766 9
41	PC2	~~	PC4	26.23365581508899 4	10.702981622325 55	2.4510605306810 27	0.01424359984853418 3
42	PC2	~~	PC2	159.9347191164931 7	40.842385661054635	3.9159005167760172	0.00009006738477301823
43	PC3	~~	PC4	19.92600308725221 2	7.9018541145095 33	2.5216870368007 92	0.01167935670138220 4
44	PC3	~~	PC3	96.23047870321216	16.350267689858047	5.8855598286563 44	3.967088435530286e-9
45	PC5	~~	PC5	10.26213345671023	5.4978322218968 67	1.8665781425333696	0.0619605222802595
46	PC6	~~	PC6	17.45815080071037 8	8.1618745558319 88	2.1389878858446 42	0.03243664948887925 4
47	PC7	~~	PC7	7.409203247457748	1.1637197152555152	6.3668279829946 51	1.9297741182811023e-10
48	PC4	~~	PC4	30.83640106820231 4	8.9391911386163 18	3.4495739703997 4	0.00056147188120503 34
49	PS1052V	~~	PS1052V	65.63780430261953	12.173303740454198	5.3919466483438 89	6.969846388926726e-8
50	INNO_DIST	~~	INNO_DIST	0.2012170950818931 4	0.03207849970843115	6.2726466918505 82	3.549618377007846e-10
51	PS3260V	~~	PS3260V	101.8765121006970 6	16.815721449825 67	6.0584086388840115	1.3747478710968153e-9
52	PS3062V	~~	PS3062V	40.92603049122716 6	7.2022497730867 68	5.6823953321020 75	1.3282120070456926e-8
53	PS2042V	~~	PS2042V	21.15550397891974 7	3.5044428243619428	6.0367667669868 49	1.5723271573619968e-9
54	PS3042V	~~	PS3042V	143.0343751348871 4	24.785222119873534	5.7709539354982065	7.882402286440993e-9
55	EC2009I	~~	EC2009I	54.80300811087836 6	8.7813045549459 17	6.2408731832453395	4.351350391118558e-10
56	PS3092V	~~	PS3092V	2.918062818585229 8	4.6900080930997 8	0.6221871605888774	0.5338188075916142
57	PS1012V	~~	PS1012V	88.75525645339965	15.277584680034 92	5.8095083949612 23	6.265655327908348e-9
58	E_ESELL	~~	E_ESELL	45.4377959846236	7.3699877742791 99	6.1652471315071 28	7.037315175040249e-10

index	Lval	op	rval	Estimate	Std. Err	z-value	p-value
59	PS2092V	~~	PS2092V	58.88560579906161	11.505057147650925	5.118236706114894	3.0840539166909764e-7
60	PS3340V	~~	PS3340V	37.56751746223349	8.735654805325007	4.300480994204246	0.000017042778840403727
61	PS2022V	~~	PS2022V	25.396947498622687	5.753663880446582	4.414047818282885	0.000010145553381635253
62	PS3082V	~~	PS3082V	120.53485359011933	20.68703658406495	5.826588699657471	5.657180501827952e-9
63	PS1022V	~~	PS1022V	48.98746707109836	8.458982987968094	5.791176922896235	6.989490097808471e-9
64	PS2032V	~~	PS2032V	21.195954612027602	4.316514573781168	4.910432769245934	9.087560961518193e-7
65	PS3290V	~~	PS3290V	22.919824334707474	7.297214119092229	3.140900617776521	0.0016842917601676
66	PS1082V	~~	PS1082V	61.70190662106525	11.649177344097138	5.296675018199933	1.1793030441076269e-7
67	PS3250V	~~	PS3250V	99.75730561999413	16.214963570479009	6.152175747197226	7.642710908584149e-10
68	PS3320V	~~	PS3320V	14.851745249731545	3.363765713395616 3	4.415213934366064	0.000010091014383650787
69	PS3330V	~~	PS3330V	26.178112160678296	6.248001580270161	4.189837634378795 5	0.000027915412931012185
70	E_ERP1	~~	E_ERP1	288.3568830452856	45.654571826368446	6.316057111255935	2.683209210374571e-10
71	PS3310V	~~	PS3310V	41.67593182696736	11.250476774091988	3.704370282594292	0.000211916516070331 8
72	PS3122V	~~	PS3122V	2.921735320160619 7e-16	1.163719715299976 3	2.510686449447118e-16	0.9999999999999998

CONCLUSION

This PhD dissertation showed the importance of the dimensions of a city (i.e., governance, technical-economic, institutional-social, urban and environmental) and its elements that should be developed over time. It highlighted the role of governance as a meta-dimension that will enable this urban transformation process, but it also showed that smart cities development follows some steps that start with the design of strategies and, then, implementation of them through projects and smart solutions.

In short, as an evolutionary process, a city to be smart depends much more than the articulation of stakeholders. It should establish robust governance structures and mechanisms in order to improve, change or maintain the elements that will drive the city towards a smarter level.

It is important to highlight that this study started before the global health crisis, but it is important to mention that it still has impacts on several domains of our society and, especially in cities. With the advancement of the pandemic and the acceleration of digitalization, many people were wondering if cities will survive in the world of the "new normal".

The answer is yes and, in fact, they will play an even more important role. Paradoxically, cities, often pointed out as the causes of today's greatest global challenges such as violence, pollution, inequality, diseases are also the best socio-economic technology ever created that can solve them.

As one of the main outbreaks of the spread of the virus, it is in them that the large hospitals, laboratories and human capital that developed the long-awaited vaccines are located. The home-office routine, the 'new' forms of production, sale and consumption and even entertainment are only possible because cities offer (even if insufficiently) the digital infrastructure necessary to enable new business models, lifestyles and work without leaving home. The residences, without a doubt, revalued during this period. But the fact is that, because they are inserted in an urban context that provides a series of basic services, they manage to bring the security and the minimum stability that human beings need to maintain their activities and plan their next steps.

Furthermore, only cities provide one of the most important elements for the generation of wealth in the 21st century, the spontaneous (or informal) encounters between people. Given the current context, this has happened less frequently, either

because of the obvious restrictions of social distancing, or because of the ease of digital technologies. However, these meetings are triggers for creativity, entrepreneurship and innovation. Due to the fact that we are sociable beings and have the predisposition to collaborate, it is often in unexpected places such as bars, restaurants, parks, university canteens, among others, that ideas, projects and new ventures arise.

However, despite all these natural advantages, it does not mean that all cities will continue to be important. It is necessary to ensure that its primary functions such as protection and production, and others more sophisticated are aligned with the dynamics of a digital economy based on knowledge and focused on sustainable solutions. In the paradigm emerging in the twenty-first century, focused on the knowledge economy, elements such as collaboration, sustainability, health, mobility, accessibility and connectivity are main drivers.

Cities have become service oriented and frequently chaotic living place for workers. Within this scenario, where brainwork has become the most valuable economic asset, bypassing machines and simply workforce, people are the main source for this new economy – and they are concentrated in cities. What may be seen is the migration of the economic activity guided by the creative industry instead of the manufacturing one. Rather than identifying what is needed to expand the manufacturing industry, the challenge now becomes to identify how to attract creative people to cities and promote its development towards the new paradigm of knowledge and creative industry. High-talented people seek for a place that offers high conditions for living, working and entertaining.

It means more than solely presenting an attractive urban environment; it is important to stimulate the establishment of new ventures based on knowledge and creativity, and the interaction between these ventures with S&T institutions to raise up their technological base and promote innovation. The ongoing phenomenon has been carried out not only by public policies, but also by firms and individuals, which use their knowledge and creativity to find solutions to deal with the complex issues present in a city.

However, it is needed more. It is required that public and private sectors get together in a governance arrangement to identify the main actions to be fulfilled, which may ensure basic conditions to attract creative people and new projects to attract creative businesses, so that these people can work on them and generate wealth through

knowledge. Cities must be planned and structured to facilitate a whole innovation ecosystem in which knowledge flows smoothly.

Thus, industrial cities must be transformed into smart cities, in which the state-of-the-art knowledge is applied to develop enough economic added value solutions to generate wealth and quality of life, based on existing and new resources. To become a smart city, it is required a set of new assumptions in several different dimensions to attract and retain creative and talented people.

Smart cities may provide the necessary infrastructure so businesses, individually or through public or private partnerships, use ICTs to create goods and services, that solve urban problems and, along with it, raise the intellectual potential of the city and its competitiveness. Instead of a city that segregates its individuals and businesses through traditional industrial structures, cities in the twenty-first century must aggregate them to promote development through smart solutions.

For this, it is necessary to rethink the different dimensions of the city such as governance, economy, infrastructure and sociocultural, so that they can reinvent themselves and become healthier, safer, sustainable and smarter cities. But how can cities start (or accelerate) this transformation process?

The first paper seeks to disclose what composes a smart city and to identify how the process of smart city development occurs. The paper defines that a smart city is an urban innovation ecosystem with four dimensions (governance; environ-urban; techno-economic; socio-institutional) with driving elements that should be developed through collaborative projects following a comprehensive strategic plan. The challenge is how to bring different stakeholders to share a vision of future and co-create complex solutions towards a smarter level. Then, the governance dimension is crucial to smart city development succeed.

However, it does not happen instantly and without conflicts of interest. In fact, the lack of appropriate structural and organizational formations does not foster the involvement of local stakeholders and makes it difficult to organize and coordinate the different activities needed to achieve sustainable urban development. To overcome this challenge, the emergence of alternative governance models that combine political and social support may play an important role for the transition from a top-down to a bottom-up approach, the formation of coalitions based on collaboration and the myriad of smart projects.

In the second paper, it is presented from different case studies that a part of the strategy to make a city smarter involves introducing new organizational arrangement and reorganizing existing government structures to provide a better governance system, which are the so-called smart city dedicated organizations.

The results show that the role of dedicated organizations vary depending on their context and degree of maturity of the process of smart city development. The organizations from countries that already have overcome the barriers of legitimacy and relevance in the ecosystem act much more as facilitators and co-producers delegating the tasks of design and implementation to other partners. In contrast, the organizations from developing countries are still testing and validating their role in the local ecosystem by focusing much more on executing projects and studies to start the process of urban transformation. What is common for all these initiatives in any context, it is that the city should have an integrated governance model and supportive structures to lead this transformation process.

At same time that integrated and flexible governance is crucial for smart city development succeed, it is important to define what smart strategies a city should adopt and prioritize projects that may have a greater effect on urban performance. However, again, there is not an easy task. Given the very nature of process of urban development and its complexity, a city as an urban innovation ecosystem will present particular issues and may follow different paths, because it depends on several contextual factors that also can change over time. For a better understanding of smart city development process, it is necessary to strengthen the theoretical basis in order to explain where, why, when, how, and by whom a smart city is developed.

The third paper aims to fulfill this gap by incorporating the evolutionary approach in order to analyze of sustainable urban planning and development. The evolutionary approach comprises a set of theories and concepts that are devoted to explain the transformation processes of urban (eco)systems over time from a holistic perspective. It proposes a framework that considers the different scales (i.e., micro to macro-level) and units of analysis (i.e., individual to ecosystem) related to the implementation of strategies through projects over time. It also incorporates the evolutionary mechanisms into the analysis that may enable the identification of why and how some solutions are retained and upscaled and others do not and it enables to explain the reasons of why cities start this process of change and select some strategies and projects that should consider the local context and the previous development paths.

Considering this multiscale integrated perspective, this framework shed light on the need to analyze the characteristics of individuals and their innovation capabilities, the structure and relationships among them in the collaborative networks and the change of elements and dimensions of innovation ecosystem over the spatial boundaries of a city.

In this study, the focus was on the macro-level of smart city development that is the innovation ecosystem per se. It encompasses the city dimensions and respective elements and their interaction in the aggregate-level, which enables the measurement of the direct and indirect effects of the smart city development processes on the different spatial scales. It was proposed that smart city development can be analyzed considering the different degrees of smartness of the urban innovation ecosystem. Then, depending on the degree of smartness, the urban innovation ecosystem will be able (or not) to adapt, combine and catalyze its elements of innovation from each specific city dimension (i.e., governance, techno-economic, environ-urban and socio-institutional) towards a smarter level.

The fourth paper aims to define the concept of and to build a model to assess the impact of smartness on urban performance. The results show that the elements that generate the dynamics of smart city development are related to the environ-urban and governance dimension, represented by urban attractiveness and utilities and the techno-economic dimension related to smart business. The design of strategies and projects to improve the amenities and facilities and the quality of services provided to citizens may enhance the city smartness, as well as, stimulating business to become more digital and efficient.

Theoretical Contributions and Managerial Implications

Considering our main findings, it is possible to suggest for policymakers that every city that aims to become smart needs a governance model adapted to its smartness to start or accelerate this process, which can be done through the creation of a dedicated organization. This organization can co-produce or facilitate to design strategies and projects adapted to the local reality in order to digitize and empower businesses and people and improve the urban environment (infrastructure, mobility, public services, leisure and entertainment). The study highlighted the importance of evolutionary monitoring and evaluation system for this transformation process, by incorporating a space-time approach.

In addition, this urban development process must be analyzed from different scales, from micro to macro, from the stakeholder through collaborative networks and the aggregate of interactions with the ecosystem to define which path(s) should be followed, how to do it and who should do the activities and actions necessary to enhance the level of smartness in the city. Besides that, it is necessary to understand that the evolution of the city towards a smarter level is related to the dynamics and interaction among the stakeholders for the creation of strategies and the implementation of projects, which should be guided by city history and its current context. Only then, it will be possible to create, improve or change the elements of innovation of the different dimensions of the city in a more efficient way in order to make a greater impact and bring positive outcomes to the city.

Despite of cities' idiosyncrasies, their hard and the soft assets must be integrated. Since we are living in a knowledge economy that is based on collaboration, the urban environment should promote (or facilitate) this to happen. From this knowledge creation and collaborative networks that it will be possible to make the city innovate and improve the quality of life, showing a virtuous circle of wealth generation.

In sum, this work provided a tool to analyze smart city development from a multiscale space-time perspective. It highlights that this process of urban transformation is context and path-dependent, but it offers some insights on how to start or accelerate it. A robust governance is crucial for the success of any initiative, but it should be followed by good practices and appropriate structures, such as dedicated organizations to facilitate and boost the collaboration among stakeholders. It also is not enough to assess the outputs at city-level, because individuals and the networks created are the engines of smart city development.

Limitations and Future Studies

This study presents some limitations that should be addressed in further studies. It focusses on European cases that adopted a model of urban development that may differ from other regions. It is important to assess both quantitatively and qualitatively cities from developed and developing countries in order to gather new information and insights.

It gathered data from specific databases that cannot be directly reproduced due to methodological issues. The creation of indicators for models that are generalizable is an important step to develop integrated assessment models.

It was used a structural modelling approach that did not present satisfactory fit indices. It reinforces the need of creation of appropriate indicators and also to test other statistical and econometric models. It should be important to gather more recent data and incorporates a longitudinal approach.

It also was concerned almost exclusively on understanding the macro and meso-level of smart city development and do not deepen how individuals interact in those collaborative networks and what they need to foster urban innovation. It opens a research agenda on how stakeholders can build capabilities to design and implement strategies, manage projects and develop solutions to solve those complex urban issues.

APPENDIX

Permission letters of co-authors

Permission letter of co-author

I hereby authorize the inclusion of the paper "Driving Elements to Make Cities Smarter: Evidences from European Projects" and "The Role of Dedicated Organizations in the Governance of Smart City Development: A Multiple Case Study" as a part of the PhD dissertation of Guilherme Freitas Camboim.

As a co-author, I have contributed substantially to the methods, results, and discussion sections of the paper.

* * *

Autorizo a inclusão do artigo intitulado "*Driving Elements to Make Cities Smarter: Evidences from European Projects*" e "*The Role of Dedicated Organizations in the Governance of Smart City Development: A Multiple Case Study*" na tese de douturado de Guilherme Freitas Camboim.

Como coautor, contribuí substancialmente para as seções de método, resultados e discussão.

Paulo Antônio Zawislak
Universidade Federal do Rio Grande do Sul

Permission letter of co-author

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Universidade Federal do Rio Grande do Sul

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Denise Barbieux

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