DEVELOPMENT MODEL FOR SMART CITIES AND REGIONS IN ROMANIA

PhD Thesis – Summary

for obtaining the PhD scientific title at
Politehnica University of Timişoara
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The PhD thesis "Development model for smart cities and regions in Romania" aims at contributing to Romania's predictable, prosperous and sustainable development, by adopting smart engineering and management solutions in the public sector, given that this sector has been insufficiently modernized after the 1989 Revolution. Providing models for the smart development of cities and regions in Romania is a firm step in this direction, even if they will be implemented in the first instance by only a part of the local governments.

The development of smart cities and regions is a **world-wide, very complex research theme** that can be approached differently on a case-by-case basis according to the defined objectives and it involves multiple implementation solutions.

From the public sector perspective, the development of smart cities and regions involves **two essential desiderata**, which must be understood and managed competently: achieving the status of smart city or region (i.e. the goal) and the smart transformation process to achieve this status (i.e. the strategy). The state of fulfillment of the first objective can be assessed by applying performance indicators (preferably standardized), realizing benchmarking / comparative analyzes in relation to the world cities and regions that are acknowledged as being smart and, probably the most important aspect, by obtaining local community's validation for the achievements of the public administrations. The second goal refers to the adoption of philosophies, policies, methodologies and development practices that guarantee an accelerated smart transformation without experiencing unnecessary reluctance of the population, unfounded risks, inappropriate expenses or significant failures, as well as implementing the necessary smart solutions (appropriate for all PESTLE points of view) and ensuring the long-term sustainability of these solutions.

Public systems of smart cities and regions must be implemented, organized and coordinated in such a way that the general status-quo, legislation, technology, feasibility and acceptability from local communities' side are harmoniously overlapped to the greatest possible extent, in the formula of stable, easy-to-manage and sustainable common denominators.

Being aware of the economic, social, territorial, administrative and environmental pressure which is generated by regions and especially by cities, it is necessary to define development models so that their transformation, functioning and prosperity meet realistic expectations and, at the same time, they are in consonance with the existential contexts. Public infrastructure and services, processes, specializations and collaborative networks – all desirable to be smart – need to be studied, harmonized, modeled, standardized, adapted to local realities,

implemented, operated and controlled so that the everyday life and activities of all residents are at optimal levels. Sustainability, durability, flexibility, recovery from critical situations, compatibility and feasibility are just a few issues that need to find a competent response in the smart transformation models.

Moving from current systems of governance and public administration to smart systems of the Future, in accordance with the strategies adopted together with the civil societies, needs to be achieved by applying a well-designed process that maintains all the constituents in balance and harmony, and respects the principles of change management. Some urban and regional development constraints, as well as restrictions are already addressed by the international scientific researches (e.g. on scarce global resources), while – first of all – smart transformations require the proposal of models that have demonstrated their validity, prosperity and longevity. In this regard, it is very important to underline that artificial and natural ecosystems are bound to coexist in an as high harmony as possible, and moreover, the environment of many geographical areas of the world must be aided to regenerate.

In Romania, the need of recovering the development deficit in comparison to the western European Union countries and to strengthen the stability in this complicated geo-political Euroregion can be ensured by designing, adopting and implementing models for the development of smart cities and smart regions, based on scientific research and adapted to the local specific features. Well known are Romania's political, administrative, economic, social and territorial problems, as well as the lack of vision, incoherent strategies and the de-synchronization between systems of all kinds - which determines internal state instability, but also in respect to foreign relations and to attracting foreign investors. In conclusion and by considering the current era of globalization (phenomenon that can determine both advantages and disadvantages of multi-valent nature for Romania), it goes without saying that it is absolutely necessary to apply smart development models for cities and regions of Romania, to stabilize and make it prosperous.

As **general objective**, this thesis aims at elaborating and validating two generic and well-founded smart development models for cities, respectively regions[1] in Romania, so that public administrations can start on the path of smart transformation through a professional, programmatic, macro-systemic and multidisciplinary approach, based on the results of international scientific research, certified concepts of various prestigious organizations in the world, as well as on the expertise and experience of the author.

The **operational objectives** (OO) of this thesis were established as follows:

OO1. Identify the international context and premises of current general demarches on the development of smart cities and regions, in conjunction with the problems and pressures of the humanity;

OO2. Identify Romania’s status-quo regarding public administrations’ initiatives to implement smart solutions dedicated to cities and regions;

OO3. Conduct theoretical researches (including the set of bibliographic references), as well as synthesize harmoniously and coherently most valuable results of the international scientific research and the concepts of specialized organizations;

OO4. Study and highlight the international standards, published or under development, which are relevant to the theme of smart cities and regions (note: considering its importance, this OO is individualized separately);

OO5. Conceive the macro-systemic models for developing smart cities and regions in Romania, including the assessment and planning of smart transformation;

[1] At present, the only regions with legal personality in Romania are the counties (i.e. NUTS 3 regions, according to the EU regulations). That is why, this paper focuses on the development of counties – fact that is explained also in the chapters of the thesis. It is to be emphasized, however, that the development model for smart regions is generic enough to be also applied to future possible NUTS2 regions that will be set up in Romania.

OO6. Test and validate the above-mentioned development models by using well-selected samples, as well as perform SWOT analysis with respect to the prospects of the concerned cities and regions, and propose specific solutions for their smart development;

OO7. Conclude the undertaken research on the generality, suitability and usefulness of author's proposed development models in relation to the cities and regions of Romania.

The accomplishment of the general objective and operational objectives was done by the author by carrying out the activities described in the chapters of the thesis, which are outlined in Figure 1.

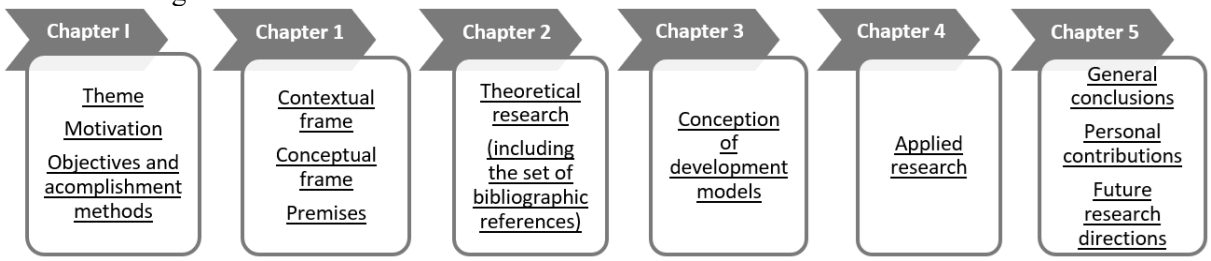

Figure 1. Overview of the doctoral thesis chapters

The association of the operational objectives with the thesis chapters, for assuring their correct and complete mapping, is indicated in Table 1.

Table 1. Assignation of the operational objectives to the descriptive chapters of the thesis

Operational objectives of the PhD thesis	**Addressing chapters**
OO1 – Identification of international context and premises	Chapters „Introduction”, 1.1 and 1.2
OO2 – Identification of Romania’s status-quo	Chapter 1.3
OO3 – Theoretical research	Chapter 2
OO4 – Studying and highlighting of relevant international standards	Chapters 2.2.5 and 2.3.9
OO5 – Conception of development models	Chapter 3
OO6 – Testing and validating of the development models	Chapter 4
OO7 – Conclusions on the undertaken research	Chapter 5

Main goal of the smart city is the highly-performant and qualitative management of infrastructure, communities, as well as private and public institutions, and its **main mission** is to transform public infrastructure and services into fully integrated smart systems. The **interpretation attributed in this thesis to the “smart” term** is: high-tech, digital, connected, innovative and knowledge-centered. Concerning the elaboration of the smart city development model, this thesis **focuses on the following aspects**: IT&C transversal technologies, collaborative governance, integrated and performant management, and smart society.

For the **development of smart regions, the author emphasizes** the connections that need to be created and operationalized between the belonging territorial-administrative components in order to produce added value – such as in metropolitan areas, urban agglomerations (e.g. conurbations) and networks of cities – see Figure 2. In this respect, contrary to the theme of smart cities, but adopting the principles of their smart transformation, the present thesis deals primarily with the PESTLE and administrative connections which are

important for the smart development of regions.

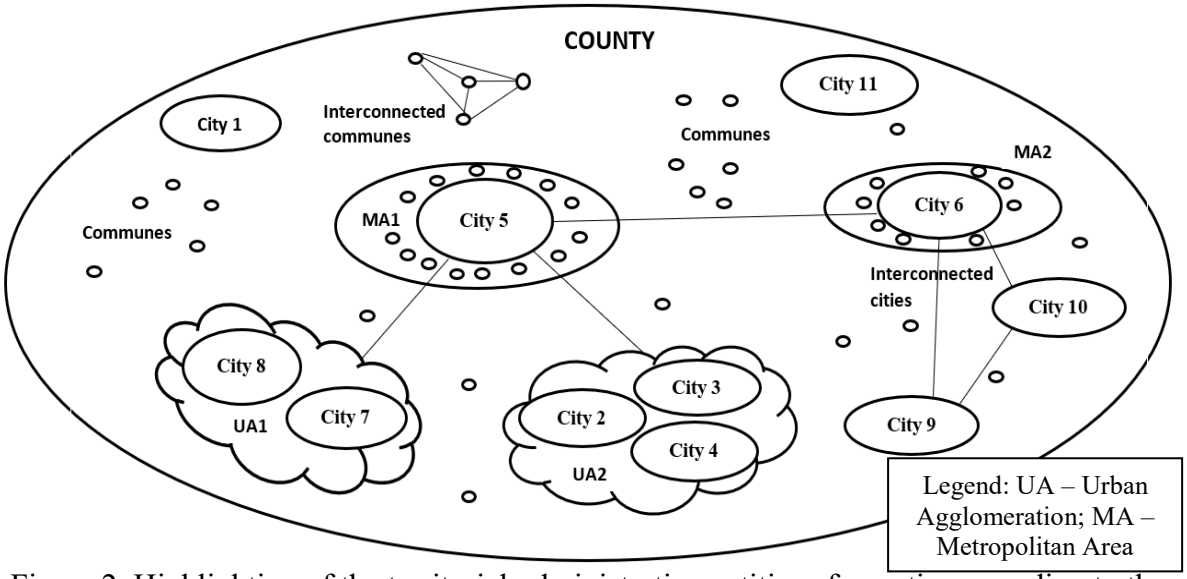

Figure 2. Highlighting of the territorial-administrative entities of counties according to the Regional Smart Development Model / Regional SMD

Chapter 1 - "Description of the contextual and conceptual framework for conducting the research" makes an insight into the issue of smart cities and smart regions, by highlighting the international context in which operationalizations are already happening for some smart public infrastructures and services, as well as for some systems dedicated to the government and public administration. It is mentioned that these initiatives are usually taking place bottom-up, given the incompleteness and lack of harmonization of the regulations in the field. The existing smart concepts are briefly described and exemplified, so that their essence is acknowledged, along with the need to crystallize smart development models. The praiseworthy efforts of various scholars or prestigious organizations of different types and typologies are emphasized, but, at the same time, it is underlined that their concepts currently create a relatively chaotic cumulation of smart elements. Therefore, they have to find their river bed in a macro-systemic integrated perspective – exactly what this thesis aims for with the research niches that are clearly indicated in this chapter. Finally, the author presents his own conclusions on the precarious situation in Romania regarding the implementation start of the modernizing smart public solutions, that are long after the international practices and trends.

In Chapter 2 - "Theoretical research on the elaboration of development models for smart cities and regions", the author went on to describe the steps taken to achieve the doctoral objectives, namely by reflecting the synthetic conclusions of the theoretical research, including the set of bibliographic references. This description was made over approximately 90 pages, given the vastness of the smart cities and smart regions themes, which – in fact – represented two different research themes, the latter being much less scientifically addressed and in a disorganized manner than the first. The abundance of problems and lack of information in some cases have led to considerable efforts by the author for synthesizing and harmonizing the related issues. Thus, essential elements of the specialty literature were highlighted with respect to the handling of smart cities, on: life perspectives, development and functioning pillars, systemic characteristics, smart models, smart infrastructure, integrated management, collaborative governance, smart financing, stages and implementation processes, international standards, key performance indicators etc., many of the enumerated aspects having a strong engineering and managerial character. In what smart regions concern, the author has identified the targeted relational and integrative elements with greater difficulty, namely in relation to: metropolitan areas, urban agglomerations, smart interconnection of regional components, multidisciplinary

integration of regional systems, smart specialization and so on. By highlighting all aspects mentioned above, including numerous concrete examples and critical factors for assuring the success, the author highlighted the inspiring sources validated by scientific and empirical research to underpin the elaboration of development models in the next stage of the research, described by next chapter.

Chapter 3 – "Development models for smart cities and regions in Romania" describes the smart models designed by the author for developing the cities and regions of Romania (i.e. Urban SDM and Regional SDM, respectively). Each of them has its associated application methodology, as well as a series of constituent elements. Thus, Urban SDM is based on a set of 96 smart solutions grouped on nine development pillars, each of which being characterized by a particular configuration of 20 triggering principles, 14 triggering (disruptive) technologies, 10 potential benefits, cybernetic risk degree (calculated according to three parameters) and 157 typical international performance indicators. For easing the identification of these smart solution configurations, Urban SDM also possesses graphical visualization tools. Furthermore, Urban SDM contains a questionnaire – a collection of 15 questions – to investigate the expectations and readiness of the local community, as well as a template for assessing and planning the smart development of cities that is based on 23 mathematical relationships (some of which with their own sub-formulas) and a related procedure. Regional SDM focuses on identifying and integrating the so-called administrative entities, which can be of Territorial-Administrative Unit / TAU type (manageable via TAU SDM, which is equivalent to Urban SDM) or of Aggregate type - notion that is introduced by the author (manageable through Aggregate SDM, which is made up of its own defining elements, including 12 smart solutions – each with a particular configuration as in the case of Urban SDM). There is also a smart regional development assessment-planning template, based on 2 mathematical relationships (each with sub-formulas) and a related procedure. The two above mentioned assessment-planning templates, corresponding to Urban SDM and Regional SDM, are actually used in conjunction with the calculation-estimation of three parameters according to data and information gathered in the field, ultimately leading to the determination of smart profiles for the development pillars, respectively general smart profile for the targeted city or region. Applying the planning templates and calculating the associated smart profiles means, in fact, a quantitative simulation of future smart development of the targeted city or region.

In conclusion, **Urban SDM** is based on the following elements, all important for the implementation of smart cities and, in general, smart TAU-s of any kind:

1. Methodology for assessing and planning the development of smart cities;
2. Set of parameters for smart city development;
3. Set of solutions dedicated to smart city development;
4. Questionnaire to investigate the expectations and readiness of local community with respect to the smart city development; and
5. Template for assessing and planning the smart city development.

Similarly, **Regional SDM** is based on the listed items (note: Aggregate SDM contains its own defining elements):

1. Methodology of assessing and planning the development of smart regions;
2. Model for developing smart territorial-administrative units – TAU SDM;
3. Model for developing smart aggregates – Aggregate SDM;
4. Questionnaire to investigate the expectations and readiness of local community with respect to the smart regional development (managed by COUNTY TAU SDM); and
5. Template for assessing and planning the smart regional development.

Chapter 4 – "Applied research on the development of smart cities and regions in Romania. Testing and validating of the models" presents the results of testing and validation activities upon Urban SDM and Regional SDM. The case studies for which the two models

were applied were Timişoara City and Timiş County, each characterized by certain research contexts. The methodology, tools (including FEPEX application created by the author), limitations, assumptions, sources of information and samples associated with the investigations were clearly set out in this chapter. In the case of Timiş County, in addition to the inclusion of the City of Timişoara, five other relevant public administrations (i.e. County Council and halls of two towns and two communes) were evaluated, together with their subordinated institutions and relevant associations they belong to. The performed investigations involved multiple stand-alone analyzes conducted by the author, interviewing 68 representatives of the beforementioned institutions and associations (of which 30 for Timişoara City) and probing 416 persons from the local communities of Timiş County (out of which 245 with precise localization in Timisoara). The calculations led to different general smart profiles, of which Timişoara was distinguished as the most advanced, albeit modest, the other TAU-s having even lower values. That is why and by integrating in the evaluation also the smart profiles of the five Regional SDM aggregate types, the general smart profile of Timiş County resulted to be modest as well. The survey results have shown overwhelmingly favorable responses to the smart principles for which the point of view was sought, by highlighting the average preferences of the residents. Additionally, analyzes were carried out on both public sector and rural environment, with results comparable to those of the general ones. Moreover, the survey revealed the lack of respondents' knowledge in relation to some smart elements, such as the triggering (disruptive) technologies, the related percentage shares being quite high in some cases.

The applied research for the City of Timişoara led to the results presented in Figure 3 and Figure 4. Legend (also for Figure 5 and Figure 6):

SDSS – Smart Degree in relation to the implementation of SDM Smart Solution;
SDTP – Smart Degree in relation to the Triggering Principles set;
SDTT – Smart Degree in relation to the Triggering Technologies set;
SDGB – Smart Degree in relation to the Generated Benefits;
RD – cybernetic Risk Degree.

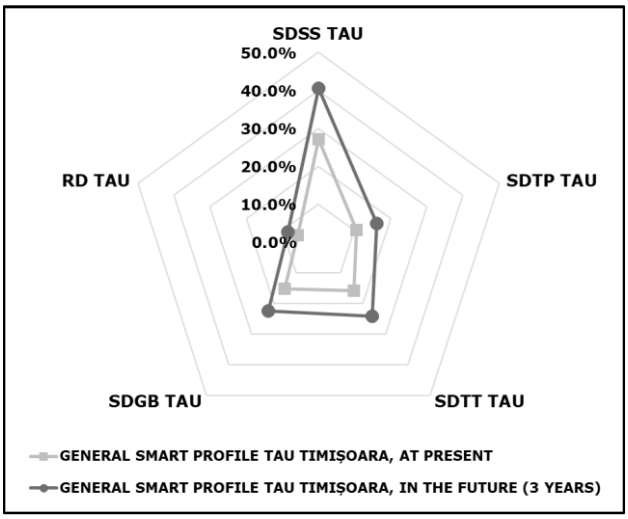

Figure 3. General smart profiles of TAU Timişoara, now and in the future

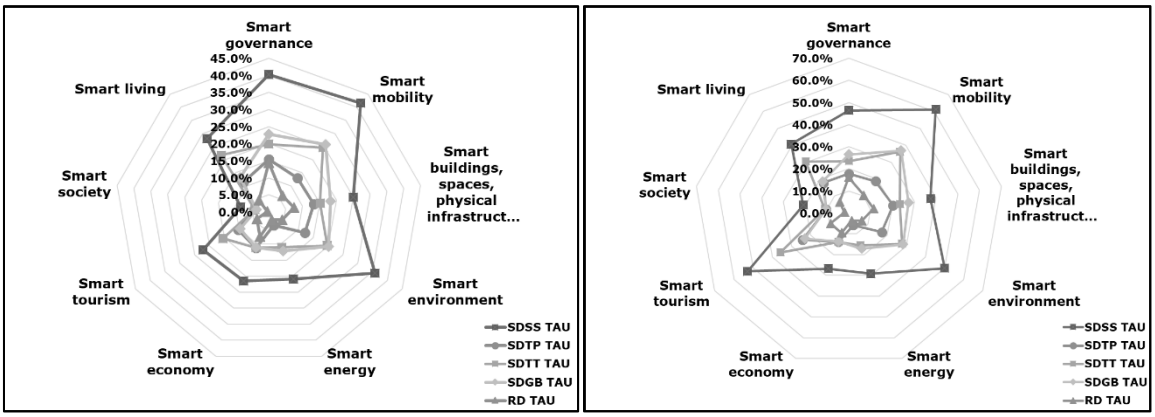

Figure 4. Smart pillar profiles of TAU Timisoara, now (left) and in the future (right)

The applied research for Timiș County – as ensemble of 100 TAU-s – led to the results presented in Figure 5 and Figure 6.

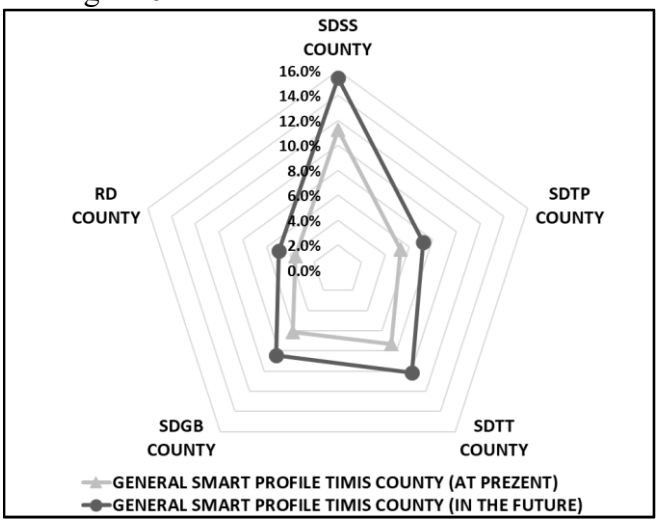

Figure 5. General smart profiles of Timiș County, now and in the future

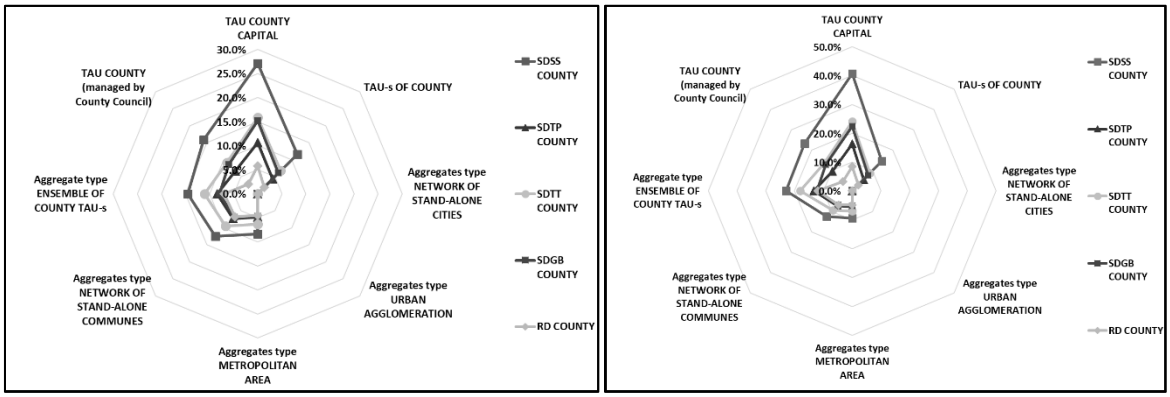

Figure 6. General smart profiles of Timis County from AEG perspective, now (left) and in the future (right)

At the end of the applied research, the author added SWOT analyzes and recommendations on the prospects for the smart development of Timişoara City (using transparent and repeatable criteria), respectively for Timiș County, by taking into account as well the results of the conducted survey for both case studies.

Chapter 5 – "General conclusions and personal contributions" presents the general conclusions of all research efforts, the author's contributions in the field of smart cities and smart regions development, along with proposals on possible future research directions that

stem from the results of this thesis. A selection of author' significant contributions in the area of the concerned research themes is the following:

a) **Research contributions on the set of bibliographic references**

- ✓ Identification and analysis of over 600 up-to-date documents of the international specialized literature (of various types);
- ✓ Successful handling of a very complex multidisciplinary approach, which included fields like engineering, management, public administration, sociology, ecology and economic development;
- ✓ Clarification, harmonization, highlighting and synthesizing most valuable essential aspects, in a coherent form;
- ✓ Introduction of completely new personal concepts (e.g. the nine IT&C dimensions of smart systems);
- ✓ Producing a compilation of essential interpretations and innovations that can be used by public or private actors in various ways and for different purposes;

b) **Contributions in the field of theoretical research**

- ✓ Urban SDM and Regional SDM are completely new general, macro-systemic, multidisciplinary and harmonizing concepts;
- ✓ Definition of the perspective for smart regional development (practically from scratch);
- ✓ Introduction-highlighting of the concept regarding the smart interconnection of cities, as well as of all regional components, at any PESTLE level;
- ✓ Introduction of the triggering principle notion, by structuring-defining the set of 20 triggering principles for smart cities, as well as refining and completing them with additional necessary information;
- ✓ Structuring of the smart characteristics set (6 groups), 14 triggering technologies, 10 potential benefits and 157 typical international performance indicators;
- ✓ Crystallization and clarification of the 9 pillars of smart development that are relevant to the local public administrations of Romania;
- ✓ Definition of the set of 96 smart solutions for cities and TAU-s (note: a part of the set was conceived and introduced strictly by the author);
  - o Identification, clarification, refining, structuring, synthesizing and exemplification of all 96 smart solutions;
  - o Analysis and establishment of thousands of relational dependencies between the 96 smart solutions and their associated smart parameters (i.e. triggering principles, triggering technologies, estimated potential benefits, estimated cyber risks and typical international performance indicators);
- ✓ Definition and introduction of the smart aggregation notion, together with its own typology and characteristic elements;
  - o Introduction of 12 specific smart solutions, as well as 2 triggering principles and 2 smart characteristics – in addition to those related to smart cities, along with the smart development assessment-planning template;
  - o Analysis and establishment of hundreds of relational dependencies between the 12 smart solutions and their associated smart parameters (i.e. triggering principles, triggering technologies, estimated potential benefits, estimated cyber risks and typical international performance indicators);
- ✓ Estimation of the potential benefits and cyber risks for all smart solutions of cities / TAU-s and aggregates;
- ✓ Creation of a questionnaire to investigate the expectations and readiness of local community – 15 questions (each with a well-defined set of possible answers) and 2 corresponding mathematical relations;
- ✓ Creation of visualization tools for the association maps and smart profiles for solutions,

pillars, cities/TAU-s, aggregates and regions;

- ✓ Elaboration of the smart development assessment-planning templates corresponding to Urban/TAU SDM models, Aggregate SDM and Regional SDM, based on 26 mathematical relations (together with their sub-relations);
- ✓ Complete definition of the smart development models (i.e. Urban/TAU SDM, Aggregate SDM, Regional SDM), including the assessment-planning methodologies;

c) **Contributions in the field of applied research**

- ✓ Creation of the FEPEX application for Urban/TAU SDM, Aggregate SDM and Regional SDM;
- ✓ Publication of the research results for Timisoara and Timiș County (including SWOT analyzes and concrete proposals for smart development), thus setting an important starting point for the smart initiatives of the public administrations in Timiș County;
- ✓ Successful testing and validation of smart development models for cities and regions (i.e. Urban SDM and Regional SDM), which therefore can be used by local governments throughout Romania (including the possible future regions with legal personality), but also at international level.

Considering all previous mentions, final conclusion of the thesis emerged to be positive and edifying, the research theme being successfully completed and the overall objective, as well as operational objectives being fully met. The two models designed by the author, Urban SDM and Regional SDM, have demonstrated their suitability and utility, producing the expected results in the applied research, thus being fit to be used for the development of all cities and counties (including the possible future regions with legal personality) in Romania.

The results of the theoretical research, including a part of the applied research, were disseminated by publishing five scientific articles / papers in journals and volumes of international events, all indexed by ISI Thomson or international data bases.

The author used 84 figures, 56 tables, 28 mathematical relations (excluding their sub-relations), 4 annexes and 227 bibliographic titles quoted on 284 pages (in the format of Politehnica University of Timișoara's publishing house) for the elaboration of the doctoral thesis.

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