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EVALUATION MODELS OF SMART CITY PROJECTS: SMALL AND MEDIUM-SIZE CITIES

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The importance and complexity of the challenges that cities face is a fact assumed by the scientific community. The great relative weight of the solutions with which urban centers face their challenges is the subject of study and concern. The concept of Smart City is presented as a very extended line of action to meet these challenges.
In recent years, work has been done on the development of various evaluation models that allow both strategic investment decision making and the prioritization of projects within the Smart label.
This work analyzes the different performance evaluation models, based on the extensive literature available. The focus is placed on medium-sized small cities (between 45,000 and 150,000 inhabitants) and the emerging concept of “smart territories” that emerges as a possible response to part of the problem of these cities. The implementation of an innovation strategy and culture is considered fundamental as a basic philosophy of work in smaller cities, even with greater relative importance compared to their larger sisters.

Keywords: smart city; evaluation model; small cities; smart cities

MODELOS DE EVALUACIÓN DE PROYECTOS SMART CITY: CIUDADES PEQUEÑAS Y MEDIANAS

La importancia y complejidad de los retos a los que se enfrentan las ciudades es un hecho asumido por la comunidad científica. Es objeto de estudio y preocupación el gran peso relativo de las soluciones con las que los núcleos urbanos enfrentan sus desafíos. El concepto de Smart City se presenta como una línea de actuación muy extendida para afrontar dichos retos.
En los últimos años, se ha trabajado en la elaboración de diversos modelos de evaluación que permitan tanto la toma de decisiones estratégicas de inversión como la priorización de proyectos dentro de la etiqueta Smart.
Este trabajo, realiza un análisis de los distintos modelos de evaluación de desempeño , basándose en la amplia bibliografía existente. Se pone el foco en las ciudades pequeñas medianas (entre 45.000 y 150.00 habitantes) y el concepto emergente de “territorios inteligentes” que surge como posible respuesta a parte de la problemática de estas ciudades. La implementación de una estrategia y cultura de innovación se considera fundamental como filosofía básica de trabajo en las ciudades de menor tamaño, incluso con mayor importancia relativa respecto a sus hermanas de mayor tamaño.

Palabras clave: ciudades inteligentes; modelos de evaluación; ciudades pequeñas; smart city

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1. Introduction

Sustainable and smart projects are daily news these days. However, the results of those projects are not often mentioned. Performance evaluation models allow a quantitative measure of the success of the implementations of those projects (Giffinger et al., 2007).

Cities can be classified due to their inhabitants. The European Commission (2012) considered:

- a small city with a population between 50,000 and 100,000 inhabitants
- medium-size city between 100,000 and 250,000,
- big city between 250,000 and 500,000,

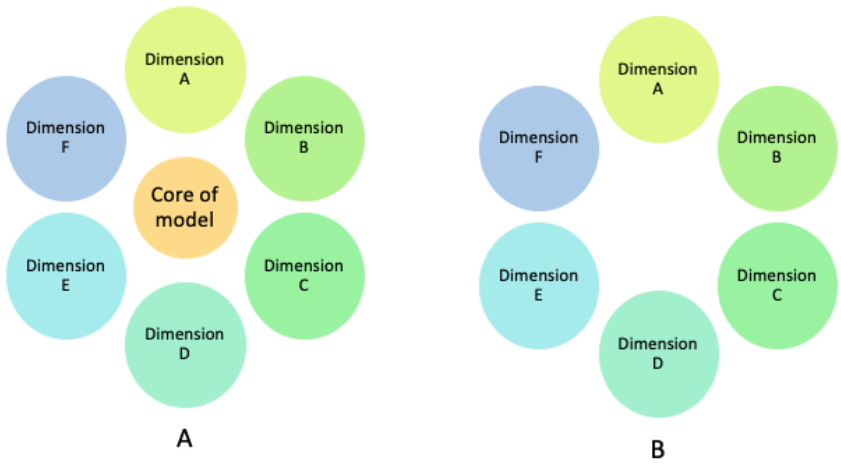
Over this value, extra-large, extra-extra-large, and global city are also defined.

Because of their resources, big cities (and bigger ones) have a robust structure to address transformation projects into smartness, and to work with sustainability as the cross concept; it should be to preserve our planet. Medium-size and small cities usually face difficulties when assigning resources (technical, human, and economic) to these transformation processes (Arroub et al., 2006). As a solution, some models include a fourth definition called "smart territory," as a group of neighboring cities with a common goal, their transformation into more sustainable and smart cities (Larios-Hernandez & Borbolla-Alvores, 2020; Saiz-Alvarez, 2020).

The first analysis made trying to assess a city's smartness was conceived as a ranking, where medium-size European cities are classified and organized. The sample of cities followed not only the size but also the availability of database criteria to ensure a feasible analysis. This analysis includes the definition of characteristic dimensions of the smart city project as the definition of the areas or working lines built upon the "combination of endowments and activities of self-decisive, independent and aware citizens" (Giffinger et al., 2007).

The way these dimensions are defined varies between studies. Some authors set dimensions around a core. The core identifies the central pillar or center of the project, the concept that has particular relevance in the model if any stands out. Other authors simply define dimensions without considering a core or a center. Figure 1 shows an example of moth models.

Figure 1: Model structures. Example of model structure with 6 dimensions A) Models with a core. B) Model core-less



This paper explores the key concepts related to smart and sustainable cities in the literature, looking for models to assess their performances. Performance evaluation models for cities are analyzed on a first approach to understand how they conceive smart cities paying particular attention to the consideration of cities under 250,000 inhabitants.

2. Objectives

This study aims to analyze models that evaluate the performance of cities under the Smart Territories concept. The focus is placed on small and medium-sized cities, between 50,000 and 250,000 inhabitants (European Commission, 2012).

3. Methodology

A systematic literature review has been done through scientific databases:

- Web of Science, https://apps.webofknowledge.com/
- Scopus, https://www.scopus.com/

All types of documents have been included: journals, conference proceedings, books, and reports. Results have been analyzed, looking for performance evaluation models. Five searches have been done in both databases, one per keyword defined. The following keywords with no date restrictions:

- Sustainable cities
- Sustainable territories
- Smart cities
- Smart territories
- City performance evaluation

Once identified, the models have been studied and, its main characteristics, have been assessed:

- Model core
- Dimensions defined
- Small and/or medium-size cities considerations
- Territories consideration
- Qualitative or quantitative
- Indicators defined if any

Particular attention has been paid to the terms small size city and medium-size city. An additional search has been done within the documents previously identified to find out how many models have special consideration with small and medium-size cities using the keywords:

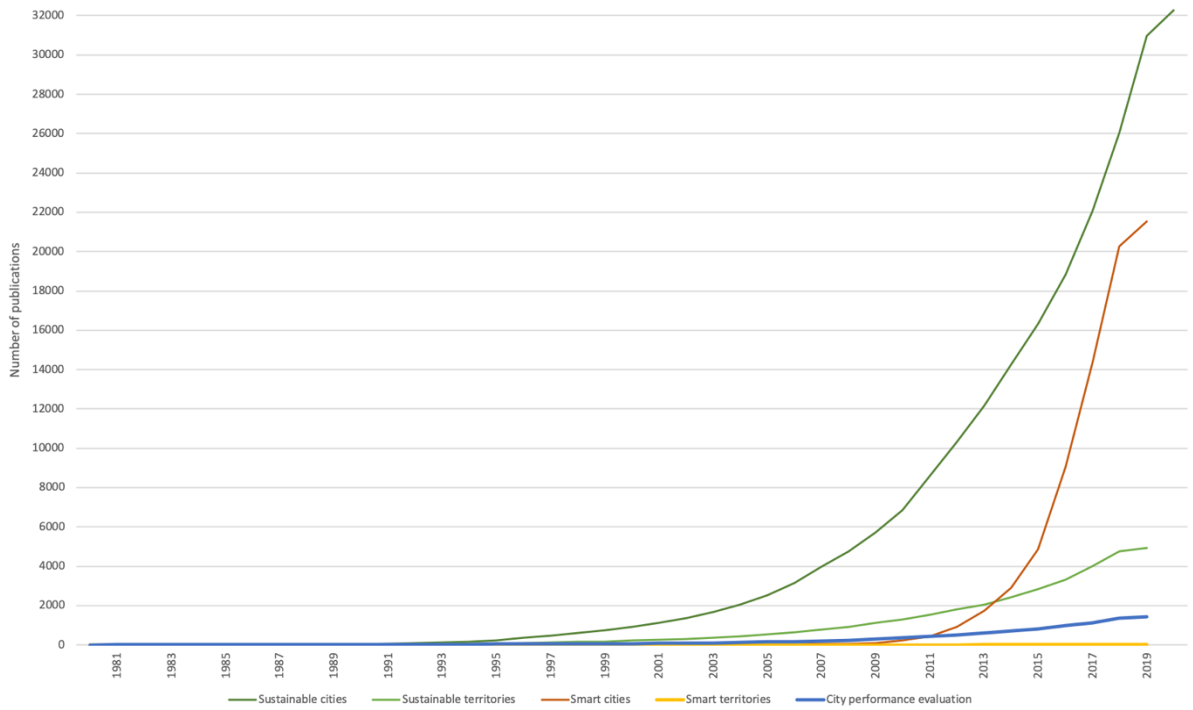
- Small city
- Small cities
- Medium-size city
- Medium-size cities

Finally, conclusions have been made considering the models' suitability for evaluating the performance of small and medium-sized cities.

4. Results

The systematic review of references, including articles, books, book chapters, and reports, has shown more than 77,000 unique scientific contributions. The contributions that include more than one keyword have only been counted once. Figure 2 shows the evolution in time of those contributions.

Figure 2: Number of publications by year and keyword



Although the Sustainable Development concept was globally defined in 1992 (UN, 1992), there are studies related to sustainable development in cities since 1979.

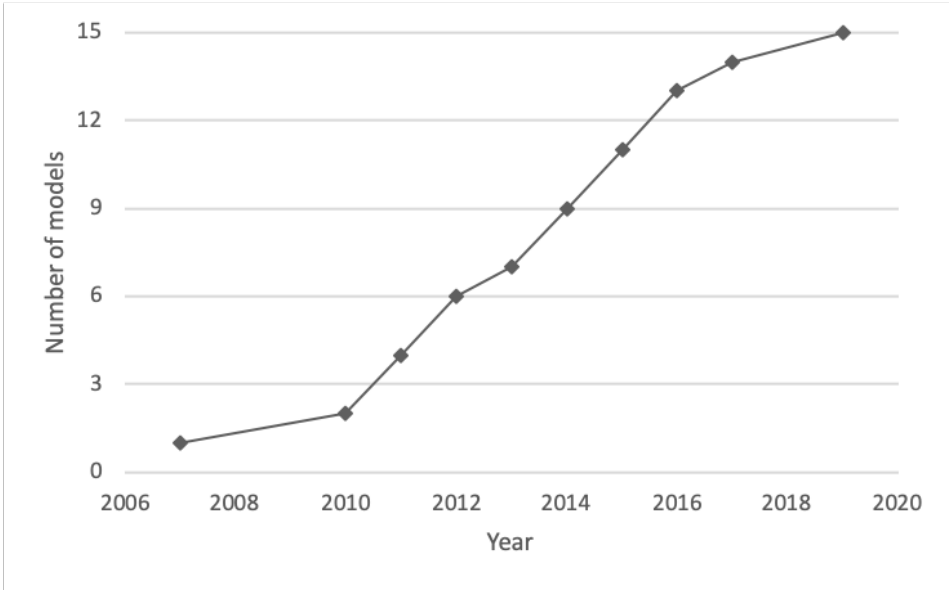
The "smart city" concept appeared in 1984. However, "smart territory" did not appear as a concept until 2010, 26 years later, as a possible scope of ubiquitous computing beyond smart cities (Duval & Woo, 2010). The total number of publications with the "smart territory" concept is less than 40, while the "smart city" appears in more than 21,000 results. It should be noticed that only 10% of the publications with the keyword "smart city" refers explicitly to small or medium-sized cities.

The performance evaluation of cities appears as scientific assessments in 1970 (Stuart, 1970). It is the oldest concept between the ones searched in this study. However, the number of publications is under 1,500, 7% of the publications referring to "smart cities."

Analysis of the literature has allowed the identification of 15 models developed to assess cities' performance. The first model was proposed as a result of a research project carried by Vienna University of Technology, University of Ljubljana, and the Delft University of Technology with the aim of rank European cities (Giffinger et al., 2007; European Commission, 2007). To build the rank, the authors developed a model to evaluate the smartness of a list of 70 European cities between 100,000 and 500,000 inhabitants and at least one university. The most recent model seeks to integrate the overview of stakeholders as part of the project developed and the changes faced by the city's initiatives (Fernandez Áñez, 2019).

As an emerging concept, between 2007 and 2016, the construction of models grew fast. Since then, although there have been new models, the trend has changed, and the creation of models has slowed down. It might be thought that the models available fulfill the requirements of researchers and city managers. This discussion will be addressed further in this paper. Figure 3 shows how the definition of models increased.

Figure 3: Chronological models development



The models that assess performance have specific characteristics that deserve to be studied as the inclusion of indicators or the consideration of different city sizes. Furthermore, when analyzing cities or organizations, other features are added to the model's core and the dimensions defined by the model. The characteristics of these models are explained in this section. The list of the 19 models analyzed is shown in Table 1, organized by year of publication.

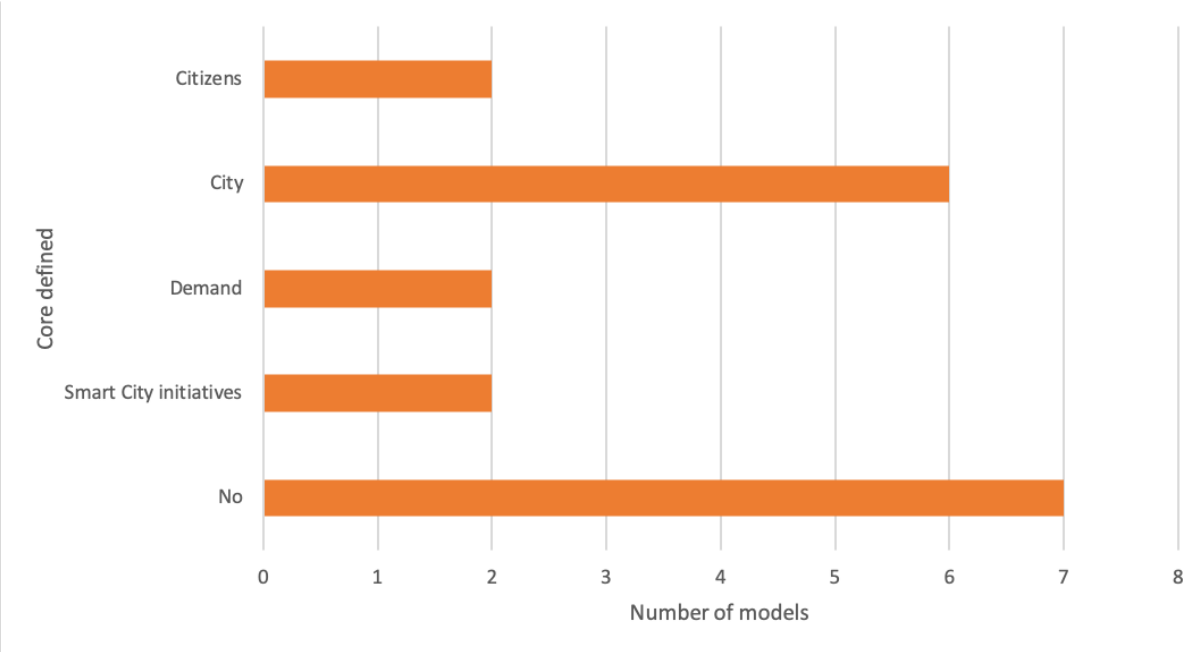
Table 1: Models and their references

Year	Reference
2007	Giffinger et al., 2007
2010	Leydesdorff & Deakin, 2010
2011	Nam & Pardo, 2011, Lombardi et al., 2011
2012	Cohen, 2014; Alawadhi et al., 2012
2013	Dameri, 2013; Technische Universität Wien, 2013
2014	Neirotti, 2014; Technische Universität Wien, 2014; Manville et al., 2014
2015	Monzón, 2015; Castelnovo et al., 2015; Mattoni et al., 2015; Technishce Universität Wien, 2015.
2016	Fernández Güell et al., 2016; Moreno Alonso, 2016
2017	The Transport Research Center - UPM, 2017
2019	Fernández Añez, 2019

4.1 Core

As defined in the introduction, the core is the element or concept used as To find out how many models have special consideration with small and medium-size cities pillar or center of the model (see Figure 1.A). Four different cores have been identified in the models analyzed, and only 37% of the models have no core. Half of the models with core are built around the city as a core. The other cores considered are the citizens, the demand, and the smart cities initiatives. This last one is only found in a model that seeks to assess the actions that the smart city takes despite the city's (Alawadhi et al., 2012). Figure 3 shows the frequency of cores in the models.

Figure 3: Cores in models



4.2 Dimensions

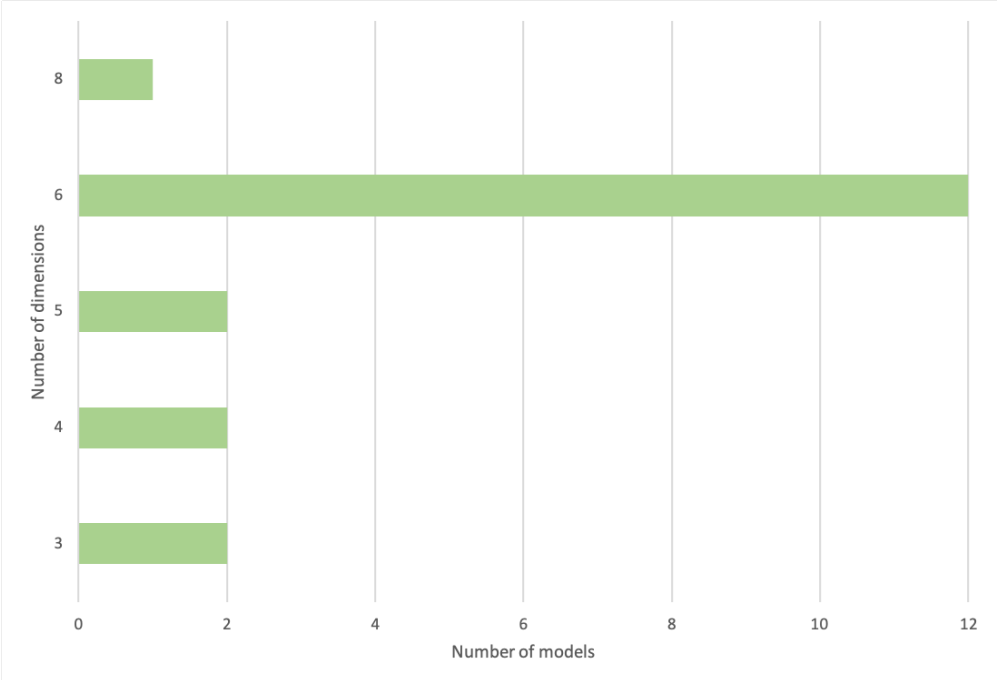
When defining dimensions in a performance model, developers consider different approaches in the analysis (I.e., health, environment, economy). The number of dimensions varies between 3, a triple helix model, and 8 dimensions. Figure 5 shows the frequency within the models analyzed, where 6 is the most frequent.

The six dimensions that predominate in these models are:

- Economy
- People
- Governance
- Mobility
- Environment
- Living

These are also the most frequent dimensions defined. These dimensions have been defined for the first time by Giffinger et al. (2007) and are generally accepted by the scientific community. In 2014, the European Union adopted them as a standard (Manville et al., 2014). Actually, the vast majority of the recent assessment models take these dimensions as a starting point (i.e., Monzón, 2015; Moreno Alonso 2016 and Fernandez Añez 2019).

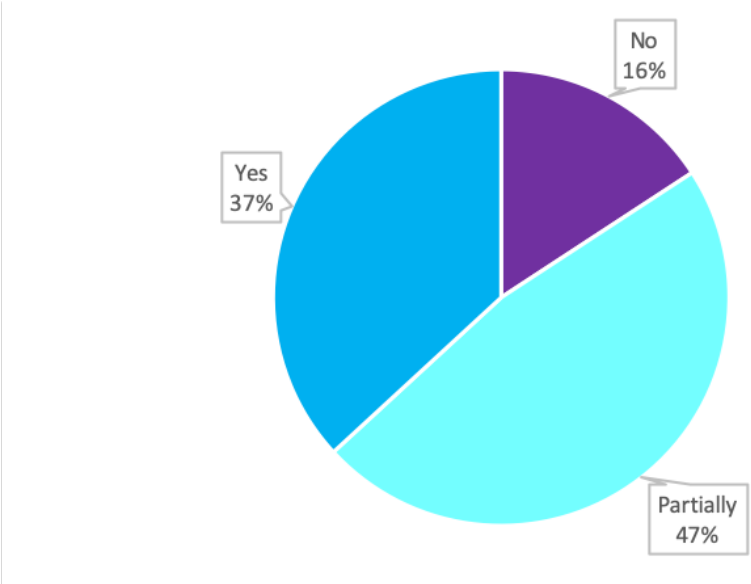
Figure 5: Dimensions in models



In the second place, triple helix models and four-dimensions models are defined with a significant difference as there are only 2 cases of each. However, these models can be considered together as the four-dimensions model share the three dimensions of the triple helix models: business, governance, and university as a source and enhancer of knowledge.

Innovation stands out as a dimensioned considered all models somehow, although only a 37% defined explicitly. A 47% include innovation partially in the model by different formulas but without giving them the category of dimension. The other 16% do not consider any aspect of innovation, although they mention it as a weakness or a further research approach. Figure 6 shows the distribution.

Figure 6: Innovation concepts in models



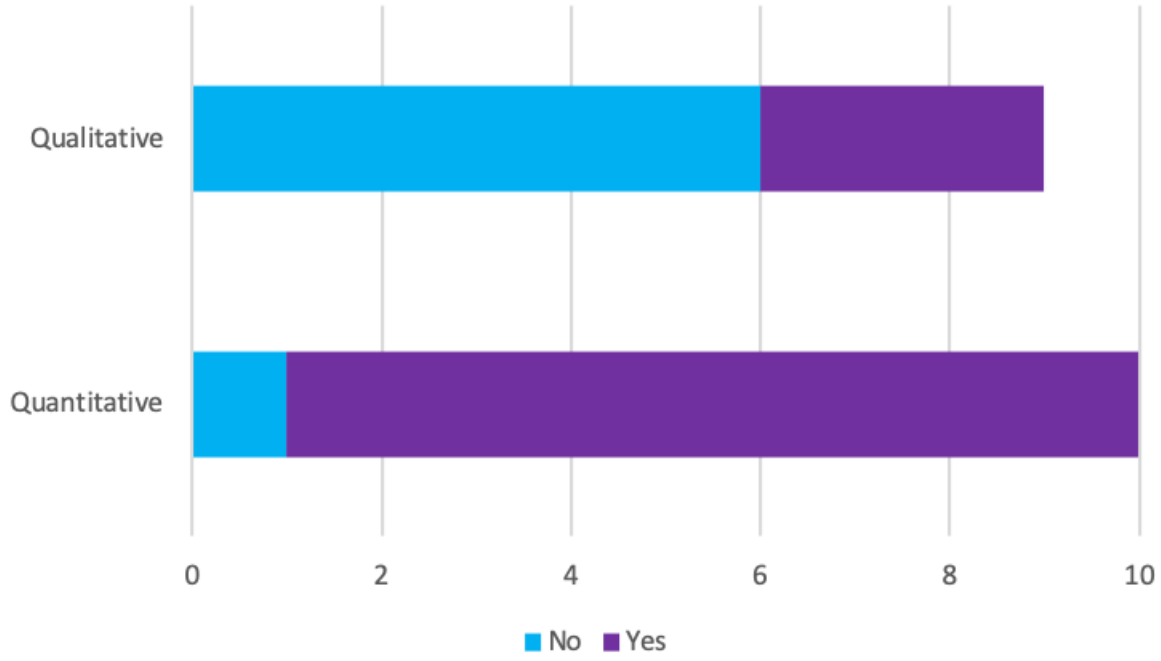
The other dimensions considered in the models are technology, urban planning, infrastructure, organization, and policy.

4.3 Qualitative or quantitative and indicators

Models can be classified into two categories: qualitative or quantitative. Qualitative models identify and suggest guidelines for a smart strategy or provide assessment tools for projects. The quantitative model defines levels of smartness and quantify results within different geographic scopes. These models often build a ranking of cities. Both types of models might provide a set of indicators to help in their implementation.

Authors that escort the model with indicators aim to provide, besides other reasons, a tool for improvement (two-thirds of the models). Most of these models are quantitative models. The number of indicators varies significantly. Only one third does not give any indicators (Fig. 7).

Figure 7: Definition of indicators

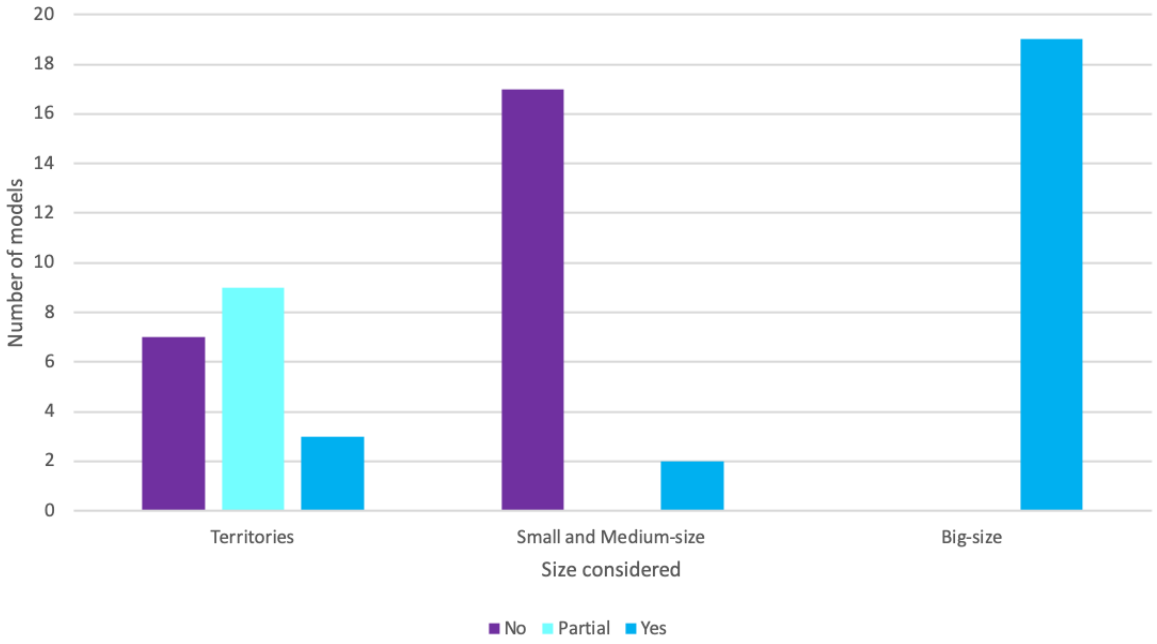


Indicators are always associated with a dimension. The number of indicators by dimension also varies significantly between two and twenty.

4.5 Size consideration

All the models studied were built for big cities, over 250,000 inhabitants. However, some models make considerations for small and medium-sized cities. Moreover, some models present approaches for territories beyond cities. Figure 8 shows the number of models that considered each size.

Figure 8: Size consideration



5. Conclusions

The sustainability of cities has been a concern almost twenty years before the definition of sustainable development. However, performance models of cities are based on a younger concept, the smartness that includes sustainability as part of the equation.

Performance evaluation models of cities consider a broad range of dimensions as people, environment, governance, economy, living, infrastructure, technology, and knowledge. Innovation is a constant in the analysis, although its assessment is not always included.

Smart city as a concept or as a developing urban model has evolved from a technology-focused conception to the generally accepted approach of a holistic concept, focused on the citizen and the public demand with information and communication technology being used as a tool and never a target. The most recent models give particular relevance to an alignment between the challenges of the cities and the smart initiates and projects to be developed involving all the main city stakeholders in the process.

A gap in assessment models focused on small, smart cities and smart territories as a way that small cities may face the scarcity of financial and economic resources has been identified. So it seems that models and decision tools in order to help small cities and groups of them in smart territories, are needed to fill that gap, helping them to find the right guidelines and strategies, and considering their weaknesses but their strengths too, oriented to their challenges and with a particular focus in developing soft smart city aspects based in innovation with a low financial impact but a high one in quality of life.

This study allows the comparison of the main characteristics of 19 models developed to evaluate the performance of cities within the framework of the concept of Smart City. All models are based on cities over 250,000 inhabitants as they ensure resources to address smart projects. However, several authors considered medium-size and small-size cities as feasible smart cities that required models adapted to their characteristics. Territories can be defined as groups of neighboring cities with a strong capacity to implement and manage

projects of smart transformation. Territories can be the answer to overcome the lack of resources of small and medium-sized cities. This research group is studying innovation policies as an enhancer of smart territories.

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