Top-down and bottom-up collaboration as a factor of the technological development of smart city. The example of Taipei

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Abstract— **The aim of the article was to identify the benefits and risks resulting from combining top-down and bottom-up initiatives in the context of the technological development of smart cities. In order to achieve the goal, an interview has been conducted with the Deputy Secretary General of GO Smart. It has been shown that the cooperation of top-down and bottom-up initiatives has a positive impact on the city's technological development. The most important benefits of this type of cooperation include increasing innovation and the level of creativity of technological solutions introduced in a smart city, opening the city to new opportunities, as well as increasing the activity of the private sector and the involvement of residents in the city's development. The main risks are related to determining the scope of responsibility for individual initiators when implementing a project as well as the duration of processing applications.**

I. INTRODUCTION

ACCORDING to the data provided by The World Bank, in 2020 the number of people living in cities exceeded 56% of the entire global population [1]. By 2050, the percentage of people living in urban areas will increase to 66% [2]. The process of urbanization, taking place all over the world, constitutes a major challenge for city authorities. Proper living conditions must be created in a limited urban area for a constantly increasing population. The increasing standard of living is accompanied by a constant strive to increase the quality of life of citizens.

Both of the above mentioned trends contributed to the creation of the idea of a smart city. The main feature of this concept is taking advantage of modern technologies both to improve the efficiency of an urban infrastructure and to communicate with residents. The question arises: who and how can present new technological ideas to the decision making entities and who handles their implementation. In the context of smart cities, it is possible to distinguish two main types of technological initiatives: top-down and bottom-up ones [3]. Both concepts are very important for the sustainable development of urban areas.

The aim of this article was to identify the benefits and risks resulting from combining top-down and bottom-up initiatives in the context of the smart city technological development. The city of Taipei, considered to be one of the most modern cities in the world, has been chosen

for the study. Taking advantage of an interview with the Deputy Secretary of the Global Organisation of Smart Cities, Anita Chen, the Smart Taipei Collaborative Ecosystem model used in Taipei, which combines top-down and bottom-up initiatives, has been analyzed.

Individual elements and infrastructure systems of Taipei have already been described in the scientific literature. Researchers focused, for example, on public security [4], transport [5], education [6], or the role of the Taipei Smart City Project Management Office in the process of the city's technological development [7], and the top-down communication in Taipei [8] has also been analyzed.

A combination of top-down and bottom-up initiatives has also been described on numerous occasions. However, these publications concerned either models of using top-down and bottom-up in the development of other cities [9, 10, 11], or the general characteristics of the concepts mentioned above [12, 13]. This article will constitute an expansion of the knowledge concerning combining top-down and bottom-up initiatives by presenting a specific model of the Smart Taipei Collaborative Ecosystem. The information about the described model has been obtained during an interview with the Deputy Secretary General of the GO SMART organization that has been established in Taipei but has a global reach.

II. THE CONCEPT OF A SMART CITY

The idea of a smart city appeared at the end of the 20th century as a result of research on the process of urbanization and the development of ICT tools. According to one of the early definitions, a city referred to as smart is an efficient and environmentally safe space of the future, in which all processes and systems are controlled electronically [14]. This space aims for an optimal interaction of individual urban infrastructure systems, such as: administration, transport, construction, waste management, education, health care, public safety, and recreational spaces [15]. Modern ICT technology constitutes the element that allows a symbiosis of the above-mentioned systems.

Smart cities are characterized by a smart management

style. Filling the public space with smart sensors, measuring devices, as well as programs and apps for collecting and processing data has an impact on the rapid flow of information among city stakeholders [16], which in turn makes it easier for urban authorities to make decisions and create plans related to further improving smart cities. In this case it is important to pay attention to all sectors of the infrastructure when allocating urban resources as well as finalizing official matters in an efficient manner.

Increasing the city's efficiency has an impact on the improvement of the well-being of citizens [15]. According to the assumptions, residents of smart cities should feel safe, and they can take advantage of convenient electronic educational platforms. Additionally, they conveniently finalize official matters thanks to using smart electronic systems. Web and smartphone apps allow them to quickly acquire information. Thanks to using modern ICT solutions, residents can also participate in citizens' initiatives, thus supporting the authorities in the process of planning the city development [11].

Sustainable energy resources play a highly significant role in smart cities [16]. It is crucial for all kinds of economic activities that contribute to urban development [17]. It is also necessary for the proper functioning of all sectors of urban infrastructure, including: heating of the buildings, the functioning of city cameras, controlling sensors, using the IoT and electric cars, or the operation of computers and telephones. In smart cities, renewable energy sources, such as photovoltaic farms, hydroelectric power plants, and wind farms, are considered to be optimal sources of energy.

Since the formation of the smart city concept, four main research areas can be distinguished, presented in Table I [18]. As shown, publications handling the subject of smart cities concern both the definition of the concept, the characteristics of specific urban centers, individual elements of smart cities infrastructure, as well as specific methods used in the process of creating and implementing smart IT solutions in terms of the city's activity.

Due to the development of subsequent technological innovations and system methods, these issues appeared in research works at different periods of time. During the initial stage of developing the smart cities concept, researchers focused primarily on implementing ICT solutions in the processes occurring in the city [19]. The aim of implementing new technologies was to increase the efficiency of the city while taking care of the ecology. Singapore was an example of a smart city during the initial stage of the concept's development [20]. Along with a significant increase in data transmission resulting from implementing new technologies in the second decade of the 21st century, the process of city's the datafcation [21] and cybersecurity began to be analyzed [22, 23]. During the same period of time, using the IoT in smart cities was also studied [24, 25]. The currently created publications concerning smart cities are mainly devoted to specific initiatives and projects increasing a city's efficiency. These projects concern, for example, analyzing large data sets [19].

III. Top-down and bottom-up initiatives

Top-down and bottom-up concepts are used to describe phenomena and behaviours in various aspects of life. In philosophical terms, they define contradictory theories regarding the rights and properties of nature [26]. In psychology, they are used to describe, among others, autobiographical memory [27]. In biology, they can describe a process of tissue formation starting from the top or bottom [28]. These concepts are also very common in management. The top-down initiative combined with bottom-up comes from 90's Knowledge Management. Here, top-down means initiating a given process by entities with a higher position in the structure of a given organization, while bottom-up means the opposite [29].

In the context of smart cities, top-down initiatives stand for actions of administrative authorities undertaken in the process of city management [30]. They usually concern long-term planning and are characterized by a comprehensive and predictable character [31]. Their aim is often to maintain stability in the city or to carry out inspections in individual sectors. The implementation of top-down a concept is ordered and hierarchical [11].

TABLE I.
MAIN RESEARCH AREAS OF THE SMART CITIES IDEA

Research area	Main topics within the research area
Concept description	Smart cities definitions, scientific discourse concerning the concept, theories of spatial development, etc.
Characteristics of specific smart cities	Smart cities rankings, new urban planning, urban problems and propositions for their solutions, promotion of tourism, the role of the public sector and city residents in relation to the goals and benefits of individual cities and countries, etc.
Elements of smart cities	Various types of sensors used in the urban infrastructure, IoT, big data, smart solutions in terms of specific sectors: education, environmental protection, tourism, transport, public safety, food supply, waste management, water management, energy, etc.
Methods of creating and developing of smart cities	Smart applications, smart government, top-down and bottom-up initiatives, ICT companies, participation of universities, etc.

Bottom-up initiatives are related to the ideas of citizens and businesses. Such initiatives are often carried out on a much smaller scale than top-down initiatives. They have a test and experimental character [11]. According to [32], these initiatives are mainly submitted by representatives of the business sphere. However, other sources point to an increasing number of apps and platforms enabling bottom-up initiatives also for citizens. Examples of these solutions include the Taipei Smart City Project Management Office [33] platform, The Open Data Organization, The Community-based Information Service Organization [34], or tens of tools addressed to bottom-up initiatives in Amsterdam [35].

Currently, local governments more and more often point to the advantages of combining top-down and bottom-up initiatives, such as increasing a city's level of technological innovativity by taking advantage of the creativity of businesses and units while maintaining standards and rules set from above. Top-down and bottom-up cooperation is possible through, for example, creating specialized development programs and dedicated online platforms, thanks to which business representatives and residents participate in the city's technological development. Examples include the Taipei Global Organization of Smart Cities [36], the China's Community Duty Planners [11], or the Smart Taipei Collaborative Ecosystem [37] model.

However, in scientific literature it is often emphasized that the relations between top-down and bottom-up initiatives are often contradictory [11], and thus combining these initiatives can be a major challenge for smart cities [30]. The main conflicts occur in terms of [11] the scope of a given initiative (comprehensiveness vs. fragmentarization), duration (long-term initiative vs. short-term testing) and the degree of standardization (complete standardization vs. creative approach).

Municipal authorities often have different goals than bottom stakeholders who have to comply with the laws from above. Bottom-up initiatives may stand in opposition to spatial development plans or other regulations imposed by municipal authorities. An example of this type of conflict of interest is the one between the politicians establishing the maritime protection zone in the UK and the fishermen [30].

Experts on the subject also draw attention to the growing dominance of IT corporations in terms of planning and designing buildings in a city. This includes the cities of Songdo in Korea, PlanIT Valley in Portugal, and Masdar in the United Arab Emirates. A similar process can be noticed in China [11]. The growing impact of corporations on the development processes of smart cities may result in an increasingly small percentage of residents' participation in the shaping of the city.

IV. RESEARCH METHODOLOGY

The aim of the presented study was to identify the benefits and risks resulting from combining the top-down and bottom-up initiatives in the context of the technological development of the city of Taipei. This aim corresponds to the fourth item in Table 1: Methods of creating and developing of smart cities. Two research hypotheses have been presented:

H1: Creating of intuitive communication channels between bottom initiators and authorities increases the involvement of residents in the technological development of a smart city.

H2: Combining of the top-down and bottom-up initiatives has a positive impact on the technological development a smart city.

Choosing Taipei as the studied city was not random. In 2021 Taipei was ranked 4th in the prestigious Smart City Index created by IMD and Singapore University of Technology and Design [38] compared to 8th place in 2020. The city also organized the Smart City Summit & Expo 2021 and 2022 [39].

To achieve the intended goal, a qualitative method has been used – a structured interview. It was conducted on 29.03.2022 with Anita Chen, Secretary General of the Global Organisation of Smart Cities (abbreviated: GO SMART), who is also the Project Manager of the Taipei Smart City Project Management Office. Anita Chen has been professionally handling the creation and implementation of Taipei government programs for over 9 years. At the same time, she possesses experience in international initiatives (4 years in terms of the smart city and 4 years in cooperation between Taiwan and India). During the interview, the focus was put on analyzing the Smart Taipei Collaborative Ecosystem model used in Taipei which combines both types of the mentioned initiatives.

The interview took the form of a video conference conducted via the ZOOM platform. The final date and time of the interview (taking into account the 6-hour time difference between Poland and Taipei) were determined on 28.03.2022 during a conversation on LinkedIn chat. At the beginning of the video conference, Anita Chen expressed her consent for recording the interview and to disclosing her name in this publication.

During the interview, the following questions were asked:

1. What are the basic elements of the Smart Taipei Collaborative Ecosystem?

2. How can bottom initiators communicate with the city authorities? How do you assess the impact of these communication channels on the city and its residents?

3. Does creating intuitive communication channels between bottom the initiators and the authorities increase the involvement of residents in the technological development of smart cities?

4. What advantages and disadvantages of top-down and bottom-up strategies do you notice?

5. What is the average time of processing a project?

6. Is, in your opinion, the Smart Taipei Collaborative Ecosystem an effective solution from the perspective of the city and residents? Do any of its elements need to be improved?

An additional method used for the purposes of this publication consisted in examining of the existing documents. 2 types of formal documents have been analyzed: a document made available by the Department of Information Technology of the City of Taipei, the Smart Taipei prospectus *Government as a Platform. City as a Living Lab* [Department…], as well as documents published by GO SMART: *GO SMART. Global Organization of Smart Cities since 2019*, *GO SMART. Annual Report 2020* and *GO SMART Opportunity Report* [GO SMART].

V. THE RESULTS

On the basis of the answers given by Anita Chen and examining of the above mentioned existing documents, all the questions mentioned above have been answered. First of all, the question has been asked concerning the essence of the model of creating and the implementation of new technological solutions, referred to as the Smart Taipei Collaborative Ecosystem. The process of the city's technological development is supervised by the Taipei Smart City Project Management Office (TPMO), an entity established by the Taipei City Government in 2016. Its aim is promoting top-down and bottom-up projects in terms of creating new technologies, increasing the comfort and convenience of residents in every area of urban infrastructure. According to the director of TPMO, Dr. L. Chen-Yu, the effect of the actions undertaken by his subordinate unit should consist in transforming the city of Taipei into a living lab [40]. The remaining units responsible for the technological development of Taipei are: Department of Information Technology (DoIT), Taipei City Police Department (TCPD), Department of Urban Development (DoUD), Department of Transportation (DoT), Department of Education (DoE), Department of Health (DoH), Department of Environmental Protection (DoEP), and the Department of Industry and Business (DoIB). The main connections between the individual stages of this model are shown in Fig. 1

According to Fig. 1 the Smart Taipei Collaborative Ecosystem consists of four stages. The first of them is the Strategic Map, meaning a strategic planning of technological innovations in a smart city. It is a process initiated both by the city's administrative authorities as well as by various types of research, visions, and solutions used outside Taiwan.

The second stage consists in creating a structure of new ideas. At this stage, the difference between top-down and bottom-up initiatives becomes clear. On the government side, it proposes specific pilot programs. The private sector becomes familiar with existing programs. An important role is played by the TPMO platform, which is used to inform the private sector about the government's proposals, and the government about the proposals of the private sector.

The following stage is the Proof of Concept, the core of which are: identifying a problem/area to be improved in the city, submitting proposals for a technological solution to a problem, evaluating the submitted projects, planning the implementation as well as conducting the necessary tests. Here, combining the private and public sectors takes place. The private sector needs the support from the authorities (budget, legal regulations). While top-down initiatives must be implemented and tested with the participation of business representatives and residents. On the government side, the units involved at this stage are: TPMO, DoIT, and the department corresponding to the area of a given technological solution. The main bottom stakeholders consist in representatives of academic centers, the business sphere, and research institutes. During the testing stage, both groups of stakeholders contact each other on an ongoing basis in order to eliminate possible problems.

Submitting initiatives takes place via the TPMO platform. During the calendar year, two calls for proposals are announced. Bottom initiators can also take advantage of the help of the Taipei Global Organization of Smart Cities (www.citiesgosmart.org), an institution mediating between representatives of the business sphere and the government in term of the city's technological development. The GO Smart organization is a facilitator, facilitating contacts with the government primarily for start-ups, which due to the lack of experience and reputation on the market find it more difficult to effectively negotiate with government representatives. The establishment of TPMO and GO Smart is considered to be highly beneficial in the process of Taipei's technological development. An element that encourages proposing new initiatives is the Smart Taipei Innovation Award, which aims to select and reward high-quality technological projects.

The final stage of the model consists in promoting the accepted technological solution. It means not only introducing innovation into the city's life, but also promoting it among residents and advertising it in external environments, such as, for example, international organizations or introducing ICT solutions into force. An example of this type of organization is the previously described GO Smart.

During the interview, a question was also asked about the participation of residents in the city's technological development. According to the received answer, the main form of the residents' participation in the development of Smart Taipei is the opportunity to vote for proposals for technological solutions submitted in various types

Top- down

| Strategic Planning: Central Policy, Vision, Integration, Annual Plan | SC Pilot Project: Requirement/Services Integration – Solution Matchmaking, DoIT - TPMO | Test Field Opened: Cross-domain cooperation, TPMO – Related department – DoIT | SC Renewal: Policy, Infrastrukture, Overall Planning, Phase Build, Business Model DoIT – Main Focus Department |

| **Strategic Map** | **Development Structure** | **Proof of Concept** | **Promotion** |

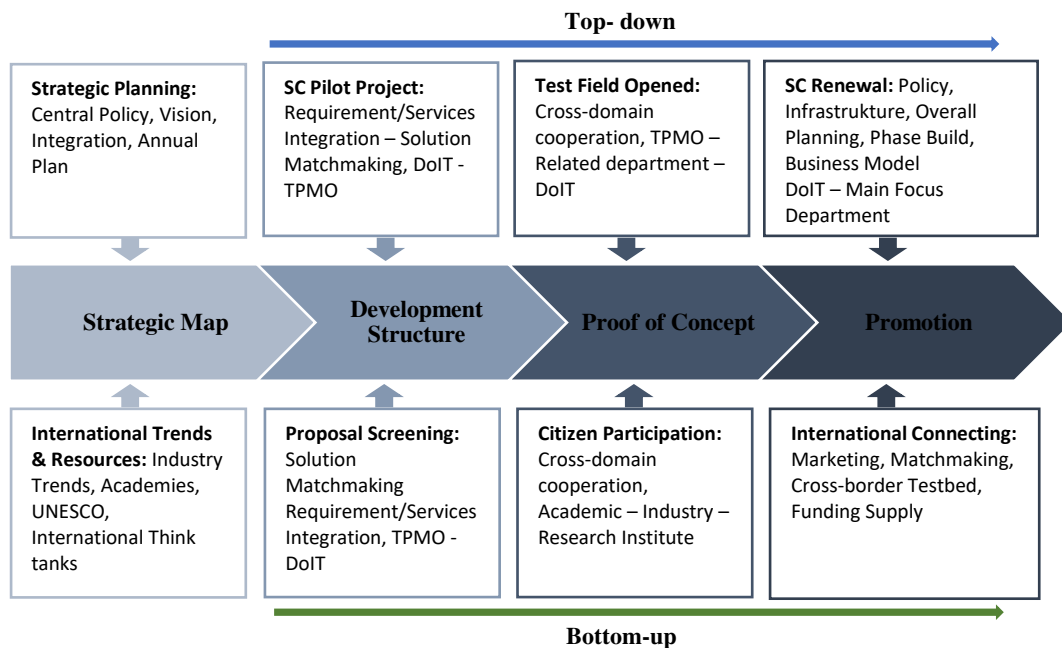| International Trends & Resources: Industry Trends, Academies, UNESCO, International Think tanks | Proposal Screening: Solution Matchmaking Requirement/Services Integration, TPMO - DoIT | Citizen Participation: Cross-domain cooperation, Academic – Industry – Research Institute | International Connecting: Marketing, Matchmaking, Cross-border Testbed, Funding Supply |

Bottom-up

Fig 1. Smart Taipei Collaborative Ecosystem

of competitions. Voting takes place via the TPMO www.smartcity.taipei online platform, which is very convenient for the residents and increases their involvement in the development of Smart Taipei. Voting is usually carried out during the Proof of Concept stage presented in Fig. 1 of the Smart Taipei Collaborative Ecosystem model. The results are not binding: the city's authorities decide on the future of the project on the basis of their own analyses. However, the government takes into account the opinion of the residents, and they are aware of it. This answer has been considered as a confirmation of the H1 hypothesis: *Creating intuitive communication channels between bottom-up initiators and authorities increases the involvement of residents in the technological development of a smart city.*

Residents can also participate in events devoted to new technologies or build pro-innovative communities, and even participate in submitting and implementing projects devoted to the city's technological development. Surveys carried out among the residents concerning their life needs are also important from the point of view of the city authorities.

According to the Secretary General of GO Smart, both forms of projects: top-down and bottom-up, result in a number of benefits for the city. However, they are also related to challenges for initiators. The most important benefits and challenges identified during the interview have been presented collectively in Table II. Top-down initiatives usually have a larger reach than the bottom-up projects. This results mainly from easier access to funding sources and the possibility of cooperation between different departments in a short period of time. Direct access to the decision making person/people (city president or

mayor) has an impact on the shortening of a project's processing. Residents can feel proud to live in a city whose authorities are open to technological development. However, at the same time, residents often consider contents provided by government units via apps or websites as less attractive. Top-down projects are usually not as creative and do not involve the business sector as much as bottom-up initiatives.

In turn, bottom-up projects have a smaller reach than top-down, which is consistent with the views presented by Zhou and Hollands [11, 32]. However, they contribute to a faster development of companies and non-governmental organizations as well as to an increase in the involvement of the residents in the city's matters. These initiatives are also regarded to be more creative than top-down initiatives. Thanks to this they often inspire subsequent people, companies, and even entire cities to introduce technological improvements. For city authorities, bottom-up initiatives are more risky, because if they fail, the people in charge will be blamed by citizens for the incorrect allocation of the taxpayers' money. For this reason, top-down initiators must devote more energy and time to conducting negotiations with representatives of the authorities.

According to Anita Chen, the Smart Taipei Collaborative Ecosystem is very beneficial for both the city and its residents. Combining these two forms of initiatives has a positive impact on the city's development, as it allows collecting creative ideas from the private sector while maintaining the order and structure established by the authorities. The city becomes more open to new possibilities. Whereas, by participating in the process of evaluating projects, the residents feel co-responsible for the technological development of Taipei and become more

TABLE II.
ADVANTAGES AND RISKS OF TOP-DOWN AND BOTTOM-UP INITIATIVES

	Top-down initiatives	Bottom-up initiatives
Advantages	▪ Often with greater reach than bottom-up; ▪ direct access to a decision making person; ▪ shorter processing path; ▪ easier access to the budget; ▪ the possibility of cooperation between several departments; ▪ the satisfaction of residents with the fact that "their" city cares for development.	▪ Development of the private sector; ▪ increasing the involvement of residents in the city's development; ▪ adding more creative content/solutions; ▪ they are an inspiration for other people/companies/cities.
Risks	▪ Content provided by government projects/apps is often unattractive to citizens; ▪ usually less creative than bottom-up; ▪ less engaging for the business sector and individual residents than bottom-up.	▪ riskier than top-down; ▪ the government fears the loss of its good image in the eyes of residents in the event of the project's failure; ▪ require longer negotiations with the authorities; ▪ require more energy from the initiator; ▪ most often with a smaller reach.

involved in the city's technological development. At the same time, the interviewed person agreed with R.G. Hollands [32] who states that bottom-up initiatives are mainly submitted by business representatives. However, at the same time, the interviewed person emphasized that the sole possibility of voting on projects submitted by other entities also significantly increases the involvement of residents in the city's development. Thus, hypothesis no. 2 has been confirmed: *The combination of top-down and bottom-up initiatives has a positive impact on the technological development of a smart city.*

During the interview, Jones' views have been confirmed [30], as according to them combining top-down and bottom-up strategies is related to risks. Anita Chen points to the often problematic issue of determining the scope of responsibility of individual entities, including the need to bear fees charged during the implementation of a project, or the responsibility to correctly prepare project documentation. An element that requires improvement is the duration of processing applications. The average time for implementing a project in 2021 was 11.3 months, with individual initiatives being processed from 1 month to as many as 44 months. It would also be desirable to increase the number of projects implemented through the Smart Taipei Collaborative Ecosystem. In 2021, the number of projects implemented via www.smartcity.taipei was 46.

VI. CONCLUSIONS

The city of Taipei has an area of 271.8 km^2. As many as 2.7 million residents live in an area almost half the size of Warsaw. Therefore, the need to create an orderly urban infrastructure, in which every resident would feel comfortable, is very justified.

On the basis of the conducted interview, it was found that public-private partnership (PPP) constitutes a very large potential for implementing technological projects in smart cities. The main benefits of combining both initiatives are faster implementation of creative technological solutions in the city, control of financing sources for a given project and increasing the involvement of residents in the construction of a functional smart city.

In order to avoid excessive or too strict regulations related to public-private cooperation, it is worth taking care of intuitive communication channels between top-down and bottom-up stakeholders, such as the TPMO platform: www.smartcity.taipei. They have an impact on a faster and better flow of messages as well as increasing the involvement of residents and business representatives in the city's development.

At the same time, it is worth taking care of preparing a proper model defining the framework of interaction between top-down and bottom-up projects. An example of this type of model is the Smart Taipei Collaborative Ecosystem. Thanks to establishing clear rules for cooperation between the public and private sectors the chances of implementing creative and inspiring technological solutions in the urban area will increase, just as transforming the smart city into a living lab. Both the smart city as well as the residents will benefit from this type of regulations.

The combination of top-down and bottom-up initiatives in Taipei can also be a benchmark for smart cities in other regions of the world. In some cities, there are currently attempts to combine government initiatives with citizens' initiatives, but the transparency of the TMPO model would certainly add value to numerous urban centers, incl. in Poland.

In the future, it would be worth verifying the level of satisfaction of business representatives and individual residents concerning the possibility of participating in the smart city's technological development. Such a study would show, for example, the extent to which bottom stakeholders are satisfied with using dedicated online platforms and cooperating with institutions supporting contacts with the public sphere.

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