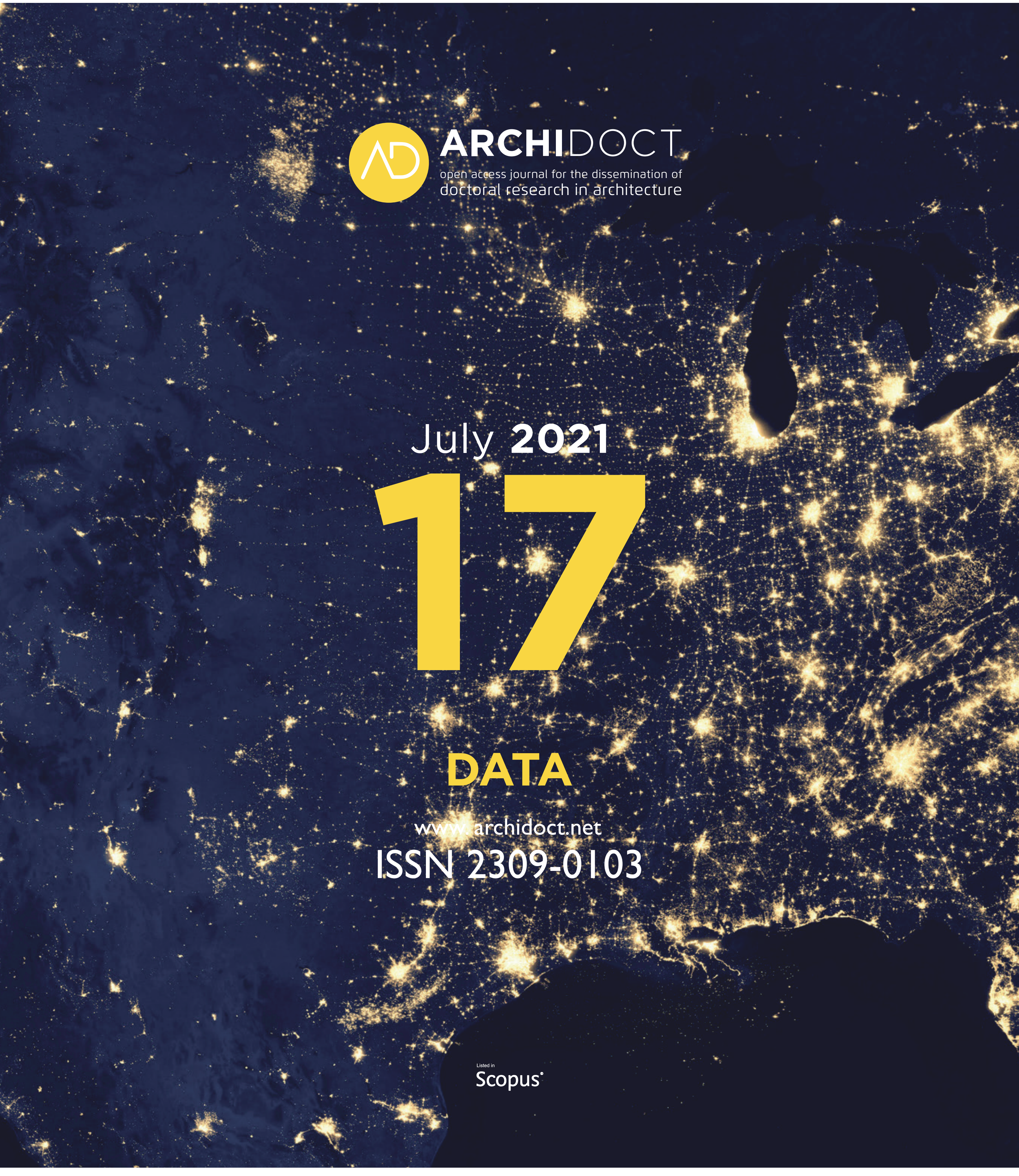

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Editorial

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Keywords: data, granularity, information, interconnections, design by simulating

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ArchiDOCT 17th aims at exploring the theme of 'data' in the built environment and their recurrence and currency in either the realm of theory or the realm of applications. Even though the topic has been seemingly exhausted in recent years, a systematic record of approaches to doctoral education on the build environment and data has not been undertaken. The breadth and the various degrees of 'granularity' will be showcased in this and the forthcoming issue of ArchiDOCT towards indentifying the potential of data to (in)form or even shape tomorrow's built environment.

Considering the breadth of the discourse on data, and an effort to understand their relevance to the design process through both a theoretical or practice-based approach, we could not exempt ourselves, also in regards to the reader, from framing our exploration from a precisely theoretical point of view and manifesting our critical position within this vast field of interest.

In 1980, the American Sociologist Alvin Toffler published his famous book *The Third Wave* (1980). In the text, he maintained that different eras have succeeded each other based on different sources of value. The *First Wave* coincided with the agricultural society, which mostly prevailed after the Neolithic Revolution lasting several thousands of years. The *Second Wave*, covering a span of time of around 150 years, is related to the Industrial Society which, according to Toffler, is based on «*mass production, mass distribution, mass consumption, mass education, mass media* [...] *standardization and synchronization*». Finally, the *Third Wave* took place when most countries transitioned to a globalised society where relationships among people and political and economic structures were significantly altered by the disruptive impact of new technologies. At the core of this shift lie data, information, and their treatment. New models arose and the incidence of this transition has impacted the domains of architecture and design.

To contextualise our discussion even better, we can recall another fundamental moment in the history of science and technology. In 1989, at the International Society for General Systems Research, American organizational theorist Russell Ackoff presented for the first time a graphical representation of the **DIKW** pyramid. Rather than a simple descriptive model, the latter defines purported structural and/or functional relationships among **d**ata, **i**nformation, **k**nowledge, and **w**isdom. With regards to Ackoff's theorization (1999), data stand for a set of pure symbols and signals, hence stimulus, which represents the founding properties of objects and events. Thus, data are basic particles of knowledge, while the latter represents the complex forms of rules, patterns (synaptic connections), and algorithms, through which data are processed, interrelated and then visualized, in order to obtain a specific meaning and presence in the realm of existence.

More than ever, architects need to develop a powerful (human) computer "eye" (Pedrycz, 2005) – a sensitive, critical, and knowledge-based one in order to understand data and undertake sensible decisions. The key to this process stands in 'clustering' data to discover their inner structure and give meaning to the granularity which they are composed of. Since the 1930s, the rapidly growing interest on this topic, together with the fast technological development of the last decades, had given birth to methodologies and algorithms that were predominantly data-driven and where any optimization was exclusively data-oriented. Thus, our purpose, as architects, is to understand the influence that data can have on architecture and urban planning; to expand the limits and the new possibilities of data for, from, with, and, against the built environment. Furthermore, we need to explore two different - but interrelated – moments of clustering procedures: how data are gathered, and how to build meaningful platforms to describe multidimensional and heterogeneous data spaces.

«*Many forms of data are far more useful as visualization*» stated Ian Millis (2017) in his *Data Visual: Editorial essay* published in 2020 on ArtLink. And surely, their proper visualization allows us to create design models where the magmatic amount of data is interrelated and dynamically inter-

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twined as responsive material. Through the correct analysis and representation of data, we can constantly simulate by designing and design by simulating and, quoting Fritjoj Capra (1996), instead of ending up with 'static things' we deal with interconnections.

It becomes clear then, how the last four decades of research in the field of architecture and the urban environment have been strongly influenced by the presence of data. This ongoing relationship between the latter and the struggle to instill in them an intention. Whether we refer to the macro or the micro-scale, architects have been trying to collect and give meaning to the magmatic amount of data in which we are constantly submerged. Sensors and actuators in the city, computational design process, script-based generative procedures, AI disruptive speculations, the Internet of Things, Big Data, are just some of the examples of almost half a century of heterogeneous research trajectories. From a first phase of inebriating experimentations based more on pushing the technological tools to their limit, a second phase of the research on 'data' relates more to their capacity to ontologically address the meaning of the discipline itself and disclose new strategies to manage the complexity, and ethics, of the world at large.

The 17th number of ArchiDOCT, entitled DATA, precisely wishes to investigate tangible examples of their implications either for applied design strategies or for research purposes, with the main aim to (in)form the debate regarding data and enlighten on their proper use within the architectural domain.

The appeal and the breadth and diversity of a large number of submissions for the issue of data was astonishing. The different points of view and critical reflections on the topic were so rich that the Editorial Board decided to dedicated the forthcoming issue to be published in February 2022 to DATA Part II. The current volume, DATA Part I contains essays on *Data and Cases Studies*, and *Data Software and Building Technologies*.

Intelligence and Co-Creation in Smart Specialisation Strategies. Towards the next stage of RIS3 is a choral contribution from several established scholars in this field[1] for our 'a Good Practice Example' section. The essay focuses on some of the key points extrapolated from the Online S3 project, funded from the Horizon 2020 program of the European Commission. Using a specific set of methodologies for strategy design, the main aim is to facilitate the implementation and actuation of Research and Innovation Strategies for Smart Specialisation (RIS3). The paper presents some of the past challenges faced by the program and offers an overview of the future ones to be addressed. Moreover, it discusses how strategies could be further improved by the implementation of critical datasets, and also facilitate the collective intelligence and the process of solutions co-creation.

The first essay, delivered by **Nicola Tasselli**, PhD candidate at the University of Ferrara, together with his advisor, Associate Professor **Federica Maietti**, is entitled **Data management implementation. New strategies addressing built assets**. Through the text, they discuss the impact of digital technologies and data modeling in the field of survey and representation, giving some results to properly direct the data processing phase. The parametrization of elements, and the standardization and, indeed, replicability of solutions through BIM technologies allows a geometric data enrichment either on the ontological or semantic point of view. Starting from the consolidated Italian tradition in the field of restoration and conservation, the paper proposes to extend the procedures now applied to Herigate-BIM also to a more widespread built heritage.

So similar, so different: diving in the physical and acoustic features of two theatres. A case study, is the paper submitted by PhD candidates **Blanca Pérez-Aguilar** and **Alberto Quintana-Gallardo** together with PhD architect **Ana Llopis** and professor **Ignacio Guillén-Guillamón**, from the Centro de Tecnologías Físicas, Universidad Politécnica de Valencia, Valencia, Spain. Through specific case studies (precisely two theaters) in the city of Valencia, the paper investigates how the combination of geometrical and sonorous data can be used to understand the actual spatial conditions of the buildings and propose more informed design strategies. Following the description of the actual buildings, and their condition within the consolidated urban environment, comparative analysis based on a three-axes strategy (geometric, acoustic absorption, and onsite analytic data) is presented and critically discussed by the authors.

Asiye Nika Kartal, PhD candidate from the Department of Architecture and the Built Environment, University of Nottingham, through her work **More phenomenology less visual: A haptic narrative and a proposed haptic 'Sensemarks' database of Istiklal Street, Istanbul**, approaches the topic from a phenomenological point of view. The city of Istanbul, and specifically one of its streets, is seen as the perfect context to discuss the concept of the haptic dimension of the space. The essay states that still today many of the haptic characters of the street are visible and proposes that this should be implemented as a proper design strategy for the different authors involved. The author proposes the creation of a database where 'haptic features' could be gathered and then further qualitatively analyzed.

Knowledge economy's externalities and urban growth. An analysis of the functional dynamics and location patterns of knowledge-based industries in the Metropolitan Barcelona, is the title of the paper from PhD **Juan Eduardo Chica**, Department of Architecture and Habitat, Tadeo Lozano University, Bogotá, Colombia, and Associate Professor **Carlos Marmolejo Duarte**, from Centre of Land Policy and Valuations, Polytechnic University of Catalonia, Barcelona, Spain.

The contribution focuses on the Centrality of knowledge-based industries (KBI) in the economy of metropolitan areas

1 The paper presented here as a good-practice example is an excerpt of a longer paper of XXX pages. Authors: Nicos Komninos, Christina Kakderi, Anastasia Panori, Eva Garcia, Katharina Fellnhofer, Alasdair Reid, Vladimir Cvijanović, Mona A. Roman, Mark Deakin, Luca Mora

in regards to their labor markets and promotion of new forms of urban growth based on KBI specialized clusters. The Barcelona Metropolitan Region (BMR) is used as a case study for a Proxscal Multidimensional Scale Analysis which explains the relationship between all the economic sectors. Furthermore, the essay suggests how such a data-driven approach can be reiterated, on multiple scales, also to other urban data contexts.

The last essay for this issue, entitled **DATA and Information in Architectural Design Process through Building Information Modeling: A New Epistemological Horizon of BIM Methodology**, is an original work from PhD **Pablo Andrés Gómez Granda**, and Associate Professor **Alfredo Montaño Bello**, both from the Faculty of Arts and Design (FAD), Universidad de Bogotá Jorge Tadeo Lozano, Bogotá, Colombia. Starting from distinct projects conducted by the authors (*Contemporary Architecture in Colombia and Optimization of building management through the implementation of digital twins*), the essay explores the pedagogical aspect of the results through some dedicated design workshops. BIM software is used to train the students in architectural design competencies. The dynamic model of the building is the vector to trigger students' capacities of lateral thinking and also to improve the decision-making aspect of their design strategies. The main aim is not only to empower the students through a mixed practice-based/theoretical approach but also to promote the need for the development of a new epistemological model for architecture education in Colombia.

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ArchiDOCT 17, 9 (1) DATA

Intelligence and Co-Creation in Smart Specialisation Strategies: Towards the Next Stage of RIS3

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a The paper presented here as a good-practice example is an excerpt of a longer paper of XXX pages originally published in 2018.

Nicos Komninos is professor emeritus at the Aristotle University of Thessaloniki. He holds a master's degree of Architecture-Engineering from the Aristotle University, post-graduate studies in Semantics with A. J. Greimas, and a PhD from the Ecole des Hautes Etudes en Science Sociales (EHESS Paris) under the supervision of P.H. Chombart de Lauwe. He has taught courses on "Intelligent Cities: Architectures and Strategies", "Design and Development of Software Applications for Smart Cities", "Strategic Planning for Urban Development", and "Learning Regions: Innovation and Regional Development in Europe".

He is the founder of URENIO Research and has coordinated more than one hundred projects under the European research and territorial development programmes (H2020, FP, CIP, LDV, Interreg, SEE, MED). His research interests are in two fields (1) intelligent / smart cities: formation and evolution; ontology; architectures of connected intelligence; intelligent city strategy and planning; smart city platforms for growth, sustainability, safety, and governance; smart city software design and development; smart cities and cloud computing, (2) cyber-physical systems of innovation: knowledge and innovation networks; innovating with data; user-driven innovation; platform-ecosystems; software applications and platforms for innovation; innovation strategies; smart specialisation strategies (RIS3); measuring of innovation performance. These are two interdependent fields of research, with cyber-physical systems of innovation being the problem-solving engine in intelligent cities.

b **Christina Kakderi** is an Assistant Professor of Spatial Development and RTDI Policies in the EU at Aristotle University of Thessaloniki (AUTH), School of Spatial Planning and Development. She is an economist (University of Macedonia, Greece), holds a master's degree on Urban Planning, from Cardiff University in Wales, and a PhD on Innovation Systems from Aristotle University of Thessaloniki, Greece.

As a member of Urban and Regional Innovation Research Unit – URENIO and, previously, of Spatial Development Research Unit, she has been involved in many EU and national funded projects related to smart cities and innovation policy. Her research interests focus on two main areas: a) intelligent ecosystems and innovation environments (use of technologies, emergence of intelligence, evolution, governance and resilience of smart cities and innovation ecosystems) and b) policies and strategies for regional and urban development including RTD (formation of smart city/ digital transformation strategies as well as of smart specialisation strategies (RIS3); technology assisted solutions for evidence-based decision making etc.).

c **Anastasia Panori** is an Electrical and Computer Engineer (Aristotle University of Thessaloniki) holding a MSc in Economics and a PhD in Economic and Regional Development from Panteion University of Athens. Her main research interests focus on regional and urban socio-economic development, data science, smart cities, and Smart Specialisation Strategies at a regional level. Since 2012, she has been working as a researcher and have participated in various H2020 projects funded by the European Commission.

d **Eva Garcia** has been managing R&I projects by European SMEs, institutions and corporations from 2003, having supported more than 350 projects during ideation, developing and exploitation stages, mainly focused into increasing their differentiation and innovative potential, improving their market fit and optimizing their business models. She also trained more than 2,000 people in this area, developing our own learning methodology, dynamics, tools and materials.

e **Katharina Fellnhofer** has been awarded the prestigious Marie Curie Fellowship, funded by the European Commission and hosted by the ETH Zurich and Harvard University. Her fellowship research initiative entitled ROLLER-COASTER (Cordis) focuses on entrepreneurs' and venture capitalists' entrepreneurial intuition during financial decision-making.

Prior to joining ETH Zürich, she has been a visiting scholar at the Weatherhead Center for International Affairs at Harvard University and an Erwin Schrödinger Fellow at the Lappeenranta University of Technology in Finland. She holds a doctorate in Social and Economic Sciences from the University of Innsbruck, Austria.

f **Alasdair Reid** joined Edinburgh Napier University in 2008 as a researcher specialising in sustainable urban development. He has since been involved in several high-profile research projects including SURegen, CLUE, EXPGOV, Smart Accelerator, Online S3 and Smart Kids, culminating in the publication of several academic papers, books and online literature. Alasdair is also a lecturer within the School of Built Environment. Alasdair holds a first-class honours degree in Estate Management (RICS accredited) and an MSc in City Planning and Regeneration (RTPI accredited). In addition, he holds a Postgraduate Certificate in Learning, Teaching and Assessment Practice in HE and is a Fellow of the Higher Education Academy.

g **Vladimir Cvijanović** is a Policy orientated research professional with expertise in industrial / innovation policy, green economy / transition to low-carbon economy and EU27 / Southeast Europe. Expert for the European Commission and the European Economic and Social Committee, project manager and project evaluator. He works on projects typically based on service contracts with the European Institutions and Horizon 2020 projects.

h **Mona A. Roman** focuses on open innovation, regional innovation systems and smart specialisation. Her research is based on qualitative in-depth case studies. She is currently working with research how to engage and facilitate the participation of citizens and civil society in the design of regional research and innovation strategies for smart specialisation.

i **Mark Deakin** is a leading academic who has provided a strong support to emerging scientific and technical developments on Smart Cities. He is author of 12 books and about 100 peer-reviewed publications on Sustainable Urban Development, Urban Technology Management and Smart Cities. These publications include Sustainable Urban Development (Volumes 1-3, Routledge 2005-2009) and Smart Cities: Governing, Modelling and Analysing the Transition (Routledge, 2013). In addition, Mark has directed several research projects dealing with Smart Cities and the Sustainable Development of Urban Environments for the European

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Keywords: evidence-driven innovation policy, policy-making, co-creation, dataset, data

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The white paper on "Intelligence and Co-creation in Smart Specialisation Strategies" outlines some key conclusions from the Online S3 project, funded under the Horizon 2020 programme of the European Commission. The Online S3 project has produced an online platform composed of software applications and roadmaps that facilitate the design and implementation of Research and Innovation Strategies for Smart Specialisation (RIS3). Using a baseline set of methodologies for strategy design, Online S3 is advancing the understanding of RIS3 as a place-based and evidence-driven innovation policy, relying on large datasets and software for user engagement, co-creation and collective intelligence in policy design. In this white paper, the core building blocks of RIS3 are presented, as they appear in EU documents and related literature, such as ex ante conditionalities, stakeholder engagement, specialisation by diversification, entrepreneurial discovery, policy co-design, monitoring and assessment. This white paper also discusses weaknesses of the current period and what can be done better in the near future; thus, puts RIS3 in retrospect and prospect for 2021-2027. At the same time, it looks into critical dimensions for the next stage of RIS3, focusing on how strategies can be improved by datasets and software, enabling the implementation of complex methods; thus, facilitating collective intelligence and co-creation of solutions, which both are able to usher a transition from the triple to quadruple helix model of collaboration. Finally, the annex presents a short description of the 28 software applications and the 4 roadmaps hosted on the Online S3 Platform, which enable the use of datasets and sophisticated methodologies by policy-makers.

1. Introduction

The second decade of the 21st century brought-in a new thinking in the European innovation policy. Under Europe's 2020 strategy for smart, sustainable and inclusive growth, the research and innovation strategies for smart specialisation (RIS3) are institutionalised as a precondition for re-

Commission, Economic and Social Research Council and Engineering and Physical Sciences Research Council in the UK. He recently completed research projects include: (1) CLUE: Climate Neutral Urban Districts in Europe (European Commission - INTERREG Programme); (2) Smart and Sustainable Cities (European Investment Bank - JESSICA Programme); (3) SmartCities (European Commission - INTERREG Programme); (4) EXPGOV (European Commission - IPTS Programme on Emerging City Governance Models); (5) SURegen: Sustainable Urban Regeneration (EPSRC Sustainable Urban Environment Programme); (6) Online S3: ONLINE Platform for Smart Specialisation Policy Advice (European Commission - Horizon 2020 Research and Innovation Programme). Mark is also in the Editorial Board of 6 academic journals. This includes the Journal of Urban Technology (Taylor & Francis), the Journal of Sustainable Cities and Society (Elsevier) and the International Journal of Intelligent Buildings (Taylor & Francis).

j **Luca Mora** is Professor of Urban Innovation at the Business School of Edinburgh Napier University, in which he is leading the Entrepreneurship and Innovation Subject Group. Luca is also Professor of Urban Innovation at Tallinn University of Technology (TalTech), where he is collaborating in delivering the €32 million Horizon 2020 smart city project FinEst Twins and the €1.3 million smart city pilot project GreenTwins.

Luca is a cum-laude graduate of Polytechnic University of Milan, where he obtained a BSc Degree in Science of Architecture, a MSc Degree in Architecture and, in conjunction with Polytechnic University of Turin and Polytechnic University of Bari, a Double PhD Degree in: (1) Innovation Management and Product Development; (2) Architecture and Urban Planning. Luca also holds a PgCert in Learning, Teaching and Assessment Practice in Higher Education, awarded by Edinburgh Napier University, and is a Fellow of the Higher Education Academy (FHEA) and a Fellow of the Royal Society of Arts (FRSA).

Over the course of his professional career, Luca has committed himself to improving our understanding of urban and regional innovation management in the digital era. His research is multi-disciplinary and connects urban studies and computer science with science, technology and innovation studies. His main research interests include: technology-related urban and regional innovation; sustainable smart urbanism; smart city development projects and strategies; Research and Innovation Strategies for Smart Specialisation (RIS3); and strategic planning for smart city transitions and RIS3.

Luca has a sustained track-record of producing high-quality publication outputs and has contributed to generate an overall University income of approximately £16 million through research and consultancy projects, mainly supported by EU funding schemes (EAFRD, 7FP, Horizon 2020).

ceiving financial support from European Structural and Investment Funds (ESIF). The preparation for these strategies started in 2011, and in May 2012 the Guide of RIS3 was published by Foray, Goddard, Beldarrain, Landabaso, McCann, Morgan, Nauwelaers, and OrtegaArgilés, as a "methodological guidance for policy-makers and implementing bodies on how to prepare for and how to design, draft and implement a national/regional research and innovation strategy for smart specialisation (RIS3)" (Foray et al., 2012).

The new philosophy of innovation policy, which the smart specialisation agenda and RIS3 introduced, is founded on previous experiences of the European Commission (EC) on regional innovation and on theories that explain regional growth patterns based on knowledge and innovation, such as new growth theory, evolutionary economic geography, and learning regions. It is the result of a very promising amalgam of progressive policy-making and a robust theoretical approach. However, these theories and policy guidance have proven insufficient to change the mind-set of regional and national authorities in strategic planning for innovation. Many factors help explain the poor design of RIS3 which can be found in many regions. For example, the gap between theory and methods of implementation, delegation of power from central control to bottom-up participation, weaknesses in the mobilisation and engagement of stakeholders, lack of evaluation and monitoring mechanisms. All-in-all, these gaps, needs for delegations of power and methodological weaknesses, outline a precarious institutional setting and a situation calling for major reforms in the design and implementation of RIS3.

Funded by Horizon 2020 under the 'Science with and for Society' programme, the Online S3[1] project is founded on the disharmony between the poor design of RIS3 and the considerable funds that became available to implement smart specialisation strategies, aiming to tackle complex and interconnected societal challenges. The growth challenges of RIS3 are complex and often characterized by uncertainty and ambiguity, including not only dis-agreements within society, but also power games between interest groups (Bütschi, 2012). They require the existence of transdisciplinary knowledge, transparency and a plurality of values and opinions. Throughout the design of RIS3, policy makers should become proactive, develop knowledgebased and user-driven attitudes, whilst build internal capabilities to manage information and user engagement. Under this context, a significant challenge is the proactive attitude that must appear and evolve within an environment, that in many respects is precarious and without sufficient institutional and methodological tools.

In order to fill this gap in strategy development, competences and methods, the Online S3 project has been set out to develop a web-based solution that will facilitate the creation of a user engagement environment, easy access to datasets and implementation of complex methodologies. This has been achieved through the development of many software applications, targeting on providing a methodical process for the implementation of smart specialisation as an exercise in strategic planning. In this regard, it was anticipated that an e-policy platform, augmented with applications and online services, should be able to assist national and regional authorities to design more efficiently their smart specialisation strategies. In this respect, the Online S3 platform (http://s3platform.eu/) leverages on existing methodologies, initiatives and tools developed by the EC, enriching them with developments that strengthen the capacity for evidence-based and collaborative policy design.

The Online S3 platform has developed and tested innovative technologies, tools and e-services, which are in line with the methodological principles of smart specialisation as conceived by the EC, innovation experts, and academics. This is done by a consortium that assembles multiple partners, composed of three universities (Aalto University, Aristotle University of Thessaloniki, Edinburgh Napier University); four technology-led companies, (Innova Integra, Intelspace Innovation Technologies, Research and Innovation Management, and Research, Technology Development and Innovation); a not-for-profit policy research lab (European Future Innovation System Centre); three business related organisations (Edinburgh Centre for Carbon Innovation, Economic Institute of Maribor, Slovak Business Agency); and three regional authorities (Central Macedonia, Galicia, Northern Netherlands). Working in tandem, these organisations have developed a web-based platform, composing methodologies, software applications and roadmaps, which has been tested in real environments. A complete guide for the design and implementation of RIS3 is also available.

The "*Intelligence and Co-Creation in Smart Specialisation Strategies*" white paper presents some lessons learnt during this socio-technological experiment in research and innovation policy and sets out how the capacities the Online S3 project develops can be drawn on to improve the design and implementation of the smart specialisation agenda.

Introduction: RIS3 and the Online S3 Project

In Europe, RIS3 has become a leading political instrument of cohesion policy (Foray, 2014; McCann & Ortega-Argilés, 2015). Over the last decade, RIS3 has received a great deal of attention, not only by academics but also by European policy makers (Landabaso & Mouton, 2005; McCann & Ortega-Argilés, 2014). The basic principle of smart specialisation is that European regions should aim to explore and exploit key capabilities for global niche markets, with the intention of creating long term competitive advantages (Fellnhofer, 2017a; Foray, 2014; Reid & Maroulis, 2017). Thus, the overall objective of RIS3 is to create innovative, but place specific, capabilities which take advantage

1 ONLINE S3 – Online Platform for Smart Specialisation Policy Advice, Funded under the Horizon 2020, SwafS, GA no: 710659

Figure 1. Core elements of smart specialisation

Figure 2. Five central steps for smart entrepreneurial discovery

of available resources and competences within a process of diversification and transformation (Foray, 2014). In particular, diversification and transformational strategies should foster cross-sectoral links and/or cross-border cooperation (Gianelle et al., 2014a; Lämmer-Gamp et al., 2014). As Figure 1 illustrates, the 'smart' attribute of specialisation strategies is a consequence of the following principles (Landabaso, 2014):

- Creative linkages between research and innovation activities based on entrepreneurial discovery process, which allows. policy makers to focus on priorities that are set in collaboration with local stakeholders.
- A place-based approach with a global ambition that aims at exploring and exploiting local resources to generate competitive advantage.

The concept of smart specialisation encourages efficient and effective investments. Nations and regions are able to strengthen their innovation capacity and economic prospects in line with a creative entrepreneurial discovery process (EDP). In Europe the policy for smart specialisation requires a tailor-made, case-by-case approach for each nation and region rather than a 'one-size-fits-all' approach (McCann & Ortega-Argilés, 2014). Overall and as shown in Figure 2, there are five steps in the EDP that deserve particular attention (Komninos, Musyck, et al., 2014):

1. selecting areas meeting a critical threshold for productive activities;
2. exploring productivity gaps and use alternative paths for productive diversification taking inter- multi- and trans-disciplinary combinations and technologies into considerations;
3. evaluating possible scenarios by entrepreneurs and experts;
4. prioritising assessed scenarios weighing the value-added benefits; and
5. experimenting with small-scale pilot initiatives before full-scale implementation.
6. concept.

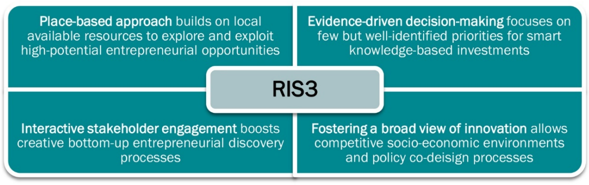

Figure 3. Core principles of Smart Specialisation Strategies

2. Building Blocks for Smart Specialization

According to guidelines and recommendations on behalf of the European Commission's Joint Research Centre (JRC), a RIS3 should promote the following (Figure 3):

- ***A place-based approach***, which builds on local available resources in order to explore and exploit entrepreneurial opportunities for economic growth.
- ***An evidence-driven decision-making***, focusing on few but well-identified priorities for smart knowledge-based investments to strengthen competitive potentials.
- ***An interactive stakeholder engagement*** that boosts the entrepreneurial discovery processes for setting priorities bottom-up.
- ***A broad view of innovation*** that promotes technological and practice-based social innovation based on socio-economic environments and policy co-design processes.
- ***A solid monitoring and evaluation system***, including effective and efficient revision mechanism should allow flexible adaption of strategic decision making.

The design and implementation of Smart Specialisation Strategies is an exante conditionality for public investments in research and innovation and smart growth. Exante conditionalities are policy and regulatory frameworks that ensure national and regional strategies are of high quality and in line with standards commonly agreed by Member States at EU level; comply with the EU acquis; and are based on sufficient administrative and institutional capacity (European Commission, 2013; Griniece et al., 2017; Komninos, 2016; Pessoa, 2016).

3. RIS3: Past and Current Challenges

3.1 RIS3 in the Past

The RIS3 was originally conceived of as comprising the entrepreneurial process of discovery (EDP) that would involve regions in a learning process resulting in decision on specialisation areas (Foray et al., 2009, p. 2). Through the EDP, RIS3 has proved to be quite successful in encouraging stakeholders' interaction, widening their participation, enabling more efficient functioning of multi-level governance, as well as enabling continuity of the process of planning and execution of a regional innovation strategy (see Gianelle et al., 2016).

However, there are issues concerning design and implementation of RIS3 when it comes to their underlying methodology. A survey of nine countries and twenty-one regions in Europe showed that the phases of the RIS3 were not followed sequentially or linearly (Griniece et al., 2017). Furthermore, 'the mapping exercise also highlighted that the robustness of methodological approaches varied and, in many regions, even the key concepts of the various RIS3 steps were not (fully) understood' (Griniece et al., 2016, p. 6; emphasis removed). Furthermore, very few online tools were used for designing RIS3 (Griniece et al., 2016, p. 7) at the time. Tools widely available before 2016, were quite limited in scope and came from the European Commission's sources.

Applications of the Online S3 platform (see www.s3platform.eu) have been developed to cover all phases of RIS3, from analysis of context, governance, strategy formulation, priority setting, policy mix, to monitoring and evaluation (for description of the phases see Foray et al., 2012), and include 28 methods and applications. Though since 2004 governance, not the regional context is the new priority, regions and countries should have a quality of governance at the level required to meet the challenges of the RIS3. The 28 Online S3 application can support this requirement. In addition, 4 'roadmaps' were developed by the Online S3 platform, allowing users to learn about and work on RIS3 in an intuitive and simple way, while working with and combining the online tools available to address specific problems and challenges.

It should be mentioned that two basic issues with the online tools for RIS3 have been identified. Online tools are generally faced with a bottleneck with regard to a general shortage of data that can be used for the design and implementation of RIS3 at the EU level. In addition, Griniece et al. (2016, p. 4) recognise a need for real-time data gathering and data visualisations that may help the entrepreneurial discovery process (EDP).

3.2 RIS3 at Present

At present, all new industrial and innovation policies – including policies for smart specialisation – share certain characteristics that confine them to the sphere of the private sector, actors of an innovation system, and markets in general (Radosevic, 2017). Societal stakeholders are not as involved in EDP as they should be (Marianelli & Perinez Forte, 2017). This essentially limits those policies as regards the choice of innovations that RIS3 focuses on. One recent exception may be the social economy partnerships in six EU regions that 'stimulate cross-border operations for mutual and cooperatives to enable them to use the full potential of the internal market in order to expand the activities of social economy, through interregional collaboration activities' (Smart Specialisation Platform, 2018). However, social innovations that have wide-ranging effects on well-being and that essentially create enabling conditions for other innovations themselves, should be taken into consideration more consistently.[2]

RIS3 should ideally be more integrative among R&D-driven innovation policy, cohesion policy, European value chains and networking initiatives, industrial policy, and grand challenges policy (Foray et al., 2018). This is consistent with mission-oriented policies[3] in the field of R&I that should have societal relevance and be multi-sectoral in nature (Mazzucato, 2018). That way RIS3 would expand the boundaries of its current scope and scale.

This has been recognised by the European Commission. Hence for the next programming period (2021-2027), it proposes, among other things, "*The bulk of European Regional Development Fund and Cohesion Fund investments will go towards innovation, support to small businesses, digital technologies and industrial modernisation. It will also go to the shift towards a low-carbon, circular economy and the fight against climate change, delivering on the Paris Agreement*".

Smart specialisation strategy in the next programming period will focus on several enabling conditions for the ERDF fund, listed below (European Commission, 2018a, p. 19): "*1. Up-to-date analysis of bottlenecks for innovation diffusion, including digitalisation 2. Existence of competent regional / national institution or body, responsible for the management of the smart specialisation strategy 3. Monitoring and evaluation tools to measure performance towards the objectives of the strategy 4. Effective functioning of entrepreneurial discovery process 5. Actions necessary to improve national or regional research and innovation systems 6. Actions to manage industrial transition 7. Measures for international collaboration*".

2 The European Commission (2018b) defines social innovations as ' new ideas that meet social needs, create social relationships and form new collaborations. These innovations can be products, services or models addressing unmet needs more effectively.'

3 Mazzucato (2018, p. 4) defines them as ' systemic public policies that draw on frontier knowledge to attain specific goals'.

3.3 Current challenges of RIS3

The expansion of the RIS3 goals that should encompass societal challenges, and of its approach that should be more integrative, has repercussion on the analysis and on governance accompanying the process. With demands for industrial upgrading posed by digitalisation trends and key enabling technologies, RIS3 of the future needs to change. While aforementioned issues with RIS3 remain, new ones are potentially added to the picture, in anticipation of the RIS3 arrangements for the programming period 2021-2027.

Firstly, as many of the fulfilment criteria for the RIS3 enabling conditions generally require better governance (criteria 2, 3, 4, and indirectly also other points on the list), monitoring of governance during the process of design and implementation of RIS3 should be implemented. With a wider definition of innovations and the RIS3 that is truly multi-sectoral and long-term, the process of governance gets more complex and more demanding to follow. Secondly, monitoring and evaluation of RIS3 will require better databases that should not just provide more up-to-date data, but also allow for an analysis of main societal challenges. A proper multi-level governance of RIS3 would enable comparison of data across regions and member states of the EU. Thirdly, there is a need for tools capable of analysing innovation diffusion and their bottlenecks. This applies in particular to the sphere of digitalisation,[4] transformative potential of which is still largely untapped.

4. Moving RIS3 forward: Data- and software-based intelligence

Policy design, and specifically Smart Specialisation, is an inherently complex activity that in most cases involves multiple stakeholders and a plethora of insufficient information. Two features that have been identified as crucial for improving strategy formulation processes, such as RIS3, are extended quantitative analytical exercises and enhanced stakeholders' participation (Charalabidis et al., 2010; Komninos, Musyck, et al., 2014; Panori et al., 2016; Rowe & Frewer, 2004). A review of existing smart specialisation methodologies emphasizes the importance to map, monitor and assess regional assets to identify opportunities for innovation through existing and emerging activities (Foray et al., 2012; Griniece et al., 2017). Smart specialisation is not a 'one-size-fits-all' approach, but rather an evidence-based innovation-driven process, focusing on the economic transformation of EU regions towards higher added value and more knowledge intensive activities. Under this framework, data collection and analysis emerge as two of the most valuable assets, not only for entrepreneurs concerned with leveraging new market opportunities, but also for regions, which are required to design strategies for strengthening their economic growth models.

To date, various contributions and preliminary RIS3 evaluation reports highlight the difficulties in designing and implementing smart specialisation strategies (Capello & Kroll, 2016; Gianelle et al., 2016; Komninos, Tsarchopoulos, et al., 2014; Kroll, 2015; Reid et al., 2012). The initial European Commission's RIS3 planning documents provided little guidance to regional policy makers in the rather complex process of RIS3 design policy (Cooke, 2012; Iacobucci, 2014). Iacobucci & Guzzini (2016) try to identify different methodological ways to overcome the theoretical vagueness of the RIS3 guide in selecting regional priorities, while Boschma & Gianelle (2013) investigate the ways in which technological relatedness can provide significant input to the overall EDP process. Throughout literature, it becomes evident that the observed obstacles in designing the regional and national RIS3 strategies can largely be attributed to the lack of a clear methodological guidance and data sources, as well as the inability to adopt place-sensitive policy-support methodologies that define key aspects of the RIS3 process, such as related variety, priority setting, intervention logic etc (Capello & Kroll, 2016; Reid et al., 2012).

Currently the JRC S3 platform (http://s3platform.jrc.ec.europa.eu/) features several online tools designed for RIS3 strategy design processes, including mostly databases and mapping tools. More specifically, the tools aim to help users to extract information on the selected RIS3 priorities across European regions, understand the earmarked ESIF funding allocations, provide background information on sectoral trade patterns as a proxy indication for main competitor regions, as well as benchmark regions with similar structural characteristics. In other words, the available online tools offer mainly the opportunity to scope the emerging landscape of specialisations and identify benchmark regions for improved cross-border learning. Through a critical perspective, they offer limited analytical insights in supporting regional policy-makers and experts in charge of RIS3 processes, whereas they do not support more sophisticated online functionalities for RIS3 processes (Griniece et al., 2017; Panori et al., 2017).

On the other hand, advanced methods in smart specialisation include strategy development processes that rely heavily on large-scale user engagement, datasets coming from several sources, and high complexity computations. More specifically, there is a need to strengthen multi-level policies that require a wide range of combined evidence to collectively identify and select regional priorities (Kleibrink & Magro, 2018). Based on this rationale, effective RIS3 processes should result as an outcome of sophisticated and well-coordinated interactions between datasets, methods and actors, each one of them contributing in a different way to the overall strategy development (Ranga & Etzkowitz, 2012). Coordination and support of these interlinked building blocks could be a critical parameter towards increasing

4 For data on digitalisation, see Eurostat https://ec.europa.eu/eurostat/web/digital-economy-and-society/overview

the effectiveness of RIS3 policy-design and monitoring processes.

In this aim, the emergence of digital platforms as an intrinsic feature of a continuously evolving economic structure, has opened new opportunities that relate to issues concerning stakeholder participation and the exploitation of advanced datasets. Platforms offer cyberspaces which enable the formation of new ecosystems, where users can effectively collaborate across a broad range of activities (Biber et al., 2017; Kenney & Zysman, 2016; Oskam & Boswijk, 2016). In this arrangement platform environments can be exploited for dissemination activities and sharing common vision goals, towards enhancing stakeholder collaboration and user-driven innovation during a RIS3 design process (Kakderi et al., 2018; Komninos, 2018). Smartness, in terms of innovation, collaboration and coordination, can be effectively elaborated through network-based relationships (Antonelli & Cappiello, 2016). To this end, the use of online platforms in policy and strategic planning could be received as an essential ingredient, given that big datasets, pilot experimentation and continuous assessment guide decision-making processes (Komninos, 2018).

The Online S3 Platform constitutes an experiment of reference towards empowering RIS3 processes by advanced methods, software and roadmaps for several reasons. First, it focuses on providing an online environment for managing the design process of a RIS3 strategy. Second, it tries to foster effective online collaboration between different actors, offering the opportunity to cover all quadruple helix stakeholders. Third, it ensures equal access opportunities to existing datasets and RIS3 methodologies (simple or more sophisticated), since all tools are freely available and open access. Finally, it provides a monitoring module, including a set of applications that focus on the implementation process of RIS3 actions and measures. The developed applications cover all existing phases of the RIS3 process, offering the opportunity to the users to better understand existing methodologies and their main rationale. The development of a set of roadmaps on the platform (see Annex pp. 43-44) aims on helping decision-makers to systematically organise their actions and enhance their effectiveness. More specifically, the Mini-S3 roadmap has been designed, including only a short list (14 applications) of the most essential methodologies and tools that should be used during a RIS3 design process. The applications have been chosen based on the importance of the corresponding methodology, as well as the feedback from the users regarding their user friendliness. At the same time, the EDP roadmap has been structured based on the EDP methodologies followed by the JRC and the World Bank, including three main tasks: knowledge production, stakeholder engagement and knowledge sharing and collaborative decision-making.

The last two roadmaps mainly focus on the identification of emerging and niche sectors of the regional markets that could be prioritized through a RIS3 strategy in order to boost regional economic growth. The Specialisation roadmap explains its role and usefulness in the RIS3 and describes three possible approaches to the analysis. A conceptual framework for specialisation analysis and accompanying methods for implementing it are presented, as well as a selection of 10 Online S3 applications that may be used in this process. On the other hand, the Vertical roadmap proposes a five-stage process for designing innovative investment projects per niche industry market, using a set of 14 Online S3 applications. These focus specifically on actions, such as: mapping sectoral and regional strengths, identification of actors per sector of interest, actors' engagement, collaborative project design, monitoring and evaluation

At this point, it should be noted that the success of an online platform, which is designed to facilitate a wide range of users with different background and levels of experience, largely depends on following co-creation principles, to get feedback from a multi-stakeholder audience, as well as its ability to adapt in different geographical and development contexts. The no-'one-size-fits-all' approach has also been followed in the Online S3 case in terms of software design, to ensure that all users can easily understand and personalize their strategic planning process. These principles have been incorporated in the Online S3 Platform throughout the design of the applications and the creation of the 4 thematic roadmaps (Panori et al., 2018). Therefore, the Online S3 Platform provides an essential effort towards reinforcing regional authorities capabilities for revising and enhancing existing RIS3 strategies through advanced methods, software, and roadmaps, opening the road to the Smart Specialisation 2.0 era.

5. Moving RIS3 forward:Co-design and collective intelligence

Collaborative co-design, data-driven intelligence and collective intelligence provide means to facilitate an inclusive, evidence-based process for RIS3 that is recommended in RIS3 literature. For instance, Gianelle et al. (2014b) argue that RIS3 should be based on a thorough understanding of the regional economic structure and competitive position of the economy. Furthermore, the RIS3 Guide states, "RIS3 needs to be based on a sound analysis of the regional economy, society, and innovation structure" (Foray et al., 2012). It also underlines "The fact that RIS3 is based on a wide view of innovation automatically implies that stakeholders of different types and levels should participate extensively in its design" (Foray et al., 2012).

The EDP is a core principle of RIS3. It should ensure that the views of different 'quadruple helix' stakeholders – academia, industry, public sector and civil society - are part of the smart specialisation strategy. Data intelligence serves as a key input for EDP providing information on the regional strengths and competitive advantages in relation to other regions. For instance, regional data on geography, demography and society, economy and labour, sectoral structures, business characteristics and innovation system are needed for regional profiling and to develop international comparisons (Kroll et al., 2011; OECD, 2013). In addition to the collecting and analysing data on the current stage of the region, it is important to gather data on future trends and uncertainties that can affect the future development of the region. Data intelligence on the current stage of the region and the future development provide sound bases for regional quadruple helix stakeholders to develop together a shared vision of the future and to identify key priorities for regional development.

Prior literature has called for collaborative co-design of a regional RIS3 action plan and RIS3 monitoring and evaluation system (Gianelle & Kleibrink, 2015). The engagement of regional stakeholders is vital to ensure stakeholders commit to RIS3 strategy and feel ownership of it (Gianelle et al., 2016). Indeed, prior literature has emphasized that EDP should be a continuous process to realize full benefits of smart specialisation (Gianelle et al., 2016; Marianelli & Perinez Forte, 2017; McCann & Ortega-Argilés, 2016; Roman & Nyberg, 2017). However, many regions have faced challenges in engaging different types of stakeholders to facilitate true interaction between the different stakeholder groups (Aranguren et al., 2018). Thus, regions are in need of further guidance to implement a truly participative EDP (Fellnhofer, 2017b; Gheorghiu et al., 2016). Methods like participatory foresight and horizon scanning are interesting ways of involving all regional stakeholders in the RIS3 development. Participatory foresight is demand-side driven and is meant to directly involve beneficiaries and users of the RIS3, providing insight into the demand for societal challenges. This method usually involves public consultations feed-in and steered with expert recommendations, in many cases facilitated by web-tools to carry the information flow (Griniece et al., 2016). Horizon scanning involves searching, finding, analysing and assessing how developments, emerging and existing, will have an effect on the ‘pertinent’ environment. The data comes from a wide variety of sources including government, commercial and scientific documents, but also from social media, events and conferences, through a variety of techniques including document scanning, expert groups, surveys, social media and text mining techniques (Griniece et al., 2016).

As an example, at European level, the European Cluster Observatory has performed foresight analysis on industrial and cluster opportunities with the aim to explore new societal, technological and economic trends, as well as the ways in which cross-sectoral collaboration could affect value creation structures and innovation processes. The exercise followed a Delphi-related approach and used a mix of different methods such as desk research including a literature review, expert interviews, an online survey, internal and external workshops, horizon scanning and scenario planning (Teichler et al., 2015). Another example of broad foresight exercises is from Lithuanian RIS3 process that used a mixed of qualitative and quantitative methods including expert panels, surveys, statistical and bibliometric analysis, roadmaps, and analytical studies on the emerging trends and long-term challenges (Paliokaitė et al., 2015). Online tools and web environments were also developed to support co-design of innovation strategy and policy, such as the open innovation platform (https://goo.gl/jDzujB); the web environment for sharing applications promoting participation and collaboration in communities, local ecosystems and complex projects for the region of Lombardy (https://goo.gl/uSRW7A); the smart specialisation map (https://goo.gl/9768qd); the regional ecosystem scoreboard methodology to analyse regional development framework conditions (https://goo.gl/JAUf59).

The Online S3 project has aimed to bridge the gap between RIS3 theory and practice through the development of online tools for data intelligence such as Regional Asset Mapping and Scenario Building and for collaborative co-design such as the Intervention Logic tool. Regional Asset Mapping allows regions to compile their regional profile and to compare it to other regions. As part of the European Structural and Investment Funds (ESIF) agreement, all EU regions must produce a descriptive analysis on their regional assets, e.g. economic performance, employment and infrastructure. Regional Asset Mapping integrates the regional profile data into a searchable platform, to enable anyone to access, compare and produce visually appealing reports on regional assets across the EU. The application uses data provided by Eurostat and follow Eurostat’s NUTS (Nomenclature of Territorial Units for Statistics) system for dividing the economic territory of the EU.

Scenario Building tool supports the development of regional scenarios and the assessment of their implications for the region. Not all regions have the competences and experience of scenario building, which motivated the development of the Scenario Building tool that consists of five templates that facilitate the implementation of each of the following key steps of the scenario building process.

1. Identify future trends and uncertainties (PEST analysis template)
2. Assess the importance of each trend and uncertainty (Impact analysis template)
3. Form scenarios (Scenario building template)
4. Describe scenarios in-depth (Scenario description template)
5. Assess scenario implications and plan for preparatory actions (Preparation plan template)

PEST (Political, Economic, Social, Technological) analysis is a framework which allows structuring trends along uncertainties and impact. Since there are a multitude of factors that may affect the region’s future, the uncertainties and impact become easier to assess when they are categorised in the PEST categories. Assessing the importance and the level of uncertainty and impact associated with all trends allows the selection of scenario axes. This activity should involve all relevant regional stakeholders to identify together the most important and uncertain factors and objectives affecting the future development of the region. The trends with the lowest uncertainty and the highest impact form the best scenario to select.

After forming the regional scenarios, the next step is to develop in-depth descriptions of the scenarios. The more intriguing the scenarios are, the more they tease out creative thinking, solutions and preparation plans in the next phase. Thus, good scenarios should include storylines and detailed portrayals of what life is like in the region in the scenario. The assessment of scenario implications includes the identification of common opportunities or challenges across the different scenarios (For-Learn, 2008). These things should feed into the development of the regional

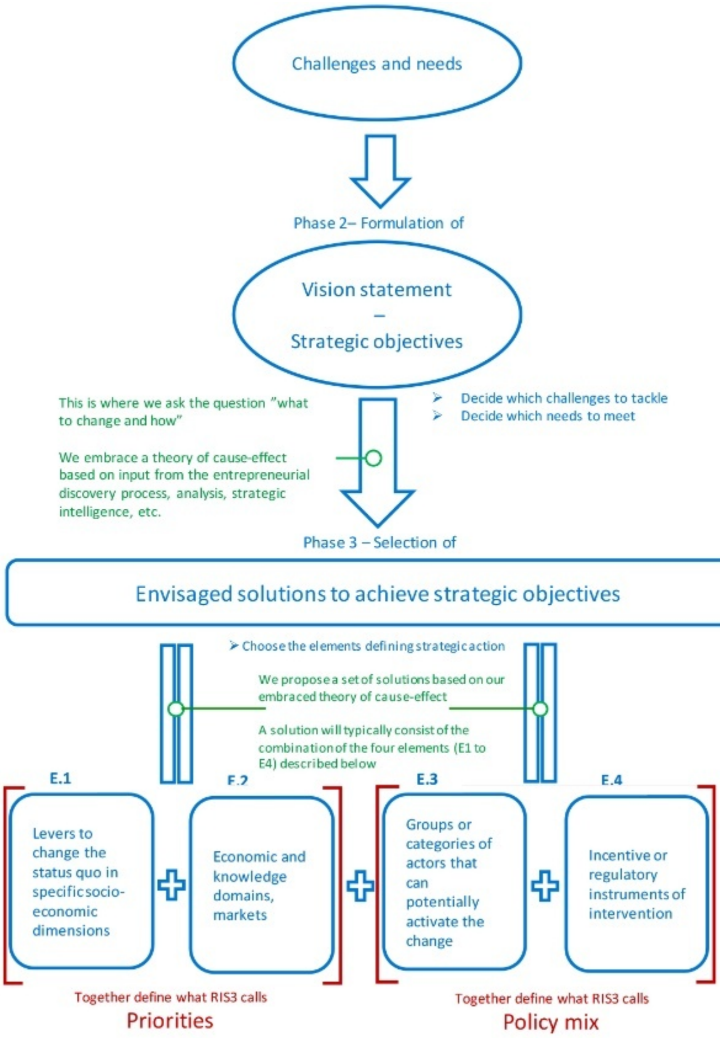

Figure 4. The model of Intervention Logic

Source: Kleibrink, A., Gianelle, C. and Doussineau, M. (2016).
Credit: Kleibrink, A.

strategy. While the desktop research supports the collection of data on regional trends and uncertainties, the involvement of regional stakeholders is necessary to analyse the data, to build scenarios and to assess their implications to understand different viewpoints and commit different stakeholders to the scenario work.

The Intervention Logic tool is based on the model of Gianelle & Kleibrink (2015). The Intervention Logic assists the regions to develop the links between their RIS3 objectives, targets, inputs, actions, outputs, results and longer-term outcomes. The overall objective is to provide the rationale behind the RIS3 strategy to all stakeholders and to promote consensus among stakeholders regarding the priorities and actions to select (Fig. 4).

According to Griniece et al. (2016), around 40% of regions have used this Logic of Intervention. Given that intervention logic should form the backbone for setting the overarching goals of smart specialisation, this seems to be a small share. Either regions are not well acquainted with the approaches to intervention logic design or they do not explicitly document their assumptions about causal chains of RIS3 policy intervention.

The Intervention Logic tool, developed in Online S3, starts with the user selecting a specific Thematic Objective and Investment Priority and incorporating the information from RIS3 strategic planning process regarding the regional context, vision, policy mix and monitoring. After this step, the user is to describe the connections between the main building blocks of the intervention logic. A set of 7 questions help the user to provide a precise description of the rationale behind the selection of the specific priorities, policy mix and monitoring indicators for the corresponding investment priority.

Data intelligence and collaborative co-design tools facilitate implementing inclusive, evidence-based EDP in the region. In addition, successful implementation of the tools and continuous participatory EDP requires strong commitment to smart specialisation at various institutional levels (Grillo, 2017; Rodriguez-Pose & Wilkie, 2017).

6. Moving RIS3 Forward: Quadruple Helix Governance

Triple and Quadruple-Helix models of research and innovation are at the centre of the EPD. The Triple Helix appears to be the model of choice for Joanneum Research (2012), whereas the EC's Joint Research Centre (JRC) see the EDP as a platform of stakeholders broader than university, industry, and government (Foray et al., 2012). Given this commitment from JRC to a broadening out of the EDP, the following shall provide a synopsis of the Triple and Quadruple-Helix models and insights these representations of the EDP offer into RIS3.[5]

6.1 The Triple Helix Model

Advocates of the Triple Helix (like Etzkowitz & Leydesdorff, 1997; Etzkowitz and Leydesdorff, 2002; Leydesdorff, 2005; Leydesdorff & Meyer, 2006), find Mode 2 accounts of social change, cultural development and economic growth limited and explain the differences between (national and regional) research and innovation systems in terms of possible arrangements. The Triple Helix model suggests each research and innovation system remains in endless transition, but this does not mean anything goes, rather that emerging systems such as RIS3 should not be mistaken as something which is yet another variation on the theme. That is as the EDP of either a national or regional research and innovation system, because the interacting uncertainties, which surround the reflexive instability of any smart specialisation strategy, does much to determine the prioritisation of science and technology they reflect as the place-based polices.

This means the Triple Helix account of social change, cultural development and economic growth offers a neo-evolutionary model of research and innovation (Leydesdorff and Deakin, 2010) and as evolutionary systems society cultivates the environmental conditions of. These are: (1) the intellectual capital of organized knowledge production; (2) wealth creation and (3) the reflexive control of the science and technology they in turn govern the regional economic growth of (Leydesdorff & Deakin, 2011).

Within this model the EDP is represented as a broad collaborative platform of stakeholders from universities, industry and government and as the key components of an eco-system in which organized knowledge production is not only socially-constructed, but also cultivated as a process of wealth creation that is smart in the prioritisation of a specialisation strategy whose reflexive control of science and technology it in turn governs as a knowledge economy able to sustain the growth of regions (Deakin, 2014, 2015; Deakin & Reid, 2018; Deakin, 2016; Deakin, 2017).

6.2 The Quadruple-Helix Model

The EC's Guidance Notes for RIS3 also recognizes the virtues of the Quadruple-Helix as the model of knowledge-based production (Foray, 2015). This model of social change, cultural development and economic growth, switches attention away from the stakeholders that underpin the intellectual capital of organized knowledge production and focuses instead on an EDP of a wealth creation able to support the reflexive control of RIS3 (Carayannis & Campbell, 2012, 2010). Which is to say, on the EDP of that wealth creation in which RIS secures a reflexive control of science and technology and this system of knowledge-based production governs the economic growth of regions on behalf of the public. In particular, on behalf of the public as the user communities of a democracy, whose participation in this governance and science and technology cultivate environments able to sustain the economic growth of regions (Carayannis & Rakhmatullin, 2014; Carayannis and Rakhmatullin, 2017).

In this model, user-communities are not only understood to be engaged in the EPD, but also involved in shaping new types of research and innovation strategies, whose specialisation is smart in connecting users with other communities and as part of a knowledge exchange distributed across universities, industry and government (Carayannis & Campbell, 2012, 2014, 2010; Carayannis & Rakhmatullin, 2014; Carayannis and Campbell, 2017; Carayannis and Rakhmatullin, 2017). This means the Quadruple Helix sees the role of these institutions not as the agents of any intellectual capital, or organized knowledge production, but instead as the media of an emergent creative sector. The media of a creative sector, whose wealth creation and reflexive control of science and technology is democratic in the sense it allows the user-communities of this emergent creative sector to participate in the governance of civil society by cultivating environments able to sustain the economic growth of regions.

6.3 Online S3 for RIS3 Governance

As a result, it is the Triple and Quadruple Helix models of EDP that underpin the governance phase of RIS3 and assessment methods which support this, either as the institutional stakeholders, or media of an emergent creative sector. The Online S3 methods and applications in question are listed below:

- RIS vision sharing;
- RIS3 debate at a glance;
- RIS3 legal and administrative framework related to the Economic and Social Investment Fund (ESIF).

5 This synopsis of the triple ad Quadruple Helix of The EDP and insights they offer into the governance of RIS are drawn from Deakin et al. (2018) The research and innovation of smart specialisation strategies: the transition from the triple to quadruple helix, Book of Proceedings for the 27th International Scientific Conference on Economic and Social Development, pp.94-103.

This synopsis of the models offers an initial insight into the Triple and Quadruple Helix and response of both the "RIS3 vision sharing", "debate at a glance" and "legal and administrative framework", to do what they call for, vis-à-vis restore public trust in science and technology and clear the democratic deficit by assembling a platform for the creative sector to participate in the governance of civil society (Deakin, 2014, 2015, 2018; Deakin, 2017).

It also serves to highlight the reflexive control science and technology as democratic and matter relating to a participatory governance in which the science and technology of civil society is able to cultivate environments that sustain the economic growth of regions (Carayannis & Campbell, 2012, 2014; Carayannis and Campbell, 2017). This results from a critique of the Triple Helix model which the Quadruple-Helix offers and the latter's representation of the former as a model whose vision od RIS3 and debate at a glance is that dominated by the proprietary system of an elite university-industry axis. That axis which is pre-dominantly corporate and whose research and innovation is organized as a knowledge-based production, in which the prioritisations of a any smart specialisation strategy that emerges, either by way of 'vision sharing", or through "debate at a glance", are proxies for a process of wealth creation whose reflexive control of science and technology is via a "legal and administrative framework for ESIF" which is not democratic in sustaining the economic growth of regions.

This goes someway to capture what distinguishes these two models of knowledge-based production. In particular, the fact they are not only research and innovation strategies, or an EPD, but also the source of (bottom-up and place-based) regional policies, whose visions and debates are constructed as the administrative framework of a RIS3 that is not only proprietary, but which is also democratic. The distinction between the models lying in the distance separating the respective vision, debate and framework on not what is proprietary, but how this system can also be democratic. In that sense, in the respective interpretations of whether-or-not any such vision, debate and framework can stand on the propriety of a research and innovation found in the university-industry axis of a smart specialisation whose strategy rests on either on the pre-dominantly corporate priorities of the independent sector, or in a system which is civic in the sense the wealth this creates assembles a platform for the third to reflexively control science and technology. For the third to reflexively control science and technology as part of a democracy whose participatory governance of civil society in turn provides the creative sector this nurtures with the "media" to cultivate environments whereby the funding of priorities secures the investment to sustain the economic growth of regions.

6.4 From the triple to quadruple helix

As the discussions in the previous section on the vision, debate and framework for governance phase of RIS3 serve to demonstrate, the public trust gap which opens up as a democratic deficit, presents the research and innovation of smart specialisation strategies with trust deficit that has significant implications for both the Triple-Helix and Quadruple-Helix models, for it is not only seen to be a transgression of public trust, but a democratic deficit also regressive for civil society.

Here, the significance of the implications is summarized in the interests of reaching beyond any formal critique of the models and governance phase of RIS3 they relate to, by moving towards what might be best referred to as the dis-content with the transgression of public trust by the Triple Helix and regression of this into the democratic deficit of the Quadruple Helix. In that sense, the dis-content, which circulates around this transgression, can be revealed as a regression that relates to:

- a lack of public trust in the EDP that underlies research and innovation strategies within university and industry and which surfaces as a gap between the knowledge economy this wealth creates and priorities such a smart specialisation sets for a reflexive control of science and technology, which is democratic and allows user-communities to participate in the governance of civil society. The reason given by the public for this deficit is that any reflexive control of science and technology does not tackle the major challenges which civil society confronts. In that sense does not tackle poverty, or combat deprivation and because of this, is either unethical or ecologically destructive. This also suggests the ethics of poverty, deprivation and ecological destruction, are ignored, because research and innovation is increasingly developed by trans-national corporations, whose intellectual property rights organize knowledge production in such a way the wealth created offers little opportunity for either the nation-state, or region to exhort any reflexive control of science and technology on behalf of the public, or as part of a democracy whose participatory governance sets the agendas for cultivating those environments able to sustain the economic growth of regions (the Triple Helix model).
- the democratic deficit within civil society which proposes that user-communities in the creative sector lack the reflexive control of science and technology needed for civil society to cultivate environments which sustain the economic growth of regions. The reason given for this being that such a deficit leads to civil society being excluded access to: 1) consultations on how to tackle poverty, combat deprivation and overcome environmental destruction; 2) deliberations over how the wealth, prosperity and ecological reconstruction of the knowledge economy, can meet these challenges by way of the reflexive control it exhorts over science and technology and through a democratic process, whose participatory governance of civil society cultivates environments able to sustain the economic growth of regions (Quadruple Helix model).

This transgression results because that trust which the public assume to be an abundant property of the EDP and readily available in methods such as: RIS3 vision sharing and debate at a glance, is that very intellectual capital which organized knowledge production in fact lacks and falls short of as the administrative framework of the EISF. That intellectual capital of organized knowledge production, which is assumed to be an abundant property of wealth creation, readily available and openly sourced, but that in reality turns out to be a system for the reflexive control of science and technology which is not democratic. Not democratic in the sense the very absence of any direct participation of the creative sector in the governance of RiS3 denies civil society access to a research and innovation strategy able to prioritize smart specialisation as the reflexive control of a science and technology credible enough for any vision of and debate over security, food, energy, mobility, health and well-being of the public to clear the trust deficit and for democracy to include those members of the public who are otherwise left out of such a framework.

In particular, those members of the public, who are otherwise left dis-empowered as user-communities and in that sense excluded from any reflexive control of science and technology, which the wealth creation of organized knowledge production should mobilize as a vision, debate and framework to confront the major challenges civil society faces in tackling the likes of food and energy poverty, combatting depravation and promoting the health and well-being of an ecological reconstruction as part of a research and innovation strategy. In that sense, the wealth creation of organized knowledge production any such vision should mobilize to scope out, discuss and frame the major challenges which civil society confronts in developing a research and innovation strategy smart enough for the wealth this vision of security, food, energy, mobility, health and well-being creates to reframe science and technology as a process of reflexive control that allows civil society to prioritize debates over poverty, deprivation and ecological destruction, by way of consultations and through deliberations. By way of consultations about security, food, energy, mobility, health and well-being and deliberations over poverty, deprivation and ecological destruction as interventions in the governance of RIS3 designed to restore public trust and clear the democratic deficit by cultivating a legal and administrative framework whose funding of such priorities secures investment to sustain the economic growth of regions.

7. Conclusions: Towards the Next Stage of RIS3

The decade of 2010s has been a period of introduction and experimentation on smart specialisation strategies and initial testing of their underlying growth assumptions. There is plenty of information on the content and challenges of RIS3 at regional or national levels - thanks to JRC peer review of strategies - and on difficulties in applying rigorous methodologies for RIS3 design, implementation and assessment. RIS3 linking regional, national, and EU policy frameworks, regulations and strategy objectives require a variety of evidence to define problems, priorities and objectives, and use suitable policy instruments to achieve them. But, how this variety of evidence become feasible in practice remains largely elusive (Kleibrink & Magro, 2018). The same decade has been also a period towards more mature Internet technologies, wider use of online services, web assistants, and large datasets that became available by online access to databases and user-generated content in social media.

Online S3 is positioned at the interface of these trends, offers web services and tools to implement RIS3 methodologies across regions and facilitate the design process with the use of datasets and software agents. Having developed online assistants for 28 methodologies, documented as the most used or useful in 30 EU regions, these web solutions have been tested in four regions (Scotland, Central Macedonia, Galicia, and Northern Netherlands). In the pilots, 142 stakeholders were engaged, 12,000 users, of which 1089 were contributed with ideas and comments by open consultation. The degree of acceptance of the proposed online applications assisting RIS3 methodologies was very high, with strong and very strong acceptance ranging between 58 - 82 percent. It became evident that online services contribute to smart specialisation strategies in three ways: (1) easier access to data, use of larger datasets, and data-based evidence on regional context and trends, (2) use of complex methods, transferring the complexity to algorithms, roadmaps, and routines embedded into software applications that facilitate their use, and (3) wider user engagement, easier dissemination of strategy vision, and collaborative elaboration of priorities and action plans.

In our mind, these directions are setting the scene for the coming programming period 2021-2027, in which the smart specialisation agenda and RIS3 will reach a more mature stage, enabling higher quality and more informed strategies.

7.1 The Significance and Contribution of Datasets

Easy access to data has a direct impact on the effort needed and productivity of the RIS3 management team. Take for instance, the Regional Assets Mapping. Finding regional data on 55 indicators by using this application and comparing with peer regions is a work of minutes. Doing the same by access to Eurostat databases needs effort measured in days. The gain in productivity is enormous. The same is true for disseminating the vision of RIS3, understanding the institutional and administrative framework of the smart specialisation, which can be done by direct access to mash-up applications and use of available templates avoiding duplication of efforts.

Evidence-based policy design is a matter of data. There is a pressing need of data for monitoring and assessment. A common EU monitoring and assessment model would be extremely useful in this regard. The first steps have already done by standardising the RIS3 actions by Thematic Objective and Investment Priority; also, by defining a pool of common outputs indicators (CO01 to CO46). But assessment needs more data. Time series by output indicator are not enough. Finding data from other regions, peer regions in particular, would enable benchmarking, and identifying the focus areas of each strategy in absolute and comparative terms. Moreover, assessing the regional impact of policy instruments demands data from many regions to investigate relationships and dependences between output and results indicators. This would reveal the real power of policy instruments to influence growth and sustainability. The Output and Result Indicators application that has been developed enables correlation and regression analysis, provided that datasets from many regions are available conformed to conditions of correlation and regression.

Another area in which data would improve the quality of RIS3 is related to user-generated content. Data from social media or user satisfaction surveys may directly inform about the added value and the acceptance of RIS3 actions. Much more effective would be content provided by stakeholders on actions already implemented, creating a European database of RIS3 actions, which would be extremely useful during the co-design process, avoiding not-invented-here attitudes. Finding datasets ready for analysis and visualisation (e.g. academic publications, patent data, specialisation data, etc.) would elucidate trends for which statistical agencies do not provide data at lower geographical nomenclatures.

7.2 The Contribution of Software to Methods

Together with data, software applications are proved very effective in improving the quality of RIS3. In combination with the guide for each application, a very clear understanding of the respective method, which is implemented by software, is obtained. There is no space of fuzzy definitions or misunderstanding on data and calculus. Moreover, when applications are open source – as happens in OnlineS3 - and the code is available on the GitHub, there is total transparency how calculations are set, and results are produced.

Standardisation is also a direct outcome of using software for method's implementation. The benefits of process standardisation are extensively discussed (Ash & Burn, 2003; Kuhlang et al., 2011; Stevens & Dimitriadis, 2005). There is improvement in technical communication and understanding, facilitation in exchange of know-how and easy technology transfer and learning, establishing of best practice how to carry out a process. All these improvements are translated to easier onboarding. Having a standard way of doing something, it becomes easier to transfer this knowledge. Standardising best practice and most efficient processes, higher productivity spreads across an organisation.

Moreover, through software applications complex methods or use of sophisticated procedures becomes feasible, even by non-experts. As know how is transferred from persons to machines, software applications in the case of RIS3, the effort needed for the implementation of methods is minimized. The machine takes over and replaces the complexity of the internal process by an algorithmic sequence. The problem is solved at the stage of software design and development. Then, complexity is replaced by repetition.

Using software applications, RIS3 methodologies obtain transparency; access become easier; and productivity gains reduce the effort needed for a state-of-the-art strategy design.

7.3 The Significance of RIS3 Participatory Model

Given the social significance of the Triple and Quadruple helix models and especially the weight they each put on the democracy of this participatory governance, merely caricaturing the division between the Triple and Quadruple helix as the difference between say, the proprietary systems of knowledge economy and participatory governance of civil society, would do them an injustice. As would any suggestion either one of them is sufficiently powerful to bridge such a deeply rooted division by themselves. For any such claim would merely serve to exemplify how the ambiguities currently surrounding the entrepreneurial discovery of research and innovation strategies, not only run the risk of misrepresenting what Smart Specialisation is, but also ignoring the real consequences of the prioritisations selected to serve a knowledge economy whose deeply rooted social divisions bring any notion of reflexive control, democracy and user-communities in a participatory governance of science and technology to the fore.

The reason for uncovering the division in the Triple and Quadruple-Helix models is not to capture any errors in the conceptual schemas they advance in relation to the entrepreneurial discovery, or how research and innovation affect Smart Specialisation Strategies. It is instead done to reveal the deeply-rooted social division underlying all of this and which surfaces as a lack of public trust in the participatory governance of science and technology, and attempts made to meet the democratic deficit associated with any reflexive control of the wealth created from organized knowledge production. In that sense, the lack of public trust in the EDP and democratic deficit in Smart Specialisation Strategies, which make up any claim about the participatory governance of user-communities in science and technology. Moreover, and in spite of what the Triple and Quadruple-helix models both claim, that transgression of public trust and deficit in democracy, which user-communities perceive as the outcome of that reflexive control which is regressive, because of how Smart Specialisation prioritizes research and innovation as entrepreneurial discoveries related to the organisation of a knowledge production whose economy is only able to sustain regional growth at the expense of civil society.

Given the weight of significance which the statement: "at the expense of civil society" takes as a reflexive control that transgresses public trust, and which results in a democratic deficit believed to be regressive, it is a matter that not only warrants further examination, but which also calls for additional consideration. Not only because at first sight this lack of public trust is exactly what the Quadruple Helix is understood to offer the prospect of delivering as that knowledge economy which meets the governance challenge the Triple Helix leaves unresolved, but for the reason a closer examination of the Triple Helix model does also bring this democratic deficit reading of the transition from the Triple to Quadruple Helix into question (Lombardi et al., 2011; Kourtit et al., 2013; Deakin & Leydesdorff, 2014). For what such a deficit reading of the transition tends to ignore is the fact those advancing the Triple Helix model do meet the governance challenge without putting so much critical distance between the intellectual capital of organized knowledge production (Deakin, 2014, 2015, 2018; Deakin & Reid, 2018) and that democratisation of the public which the Quadruple Helix calls for. That democratisation of the public which it calls for as a basis for user-communities to gain trust and clear any deficit by participating in the governance of science and technology as members of civil society (Carayannis & Campbell, 2012, 2014; Carayannis and Campbell, 2017).

For what those championing such a "Advanced Triple Helix" are fully conscious of is that neither any democratisation of the public, nor user-communities which participate in the governance of science and technology, are the exclusive property of any social ecology this media cultivates, but instead attributes of that intellectual capital which underlies the organisation of knowledge production and that surfaces in the economy of a wealth creation which this governance exerts reflexive control over. Which this governance exerts reflexive control over and that calls, not so much for the addition of another helix dedicated to any democratisation of the public, but instead an extension of the Triple Helix model's reach from the intellectual capital of organized knowledge production out into the economics of wealth creation. Not just in terms of that entrepreneurial discovery which underpins the research and innovation of any emergent "knowledge economy", but as a process that also supports the priorities of such a Smart Specialisation as a platform for the reflexive control of this democratisation by the public as user-communities. Furthermore, by the public as user-communities which participate in the governance of science and technology and in a manner that does serve to clear any deficit in the system.

This way, vis-à-vis by way of the emergent properties of an entrepreneurial discovery process underpinning research and innovation and through the organisation of knowledge production into an economy supporting this process wealth creation, it does become possible for the priorities such a Smart Specialisation sets to act as a platform of reflexive control. In particular, that reflexive control which the public would not otherwise possess as user-communities and for the reason that for all intents and purposes, they lack the intellectual capital of organized knowledge production as a platform for the process of wealth creation to democratize the knowledge economy. That is, to democratize the knowledge economy as the public of those user-communities, which do possess the means, vis-a-vis "wealth of intellect" needed to participate in the governance of science and technology, not only as special interest groups, but as members of civil society with the "wisdom of the crowd" also required for them to sustain regional growth.

This is the only way it is possible to get any equivalence between the entrepreneurial discovery process of the research and innovation strategies championed by the Triple and Quadruple Helix models of Smart Specialisation, not as a transgression of public trust whose democratic deficit is regressive, but as part of that participatory governance which is progressive. Which is instead progressive by virtue of the fact this Smart Specialisation does not turn on a strategy able to merely inflect some semblance of control over a knowledge economy, but instead demonstrate the reflexivity of that democratisation which the public is subject to and user-communities assume to be virtuous. Assume to be virtuous as a consequence of the trust which the public have in the user-communities that participate in the governance of science and technology and potential this Smart Specialisation has to clear the democratic deficit within civil society as part of a bottom-up search for place-based polices whose strategies are able to sustain regional growth.

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DATA and Information in Architectural Design Process Through Building Information Modeling: A New Epistemological Horizon of BIM Methodology

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This paper takes up the results of two research projects led by the authors: Contemporary Architecture in Colombia and Optimization of building management through the implementation of digital twins. These results are applied to a pedagogical investigation on the work developed in an architectural design workshop. The experience of the Architecture and BIM workshop of the Universidad de Bogotá Jorge Tadeo Lozano (UTADEO) is presented. This academic space, which responds to some challenges of the implementation of the BIM building information modeling in university education in Colombia, uses BIM methodology to train the student in architectural design competencies. It highlights the one corresponding to the integration of the technical dimension and its impact on space design decisions.
The experimental exercise in the workshop seeks to transpose the methodological and technological advances derived from the digital transformation of the industrial sector to the training processes in the academy. This strategy links the information modeling of the building as a method to generate a change of the projective thinking and to improve the decision-making for the production of architecture.
In the second part of the article, on section four, from the results of the workshop experience, we proceed to discuss the digital interface where data and information collide and the architecture teaching model in Colombia and to outline a new, more appropriate and current epistemological point of view for architecture education.
This exploration of the 'data' theme in architecture design process through both a practice-based and a theoretical approach suggests a prospect for the future professional practice and its associated training processes. The possible widespread implementation of these new ways of projecting can lead to the development of a new epistemological model

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for architecture education in Colombia, in accordance with disruptive practices such as the design process under the influence of digital transformation.

1. Introduction

The Building Information Modeling (BIM), as a methodology for the development of projects, is a set of collaborative processes supported by industry 4.0 technologies (Sukhodolov, 2019). These processes allow the integrated development of projects through the information modeling of each phase of their life cycle, managed through a common data environment and the use of open standards that facilitate continuous collaboration between different agents and disciplines. Therefore, the evolution of BIM information modeling must be framed within a paradigm that takes into account people, processes, and technologies in an increasingly interconnected world (Boje et al., 2020).

The implementation of BIM in the design subjects of architecture programs in Colombia has not occurred at the same speed as its implementation in the building industry. In this sense, the teaching and learning of design is not yet fully benefiting from the potential use of data, models and documents embedded in design. This would allow new paths to advance in the design process, as well as new routes of analysis and evaluation of the design in the life cycle of the project.

Information modeling connects the data that structures the design information and its application to the project as a synthesis of knowledge. The type and scope of the project, the context of the project, added to the knowledge and experience of the design team, allows defining the quantity and quality of input and output data that configure the flow of design information. Likewise, the design criteria are enriched by the quantity and quality of information that is applied to the solution of a problem in a certain context. In the design process, information processing is understood as all the actions of the designer for the formulation of the design problem and its solution (Montaño Bello & León Rojas, 2020). The BIM methodology is an ally for the management of information that affects the formulation of the problem and the search for the design solution. It advances iterations and optimizations from the conceptualization stage and efficiently organizes workflow, technical coordination, and design documentation (Montaño Bello & León Rojas, 2020).

The implementation of the BIM methodology in university teaching processes in architecture, in tune with STEAM-type educational models, University of Bologna and with theories Management contests such as Lean Construction or Integrated Project Delivery (Montaño Bello & León Rojas, 2020), mean an opportunity to strengthen architectural design competencies by incorporating them into the traditional space of the project workshop.

Since 2018, the UTADEO School of Architecture generated an action-research space in the classroom through the planning, development and continuity of the Architecture and BIM workshop. The research presented assumes as a hypothesis that the implementation of BIM methodology in the training process of future architects allows the integration of structured information as a condition for the entrance of formal and spatial production of the architecture.

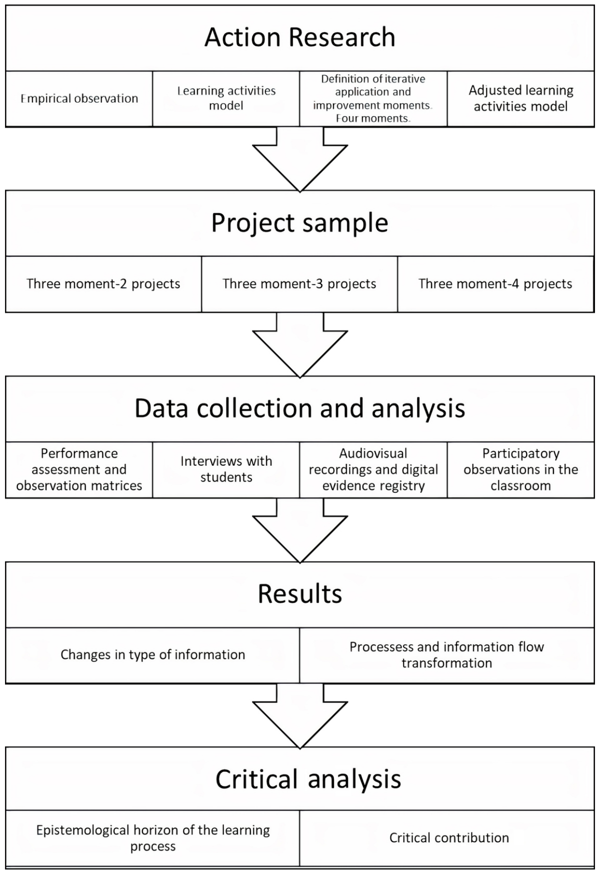

Figure 1. Methodology diagram

Source: Authors

At the same time, it strengthens a projective thinking based on the life cycle of the project and the development of high-performance architectural designs (Montaño Bello & León Rojas, 2020).

2. Methodology

Action Research (Frayling, 1993) is based on reflection in action (Latorre Beltrán, 2003). Its pedagogical research methodology starts from an empirical observation in the classroom that establishes connections between learning activities and learning outcomes. Subsequently, a hypothetical model of actions is built to structure a pedagogical planning and provide a causal explanation of the teaching and learning phenomena given in the classroom. Finally, the pedagogical planning model is subjected to multiple iterative cycles of improvement that affect practice and adjustments to the following planning model.

The applied action-research was developed in four moments: planning workshop in the first and second semesters 2019, the first semester 2020, the last feedback from this workshop and the planning of the second period 2020. The structure of the action-research is based on a design exercise proposed to the group of students, who simulate the work of an architectural agency that receives a commission declared and executed through a specific BIM Execution

Plan.

2.1. Project sample

The action-research worked on design processes developed by two workshops between 2019 and 2020 corresponding to stage two, three and four of the research. Each workshop was made up of 3 project subgroups, each with 7 members according to the specialties involved in the exercise, for a total of 9 projects evaluated in 18 months of work, as follows:

- Stage 1: Organization of the workshop teams.
- Stage 2: Team 01: Project Men's clothing store. Team 02: Cocoa Shop project. Team 03: Perfume Shop project
- Stage 3: Team 04: Watch Store project. Team 05: Cocoa Shop project. Team 06: Children's clothing store project.
- Stage 4: Team 07: Cocoa Shop project. Team 08: Cocoa Shop project. Team 09: Cocoa Shop project.

2.2. Data collection and analysis

For the Action Research (Till, 2008) process, documents, models and data obtained thanks to the following instruments were analyzed.

Performance assessment and observation matrices. Evaluation rubrics were used to establish criteria and scales for evaluating the learning evidences and their relationship with the learning objectives proposed by the workshop. The instrument allowed analyzing the performance of each team and each member in each of the moments proposed in the research design.

Interviews with students. Structured interviews were conducted with the students in each of the project committees. These were recorded and allowed their subsequent analysis. This instrument allowed us to analyze the relevance of the proposed activities as a basis for their subsequent adjustment.

Audiovisual recordings and digital evidence record. By time three and four, the quarantine derived from the Covid-19 pandemic, led to synchronous sessions with technological aids that were operated remotely. This condition allowed having a digital record of each session and the possibility of observing and analyzing the learning results in a digital repository.

Participatory observations in the classroom. During the process, notes and records were taken on the achievements obtained, as well as on the difficulties expressed by the students regarding the construction of their learning evidences, both individually and in groups. This instrument allowed the evaluation of the activities and their effects on the planning of the workshop.

2.3. Critical analysis

The results recorded in the following point three allow to formulate in point four, and from an epistemological point of view, a discussion of the architecture teaching model in Colombia. It is based on two critical contributions supported by the concepts "potency" and " asignifying" formulated by Deleuze (1981/2003), and "indexes" and "indices" a concepts worked by Van Lier (1996/2014) and Huyghe (2019). The critical contributions will link these concepts to two results of the Action Research developed in the classroom experience, with the purpose of demonstrating the changes brought about by the BIM methodology in the teaching of the project in architecture.

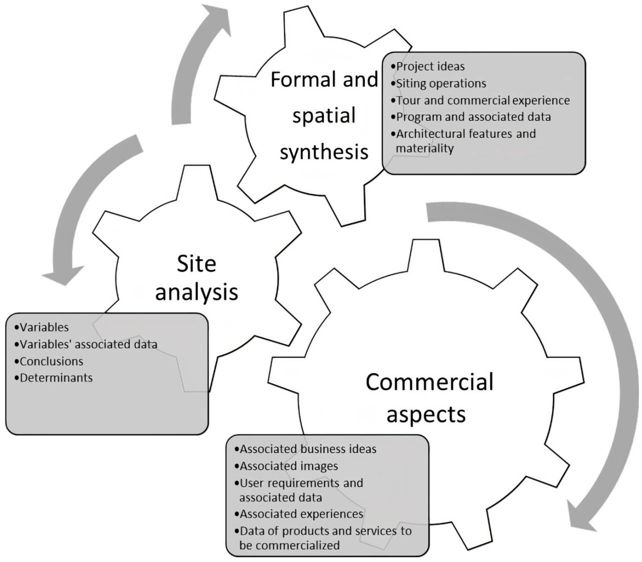

Figure 2. Conceptual map of the Kahau commercial project

Source: Architecture Workshop & BIM (2020)

3. Results

The exercise allowed us to identify findings in two important variables: 1. The change in the type of information that flows during the design process; and 2. The transformation of processes and flows of information. These changes are related to improvements in performance indicators and in learning outcomes for the traditional teaching-learning processes of architecture design.

3.1. Change in type of information that flows during the design process

In the initial stages of design, unstructured information (I) is usually constructed, that is, valuable data for the project thinking process such as sketches or analogous models. However, since they are not made through electronic means, they are not computable or interoperable. Even so, they are progressively integrated through documents and models that drive the projective thinking of designers to advance in the consolidation of more elaborate project hypotheses. Figure 2 shows examples of this unstructured information generated in the initial stages of the process.

In the development of the design, digital tools are incorporated and one can migrate to an increasingly structured information (II). Computable data and information that is organized for different purposes and uses in the project are produced, such as digital models, 2D drawings, digital images, digital documents of all kinds, etc. However, this information is usually not connected. This structured information generated early in the process involves architectural plans and renders.

With information modeling (III) it is sought that certain design data are structured and integrated into a 3D model for particular uses. For example, figure 3 shows different models of the same project that are used for the spatial analysis of the design, the structural analysis or the analysis of facilities. The structured information that is modeled allows it to be processed by the machines and used for multiple processes. Among these are the planning, simulation and testing of the solutions that are decisive to guarantee the quality of the design in the later stages of the life cycle of the draft.

The characteristics of the types of BIM models depend on different factors. The most important - which are also integrated with each other - are the type of project, the scope of its development by phases, and the dimensions that it integrates. These in turn define the BIM uses that the model will have and the level of development of the model, which is known as the LOD. This in turn is made up of levels of graphic advancement and development of integrated information. Figure 4 illustrates the relationship of these aspects in the definition of the information modeling developed in the exercise.

A final stage in the management of design and project information is the possibility of generating and using integrated data (IV), that is, interconnected and highly structured information. Such information is produced by multiple sources and managed in a common data environment that can be used in multiple projects and different platforms.

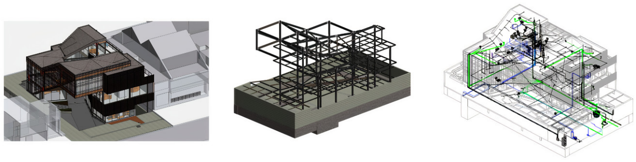

Figure 3. Information models of the Kahau commercial project: architectural, structural and technical installations

Source: Architecture Workshop & BIM (2020)

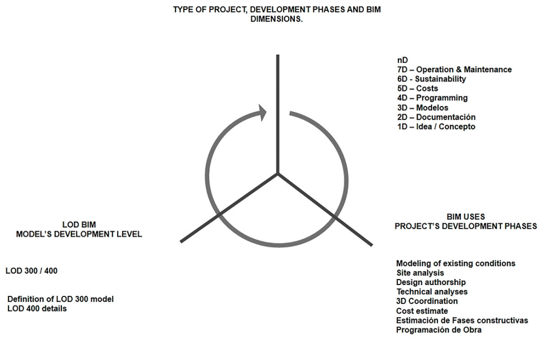

Figure 4. Aspects that define the types of information modeling in the design

Source: Authors

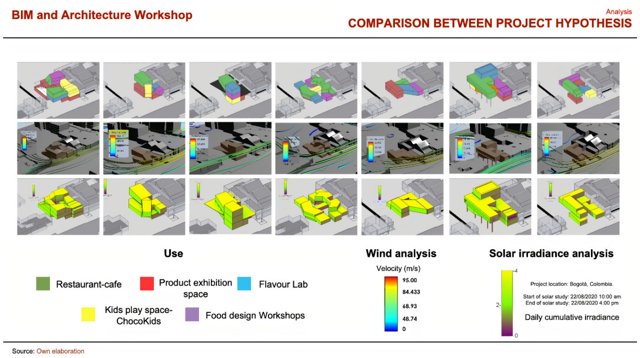

Figure 5. Analysis matrix for the selection of design alternatives for the Kahau commercial project

Source: Architecture Workshop and BIM (2020)

3.2. Process transformation and information flows

The transition from processes based on analogous media to processes based on digital media implies translating unstructured information into structured information for modeling and integration. The design process is thus fed with structured information that allows better decision-making from the early stages. The integration of data associated with the conditions of the site and its analysis, data that allow better technical analysis and 3D coordination which facilitate the estimation of costs and construction phases, or the construction scheduling are some examples of how the information-driven design can be optimized. Figure 5 shows a matrix with data integration, product of the modeling of existing conditions, and site analysis. It is useful for selecting between initial designs alternatives.

In the experimental exercise carried out, activities of the design process with different degrees of autonomy in the production of design information were identified: assisted activities in which the tasks are carried out manually by the student with the assistance of the computer, such as graphic modeling and incorporation of data into the model; automatic activities such as tasks performed by the machine after preliminary programming, for example construction simulation based on data from external programming; automated activities in which the tasks are executed by the machine, for example in processes of quantification of project areas or of components and materials. In figure 6, a diagram is presented with the three types of activities identified in the design process.

The exercise allowed evidence of improvements in the skills for collaborative work thanks to a common data environment, the use of protocols, and the flow of structured information. The quality of the information produced accounts for the improvement in the design results, synchronized with reflections on the performance of the design in the project life cycle. A better performance of designs in multiple dimensions is also projected as a result of energy, structural and bioclimatic analyzes, among others. Finally, there are improvements in control from the design on cost and time constraints of the project, an aspect generally isolated in traditional design teaching processes.

3.3. Limits of the experience

The information generated through the exercise also shows limitations derived from the technological resources used in the workshop, in terms of the degrees of integration and autonomy in the generation of information. As information is structured and integrated to advance the development of design in architecture, the importance of knowledge as a basis for decision-making and as a fundamental resource for the synthesis of design is also understood. The project is thus understood as a synthesis of knowledge based on a complex interconnection of graphic and non-graphic information, in turn based on a large amount of integrated data. The design exercise takes place in a set time of 16 weeks that limits the number of design iterations. However, the results show an awareness of the importance of integrated information for the continuous improvement of solutions, both in the progress flows verified in the production of deliverables, as well as in the revision flows verified in the feedback of the process and in the partial results obtained.

4. Critical contributions

For a theoretical proposal to be accepted as a valid conceptual framework or as a predictor of reality, it must be adequately described, explained and comprehensively tested over time and under different operating models. In addition, for a conceptual framework to continue to reflect process innovations and to benefit from emerging opportunities from information integration, this process of description, explanation, and testing must be iterative (Succar & Poirier, 2020). In this sense, the description and explanation of the experience, in addition to allowing it to be improved by other researchers and peer-reviewed through open scrutiny, questions the relevance of current epistemological frameworks in the practices of teaching - learning in architecture.

This section is developed from the articulation between the results of the study and the concepts indicated, from which the two critical contributions arise. Thus, the first contribution entitled "Computable data and visualization" links a first result of the study, the type of information that flows during the design process, with the concepts of indexes and indices, in order to make evident how, depending on the type of information, the digital visualization of design processes exceeds the visualization possibilities of the classical perspective. The second critical contribution called "towards a new epistemological horizon" links a second result of the study - the transformation of processes and information flows - with the notion of power. The objective is to explain some modifications that the BIM methodology contributes to the teaching of architecture.

4.1. Computable data and visualization

The relationship between unstructured and structured information implies that analogous non-computable data are raw material that cannot be reduced to significant data

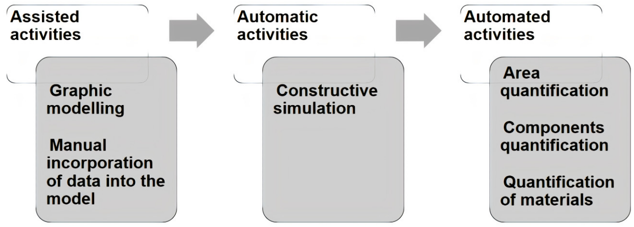

Figure 6. Some activities of the design process and associated degree of autonomy

Source: Authors

or information. However, in the digital interface where structured information enables the production of information models, some computable data act as raw material. These asignifying data behave as an event in tension with significant computable data, articulated to one purpose: the development of a high-performance project. However, asignifying computable data, without being articulated to a specific meaning, also affect the development processes of a high-performance project. Of these processes, the information visualization process is suitable for exploring the productive tension between data.

In the information visualization processes of the workshop, significant data (structured information) is recognized. They are signs of an established meaning. The student confronted with visualization processes recognizes the data as chained to the trajectory of a previous data. In this process in which the data is articulated according to a specific meaning of information visualization, for example, representing the spatial systems of a project, the parameters of the visualization processes do not necessarily vary in relation to the visualization parameters of the analogous supports governed by perspective. Now, in epistemological terms, within the framework of the parameters of the classical perspective inscribed in the processes of digital visualization, the asignifying computational data are perceived but not recognized, because they are not articulated to the parameters of the established visualization regime.

In the information modeling that integrates analytical data from the site in figure 4, the integrated data is indexed to the perspective; the information visualization is adapted to a form familiar to the student. This procedure where digital innovation of computer modeling is assisted by the past, the perspective, corresponds to the early adoption phase of the technology. Just as the way the first cars were made, when they did it in a way that intended to disguise that, in reality, it was something that had no precedent. Zuboff calls this the "horseless-carriage syndrome", the first cars were built with the appearance of carriages, like horse-drawn carriages, so that their novelty would go unnoticed (Zuboff, 2019). However, the indexing of the unfamiliar to the familiar does not exclude of the visualization field of computer modeling the asignifying data from the field of visualization of computer modeling. They are visualized as interconnected networks in three dimensions or as energy flows that trace the solar incidence on the volume in perspective. In the digital interface, the asignifying data affects the visualization of a space in perspective, which is made up of significant data.

Asignifying data are "indices" and significant data are "indexes". Indices are not signs, but rather the effects of a cause they physically signal either through 'monstration' – as when the imprint of a boar's paw shows this same paw – or 'demonstration', as when a disarrangement of furniture might reveal a thief's path through the house. Indices are non-intentional, non-conventional signs. Indexes indicate objects in the same way as the index finger might point to an object. Indexes are intentional and conventional but designate nothing by themselves (Maes, 2008).

An asignifying data is an indice that can be considered an act when referring to the domain of the real, while the significant data is an index or action that refers to reality (Van Lier, 1996/2014). Now, actions are also different from one another: one indirectly encompasses the act and indicates it; the other one encompasses it directly and expresses an increase of a potency (Deleuze, 1981/2003). The indicative "action" then differs from the action that increases the potency of computer model display images. These images would be indicative only if they represent the spatial coordinates in perspective of the analog images. However, the purpose of these images is not the constitution of a space in perspective. The perspective is no longer the line of convergence or the direction to which all the productive phases of the processes that make them possible must be articulated. In the images of a project developed with BIM methodology, the expression of the temporal and resource dimensions associated (4D and 5D) to the constructive modeling and life cycle of the projects are indices, asignifying data, acts, since these dimensions they have not been historically indexed in the image of architecture in perspective. Figure 5 shows the volume of a building in relation to energy intensity lines, which have no antecedent in the history of image, visualization and communication of architecture.

The temporal and resource dimensions, as well as the energy incidents, are indices of the real that acts in the reality of the architectural image, still subject to the perspective as reality of the architectural representation. The fact that project decisions are made in a participatory way with these indices means that such events act to increase the potency of the project. That the indices of the events are translated in terms of qualitative and quantitative information, speaks of the constant reconfiguration of the indexes from their exposure to the always-active indices. In this sense, the techniques of the present cannot be understood from the mental habits of the past; their capacities or potency increase due to the indices of the real that constantly reconfigure their interfaces and their codes.

Architecture should be thought not in terms of form but in terms of potency (Deleuze, 1981/2003). The development of projects with the BIM methodology increases the potency of the architecture since the data processing and the corresponding visualization processes allow the project space to be the effect of climate flow analysis and joint work where each one of the phases are productive. These cases are not explained from a line of convergence dependent on an idea or a vanishing point as in perspective, nor from a linear work organization where all the elements that affect their systems and interfaces, and that also make up their modeled and simulated images.

The development of parametric design projects with the BIM methodology and its visualization processes contradict the epistemological tradition, according to which the techniques, in this case a methodology in which various software participate, are finalized instruments of the designers. Understanding that a technique is unfinished implies that project thinking has been based on epistemological mistakes that, by idealizing ideas and articulations of meaning, have not retained all the data or asignifying actions that have constantly transformed the image of architecture. BIM facilitates a more productive participation to what architecture has always configured: the indices of the real.

To understand the permanent participation of data as indices of a specific reality, the epistemological and ontological paradigm of means and ends must be displaced. The purpose of architecture is always the physical construction of space. However, in its processes, there are indices of the real – solar radiation on surfaces, the fourth and fifth dimension in BIM–, which increase the action capacity of architecture. A projected space that results from the processes associated with computer modeling and a simultaneous work of conception / realization in which multiple actors participate in real time, is a more powerful space and, therefore, a more complete space with a degree of perfection (Deleuze, 1981/2003). The increase in the degree of perfection is not the purpose but the expression of a continuous increase of a potency. The modeled and simulated image allow exploring and presenting the possibilities of architecture, due to the incidence and participation of the real in its reality system. Contrary to the free simulation of the real, computer models are powerful thanks to the participation of the real.

4.2. Towards a new epistemological horizon

The teaching of architecture in Colombia is based on the French traditional model *Beaux Arts* and its conception-realization distinction. BIM information models question the project model executed according to an idea defined from the conception phase. The preeminence of the idea in this model of mental foundation corresponds to the transformation of architecture into arts liberated from its mechanics. This model still colonizes architecture teaching practices by being unconscious, not thought and, therefore, not discussed. In BIM, the conception is a phase of the project, the hierarchy of which is no greater than that of the construction or the operation of the building. The construction is no longer subordinate or separated from the conception, nor is it the execution of an idea. In fact, conception and construction begin to collaborate jointly with the other stages of the project process. BIM also implies a transformation in industrial management that links production with operations organized according to the same source (the idea), that is, according to a succession of tasks that are non-productive on their own (Huyghe, 1999/2015).

The classroom experience with the BIM methodology includes construction in project development. Unlike the idea that remains in its execution as it was conceived, thus indexing the products to the source, the construction is externalized in different elements. Products are detached (*de-indexed*) from a source, which can be architecture, but also network design or structural design. Additionally, BIM teamwork affects the economics of production and the *Beaux Arts* division of labor, since each phase of work affects the whole. If construction has to do more with production than execution, the principle of convergence of the classical production line is replaced by a mode of production whose non-convergent parts are dispersed and affect, each one simultaneously, the entire project cycle.

To conclude the analysis of the tension produced by the BIM methodology with respect to the *Beaux Arts* model, we turn to the notion of "modernity" (Huyghe, 1999/2015). Huyghe defines it by its difference with modernism, which does not do as before; it substantially modifies the heritage of the past. The economics of today's innovation society admits modernism: what was done before is done differently now; it excludes the classical in the method, but protects the classical at the level of appearances (Huyghe, 1999/2015). The same happens at the beginning of the 20th century with architecture: historicism, new materials and construction methods with an old look, suitable to be assimilated by classical taste. Here, rather than discovering inventions, they cover themselves with the past. The aesthetic, ethical and political problems that arise from such a trick - to accommodate the new to the classical taste, that is, to manipulate both the perception and the thinking of the users -, is a capital issue in terms of the strength of the *Beaux Arts* indexing systems on technological practices not adjusted to classical taste.

Modernity admits that the situation is not as before and registers the change by appropriating it. Modernity assumes the new techniques, as a *modification* of the current historical situation of the teaching of architecture, but without cutting off any relationship with the past or deceiving at the level of appearances (Huyghe, 1999/2015). This is the case at hand. As argued in the previous section, the visualization of the project development in BIM uses the classical perspective, but simultaneously, the images produced are unprecedented, and completely change the representative content of the project development processes.

5. Conclusion

Thanks to its relationship with technique, humanity can regularly redefine itself. Similarly, BIM redefines the teaching of architecture with the computer models in constant redefinition. A digital model of a building is not the building; it resembles the building, which is its objective system, but it is not its copy; it has different characteristics depending on what is intended to be understood with it. This allows digital models to improve and evolve, pressured by the facts, by establishing that the conventions of a given moment are not sufficiently compatible with the facts. The construction linked to architecture is not compatible with the epistemological model of yesteryear, which affects the academic idea of the architect.

Data management in the computer model of a building is an activity that cannot be understood from the classic epistemological paradigm of architecture, a paradigm where the architect is considered a genius whose conception work is the fruit of an idea. Before, the genius of the architect meant that his work was secret and solitary. On the contrary, the data management process in a computer model is redefined, without secrets, at each stage and in real time, thanks to the work of a community of professionals. In this sense, the architect works as a team with other professionals on projects that are developed progressively, according to the schedule, the operation, the life cycle of the project and all kinds of information necessary for the construction of the project.

The new epistemological horizon that is proposed lies in the design knowledge that is produced by the incidence of collaborative work, the technical contributions from different disciplines, and the conditions of possibility of technology related to the management of structured information from an early age of the process of design. This condition also implies a change in the design results from a new performance paradigm. These conditions, which are evidenced through the exercise of action research in the classroom, necessarily impact the pedagogy of the teaching-learning process and, specifically, the processes that occur in the space of the design workshop. The action-research exercise carried out shows the advantages of the implementation of the methodology from an early age of the design process and not only in its optimization phases.

The BIM methodology draws a new epistemological horizon by modifying the *Beaux Arts* model, the idea of an architect, and the architectural work and production. Architecture, in the end, affects all stages of the project's development. Such stages, being collaborative and creative, rather than undermining architecture, improve and enhance it.

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Knowledge Economy's Externalities and Urban Growth: An Analysis of the Functional Dynamics and Location Patterns of Knowledge-Based Industries in the Metropolitan Barcelona

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Centrality of knowledge-based industries (KBI) in the economy of metropolitan areas leads to the transformation of their labour markets and promotion of new forms of urban growth, because of creation of KBI specialized clusters. KBI are industries that are highly based on codified and tacit knowledge located in people and communities, which become important aspects for spatial employment location. The hypothesis of this paper suggests that, despite high specialization of KBI and their integration into global networks, these industries have functional linkages in regional markets, thus affecting the dynamics of employment growth as a whole. This is verified for Catalonia, in which Barcelona Metropolitan Region (BMR) is the largest urban agglomeration. Methodology includes a Proxscal Multidimensional Scale Analysis that relates an Economic Dependency matrix, which explains the relationship between all the economic sectors with a Spatial Dependency matrix, which weights the size of the localized employment with the inter-municipal distance. Results reveal, firstly, that KBI have intense economic interlinkages with other industries in the Catalonian market, however, these interlinkages do not encourage spatial proximity among them in terms of employment location, which reveals the existence of long-range economic interlinkages; secondly, proximity to metropolitan core evidenced as a key factor for location of KBI' employment; this is because in those areas firms may access to benefits of network and agglomeration economies, encouraging in this way polycentric growth. Furthermore, paper results offer an attractive and informative data-driven approach to conduct urban analysis studies that may be reproducible in other urban data contexts, to provide solutions in employment growth city planning public policies related.

1. Introduction

Since the late twentieth century, metropolitan areas have experienced a key economic shift because of mass deindustrialization and consolidation of services. In this new scenario, the so-called knowledge-based industries (hereinafter KBI) emerged as the main drivers of that process (Harris, 2001).

The earlier works of Romer (1990) and Lucas (1988) claim that knowledge and innovation tend to be highly localized, thereby conferring an increasing value on human capital and urban agglomeration as factors that encourage economic growth. This leads to the creation of knowledge spillovers in specific areas that encourage the generation of buzz environments, which boost cross-fertilization among specialized and diverse networks through face-to-face contacts (Storper & Venables, 2004), even temporary spatial proximity to develop processes of interpersonal trust

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(Growe, 2019).

Furthermore, network externalities, which are created by long-range non-hierarchical interactions between territories, encourage KBI' firms' agglomeration in central areas of large cities with deeply embedded innovations processes (Taylor et al., 2010). All those processes supported by a social capital, which involves shared codes of behaviour facilitating knowledge transfers (Lambooy, 2010). However, it remains unclear how the spatial clustering of KBI and other industries are related and what role functional inter-industry linkages, both forward and backward, have in this process.

The research paper hypothesis suggests that, despite high specialization of KBI and their integration into global networks, these industries have functional linkages in regional markets, thus affecting the dynamics of employment growth as a whole. These processes studied in Catalonia, in which Barcelona Metropolitan Region (BMR) is the largest urban agglomeration. To achieve this, this paper studies with the use of Proxcal Multidimensional Scaling (MDS) analysis, the relationship between the technical coefficients' matrix of Catalonia's input-output (I-O), which show economic interdependences among all industries, and a geographic interdependences' matrix that is calculated with municipal employment data and intercity distances. This matrix summarizes in one single value the average physical distances between total employments by industry, which are located in many municipalities. Furthermore, the MDS analysis enables to reduce the original proximity measures of both economic and geographic interdependences matrices to Euclidean distances that represent new proximity measures, which are visualized in a Cartesian plane. Hence, the position of each industry in the two resulting Proxscal MDS spaces is a synthesis of its functional dynamics and spatial location relating to all the industries of Catalonia. In that sense, this paper highlights the use of innovative data-driven approach to analyse KBI' employment growth processes and their clustering patterns in the metropolitan arena.

After this introduction, the next section reviews briefly the literature in which location theory is based; then follows an overview of data and methods used; the results presented next, a final section summarizes conclusions and recommendations to public policies related.

2. KBI's Location Factors

The three main theoretical approaches used here to explain the location of KBI are: 1) inter-industry linkages, which in the case of KBI are also related to knowledge exchanges; 2) agglomeration and network externalities, which explain the benefits that firms gain by locating close to each other in specialized cluster or in central areas of large cities that are increasingly networks' nodes through which intense flows of knowledge pass; and 3) human and social capitals, which encourage successful business relationships for innovation.

Firstly, Hirschman's concept of inter-industry linkages states that firms create backward and forward linkages in their investment decisions, which establish cross-industry ties with spatial effects. Hirschman (1958) argues that economic growth boosted by the increasing growth of industries with multiple economic interrelations. Perroux's (1955) theory of development poles also refers to inter-industry linkages as a mechanism for economic growth. Contemporary, these interactions that arise between firms are mainly related to knowledge exchanges, that local and international collaboration promote, especially in KBI' firms as Fitjar & Rodríguez - Pose (2020) study in Norway.

Furthermore, the regional policy literature has shown a renewed interest in the promotion of industries with the potential to embed themselves into regional economies. In that sense, the input-output (I-O) tables have been broadly used as a tool in regional development analyses by different authors. Hauknes & Knell (2009) utilize I-O tables, in various countries to analyse knowledge flows in industrial production; Hwang & Lee (2014) employ I-O tables in Korea to analyse knowledge spillovers creation.

Secondly, external economies, both agglomeration and network externalities, are well-known as other factors that determine the location of economic activities. This concept introduced by the economist A. Marshall (1920), to explain industrial concentration, which leads to a reduction of production costs and to an increase in productivity. In the Marshall industrial district, local networks producing the so-called external economies (Becattini et al., 2009). Of the set of external economies, knowledge spillovers have a prominent role in the clustering of KBI (Aslesen & Isaksen, 2007). These are exchanges of non-traded knowledge, which are massively important for firms because, from a firm's perspective, knowledge production is a private good (Boschma, 2005). Hence, knowledge spillovers are often localized, which means that local conditions play a critical role in the emergence and dissemination of many kinds of knowledge; for this reason, firms often seek locations close to universities (Lehmann et al., 2020) or in densely populated cities with high cultural diversity where interactions with other firms and access to a wide range of network externalities happens (Audretsch et al., 2021). Additionally, internet facilities found in large cities enable telepresence meetings to replicate face-to-face meetings as an effective way of interfirm or interorganisational collaboration (Martin et al., 2018).

Thirdly, human and social capitals become considered influential factors in attracting and retaining KBI' employment (Van Oort et al., 2009). Even nowadays digital social capital that is supported by online social networks support, encourages KBI' employment growth because it facilitates knowledge spillovers creation between dislocated actors (Tranos, 2016).

In short, in addition to classical requirements for economic growth such as transport and communication infrastructures; nowadays, skills, socio-cultural diversity, and health and environmental conditions also conceived as influential factors (Kourtit & Nijkamp, 2016). Additionally, in terms of the direct benefits of agglomeration (functional links) and indirect benefits (externalities), interaction among firms should be related to their spatial distribution, following Porter's cluster theory (Porter, 1998). However, it is not entirely clear related to KBI how spatial clustering encourages functional interrelations within them, and conversely, how functional dynamics encourage spatial clustering of those and other interlinked industries. In that sense, this paper offers empirical evidence from Catalonia regarding these processes.

3. Methodology and Data

3.1 Data

Employment data for 1991-2001 at two-digits of the EU's statistical classification of economic activities (NACE Rev.1.1) is used.[1] This comes from the population census elaborated by the Statistical Institute of Spain (INE for its acronym in Spanish). This intercensal period is a key period to understand the big shift in Catalonian labour market figures, specially KBI' employment. In addition, other data include technical coefficients' matrix (this represents the overall economic interdependences among all industries located in Catalonia), which is part of the Catalonian input-output (I-O) table of 2001 and intercity distances that come from an own analysis.

3.2 Methodological Stages

The methodology comprises two stages. In stage one, KBI are defined according to workers' educational level by industry, highlighting the industries that employ qualified workers. Furthermore, KBI are categorized according to their main consumption orientation, isolating those that are business-orientated from those that are government and households orientated. KBI consumption orientation could determine different location patterns and distinct employment growing dynamics. Additionally, the main KBI' economic interlinked industries, both suppliers (backward linkages, hereinafter KBI-iBLINK) and buyers (forward linkages, hereinafter KBI-iFLINK) are identified. In stage two, the relationship between employment location and functional interlinkages of KBI and their interlinked industries, due to input-output relationships analysed.

3.2.1. Definition of knowledge-based industries (KBI) and the KBI' interlinked industries

The industries studied are those identified by the Organization for Economic Co-operation and Development (OCDE, 2001) as high-tech manufacturing and knowledge-intensive services (ICT, research and development R&D, finance, business services, health, and education); cultural–creative also included, using the EUROSTAT classification. This classification validated by a multivariate analysis (Principal components factor analysis-PCA and hierarchical cluster analysis) built based on workers' educational level by industry according to data that comes from INE of 2001. PCA reveals relationships between employment variables by identifying new and uncorrelated variables (factors), which contain those relationships patterns. Cluster analysis reveals homogenous groups (clusters) of industries, using PCA factors. Furthermore, KBI' employment categorized according to their main consumption orientation. In doing so, a cluster analysis made with data about consumption orientation by industry from Catalonia's I-O table. Two main categories of KBI at two digits of NACE Rev 1.1 were identified, as follows: government and household-orientated consumption (hereinafter KBI-GH) that correspond to five (5) industries; and business-orientated consumption (hereinafter KBI-B) that correspond to nine (9) industries. In addition, in this latter category two sub-categories were identified: local business-orientated (hereinafter KBI-LB) and export business-orientated (hereinafter KBI-ExB). Table 1 illustrates this classification.

Additionally, to identify the main KBI' interlinked industries, both industries with high sales to KBI (KBI-iBLINK) and industries with high purchases to KBI (KBI-iFLINK) it is used the technical coefficients of Catalonia's I-O table of 2001 and after performing a cluster analysis, homogenous groups of industries in terms of KBI functional linkages found. Table 2 illustrates this classification.

3.2.2 Functional and formal positioning of KBI in two Cartesian planes (methodology stage two)

The technical coefficients of Catalonia's I-O table used to identify functional inter-industry linkages between all industries, including KBI. In addition, equation (1) is calculated to build a geographical distances' matrix of regional employment by industry. In other words, this matrix summarizes in one single value the average distances at which employment in each industry regarding remaining industries are, considering municipal employment structure and inter-municipal physical distances by road.

$$Dg_{ij} = \frac{\sum_{x,y=1}^{946} emp_{ix} * emp_{iy} * d_{xy}}{\sum_{x,y=1}^{946} P_{ix} * P_{iy}} \qquad (1)$$

In (1) Dg is the geographical distance between two given industries *i* and *j*; *x* and *y* are municipalities; *emp* are the municipal employment in 2001; and *d* is the intercity distances by road. This geographical distance's (Dg) advantages are: 1) It is a strong measure regarding the size of municipalities in terms of employment; 2) It is a solid measure concerning size differences between industries; and 3) It summarizes in one single value the average physical distances between total employments by industry, which are located in many municipalities.

The resulting matrices are *n*-dimensional. Therefore, to visualize both matrices in a low-dimensional space, Proxscal Multidimensional Scaling (MDS)[2] is used. This technique enables to reduce the original measures of proximity (that is functional inter-industry linkages and geographic distances between all industries) to Euclidean distances that represent new proximity measures obtained in a Cartesian plane. Hence, the position of each industry in the two resulting Proxscal spaces is a synthesis of its functional dy-

1 This study takes the NACE Rev 1.1 as statistical economic classification of reference.

2 Multidimensional Scaling (MDS) Proxscal has been already used in economic and geographic works (Burns et al., 2008).

Code	KBI	Classification according to consumption orientation by industry	
45	Insurance	Government and household-orientated consumption (KBI-GH)	
47	Real estate		
57	Cultural and creative activities		
53	Education		
54	Human health and social work activities		
24	Manufacture of computer and office machines	Business-orientated consumption (KBI-B)	Export business-orientated (KBI-ExB)
26	Manufacture of computer and electronic products		
27	Manufacture of surgical, precision, and optical products		
49	ICT services		
50	Research and Development (R&D)		Local business-orientated (KBI-LB)
43	Postal and telecommunications services		
44	Financial services		
46	Auxiliary services to finance		
51	Business and professional services		

Table 1. KBI classification according to their main consumption orientation

Source: own elaboration

code	Industry	Backward linkages KBI-iBLINK	Forward linkages KBI-iFLINK
9/10	Food, beverage, and tobacco industries		✓
15	Paper industry	✓	
16	Publishing products	✓	✓
18	Chemicals and Pharmaceuticals	✓	✓
19	Rubber and plastic products	✓	
22	Metal products (except machinery and equipment)	✓	
23	Machinery and mechanical equipment	✓	
25	Electrical machinery	✓	
32	Production and distribution of electricity, gas, steam	✓	✓
33	Water supply	✓	✓
34	Construction	✓	
35	Trade, maintenance, and repair of vehicles		✓
36	Wholesale trade	✓	✓
37	Retail		✓
38	Hotel and accommodation	✓	✓
39	Land transport and transport via pipelines	✓	
41	Air transport		✓
42	Warehousing and support activities for transportation		✓
48	Rental and leasing activities	✓	✓
52	Public administration and defence; compulsory social security		✓
56	Activities of membership organization		✓
		14	14

Primary - energetic *Manufacture and construction* *Services*

Table 2. KBI' interlinked industries

Source: own elaboration.

namics and spatial location relating to all the industries of Catalonia. In other words, the *Functional Proxscal space* (hereinafter F-Proxscal) shows the functional interlinkages that exist between all industries; and the *Spatial Proxscal space* (hereinafter S-Proxscal) shows the relative geographic distances that exist between employment locations by industry in Catalonia. Furthermore, the spatial correlation between these two Proxscal spaces using the *Pearson correlation index* reveals functional and employment industrial location links; this is observed for all industries and for KBI individually.

4. Results

4.1 Barcelona Metropolitan Region (BMR) as Case Study

According to the Statistical Institute of Catalonia (IDESCAT for its acronym in Catalan), in 2020 the BMR was 4.96 million inhabitants, 65% of total Catalonian population; these figures was a slightly higher in 2001 when the BMR corresponded to 67% of Catalan population, showing a population scattering process from the BMR to the rest of the region. Catalonia corresponds to a NUTS-2 in the EU's Nomenclature of Territorial Units for Statistics (NUTS). Figure 1 illustrates location and urban situation of the BMR in Catalonia.

Additionally, according to the Labour Force Survey from 2019 elaborated by IDESCAT, the BMR has 2.42 million jobs, which corresponds to the 70% of total Catalonian employment. Historically, the BMR has concentrated the mayor employment figures of Catalonia, also in KBI' employment. However, in the period 1991-2001 overall employment decentralization figures from the BMR to the rest of Catalonia already show a positive tendency; although this process is minor in KBI' employment, which reveals an inertial tendency to be located close to the metropolitan core. In the period there was a deeply negative increment of KBI' employment concentration in the metropolitan core and the subcentres of 5.7 points; meanwhile in the urban agglomeration's outskirts there was a positive increment of 2.2 points, and in the rest of Catalonia of 3.5 points (Figure 2).

4.2 The Knowledge-based industries (KBI) and their interlinked industries

According to Catalonia Gross Valued Added (GVA) from IDESCAT, in 2018, KBI represented around 36% of total regional production; meanwhile in 2001 it was 34%, which shows KBI solid value at the regional economy figures. Additionally, in 2018 the BMR represented around 79% of the total KBI' GVA from Catalonia.

Furthermore, the KBI local business-orientated (KBI-LB) employ 47% of total KBI' employment in Catalonia. Additionally, most of the KBI-LB are sectors with an extensive demand from other industries local and export-orientated, suggesting that productivity and competitiveness of the whole Catalonian economy may be influenced by the activity of KBI. In this regard, the analyses reveal that KBI have intensive and diverse forward linkages than backward linkages with other industries. Thus, in the region, 35% of overall purchases and 56% of overall sales of KBI are with other industries non-KBI. This means that more than half of Catalonian industries are dependent on KBI production. This behaviour is not identical for all KBI. Thus, business services, real estate, finance, and IT are the KBI with the largest sales rates to non-KBI, whereas business services, high-tech manufacturing, real estate, and creative industries are the largest KBI'providers to non-KBI.

In short, Catalonian overall employment growth can be positively affected by KBI' employment dynamics, especially employment growth in industries highly related to them. Hence, from the urban growth perspective, it is also important to identify if functional dynamics boost spatial proximity of employment. In the next paragraph, these issues discussed.

4.3 The KBI' functional and spatial clustering dynamics

The distribution of each industry in the Proxscal MDS spaces should be interpreted in different ways. On the one hand, short distances in the Functional Proxscal space (F-Proxscal) suggest intense industrial relationships. Moreover, industries located close to the gravity centre (coordinates 0,0) means industries that have central values in the entire Catalonian economy, either because they enjoy high demand from other industries or because they are large suppliers to other industries. On the other hand, short distances in the Spatial Proxscal space (S-Proxscal) indicate

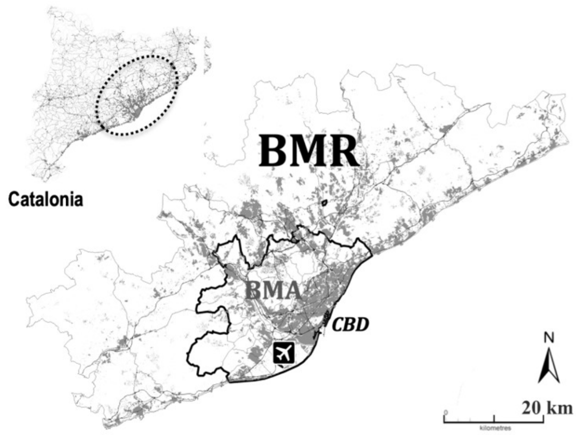

Figure 1. The BMR in the Catalonia region

Source: own elaboration

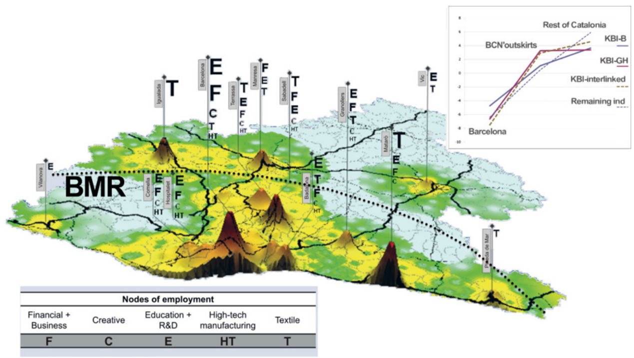

Figure 2. KBI' employment decentralization (1991-2001) at the BMR

Source: own elaboration with census data from INE.

proximity in the spatial clustering of employment. Furthermore, industries located close to the gravity centre (coordinates 0,0) means industries mainly located in the largest urban agglomerations of the region.

4.3.1. KBI's functional dynamics

Results of this analysis suggest that KBI are at the heart of economic relationships of the entire Catalan economy. Generally speaking, the distance of KBI to the F-Proxscal centre (core of economic inter-industry linkages) is 0.55 Proxscal units, while in the other industries it is 0.62 Proxscal units; therefore, it could be said that KBI are nearer the epicentre of economic relations than other industries are. However, KBI have heterogeneous functional relationships with other industries due to their varied consumption orientation. Hence, local business-orientated KBI-LB appear located closer (0.38 Proxscal units) to the economic epicentre of the Catalonian economy than other KBI types, which reveals that those KBI have the most extensive functional interlinkages with other industries. It is worth noting that all KBI-LB, finance, businesses, and IT services are closer to the epicentre of the F-Proxscal (0.12 Proxscal units). Moreover, export business-orientated KBI-ExB have low functional interlinkages with other industries; this is confirmed by their peripheral position in the F-Proxscal (0.72 Proxscal units from the centre). This fact could be interpreted as meaning that KBI-ExB demand inputs beyond the Catalonian industrial environment. Furthermore, government and household-orientated KBI-GH are found in an intermediate position between the remaining KBI types; these are 0.59 Proxscal units from the F-Proxscal centre. In that sense, the position of KBI-GH follows logical location patterns, since besides the BMR, other medium-size cities in Catalonia have a large demand for these industries. Furthermore, the analysis also reveals that KBI have more intensive functional interlinkages among themselves. In this sense, the average Proxscal distance between KBI is 0.63 Proxscal units, whereas between KBI and non-KBI it is 0.86 Proxscal units.

Figure 3 illustrates the position of all industries in the F-Proxscal, distinguishing KBI types according to the main consumption orientation; KBI' interlinked industries both KBI-iBLINK and KBI-iFLINK, and remaining industries. As mentioned above, mainly KBI-LB are at the centre of economic relationships in Catalonia, specifically, IT services (43), finance (44) and business services (51), which means that these KBI have the most intense functional dynamics at the whole Catalonian labour market. Together with those KBI are real estate (47) from KBI-GH group. In contrast, KBI-ExB that include high-tech manufacturing (24, 26 and 27) as well as KBI-LB computer services (49) and R&D (50), and KBI' interlinked industry manufacturing of electrical equipment (25) have peripheral positions in the F-Proxcal. This fact suggests the existence of specialized functional linkages among all these industries and few economic interlinkages with other industries in the region.

In short, the centrality of KBI in the Catalonian economic structure is an indicator of its transition from a manufacturing-based economy towards a service-based economy, especially in KBI. As a result, the Shannon's diversity index,[3] which is used here to measure the complexity level of functional interlinkages between all industries, reveals that KBI have larger diversity values in interindustry linkages (2.64) than remaining industries (2.36) are at the region. Furthermore, when isolating KBI, the diversity index of KBI interindustry linkages is larger for their sales (2.94) than for their purchases (2.34), which highlights the role of KBI in other industries' demand, specially of those local business-orientated KBI-LB.

The centrality of KBI' employment is also spatial. This is revealed by the central position of KBI in the S-Proxscal, which means that KBI' employment tends to be clustered in the largest Catalonian cities (Figure 4). Globally, the distance of KBI employment from the S-Proxscal centre (co-

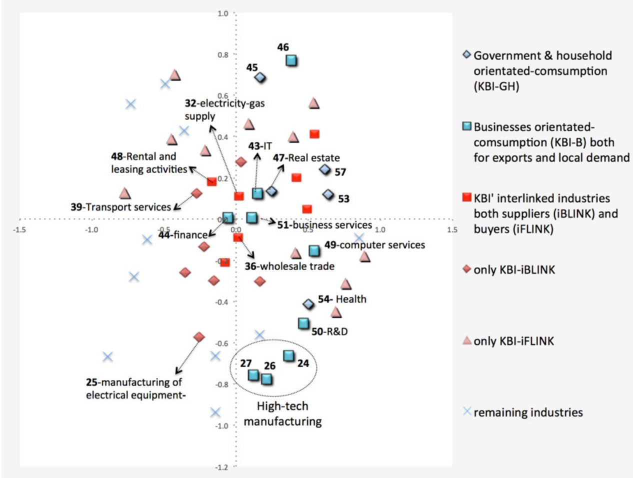

Figure 3. KBI' Functional Proxscal

Source: own elaboration

ordinates 0,0), which corresponds to the regional core of employment agglomeration in Catalonia, that is the BMR, is 0.40 Proxscal units; meanwhile the remaining industries are from 0.65 Proxscal units. Of all KBI, export business-orientated KBI-ExB have the shortest distances to the S-Proxscal centre (0.31 Proxscal units), which means highly clustered employment in these industries, specially at the BMR. This fact underlines the significant values found in the BMR for location of KBI' employment such as the international airport, the trade port, and fast train connections as well as amenities, large pools of skilled workers and innovativeness. Other local businesses-orientated KBI-LB and government and household-orientated KBI-GH are in intermediate positions of the S-Proxscal, but close to its centre, they are from 0.39 and 0.48 Proxscal units, respectively. As it was mentioned above, in Catalonia unlike what happens with the overall industries' employment, KBI' employment shows an inertial tendency to be located close to the metropolitan core following urban location patterns. More specifically, the analysis of the position of each industry in the S-Proxscal reveals that business-orientated KBI-B such as the manufacturing of electronics (26), computer services (49), IT services (43), and R&D (50) tend to be located close to the epicentre of S-Proxscal, that is in the BMR. In addition, some KBI' interlinked industries such as printing and the reproduction of recorded media (16), warehousing and transport support activities (42) and air transport (41) also have central clustering patterns. Therefore, it could be said that business-orientated KBI-B are physically closer to overall industries' employment than the other KBI are, this is revealed by their central spatial patterns in the

3 The diversity index of Shannon is calculated as follows:

$$H_y = -1 * \sum_{x=1}^{59} P_{xy} * Ln(P_{xy})$$

H is the diversity of functional interlinkages of industry y with the rest of industries; and Pxy is the probability of consumption that makes the industry x from y. In this case, the highest diversity index's values mean high diversity patterns in functional interlinkages.

S-Proxscal.

Furthermore, analysis also reveals that KBI' employment tends to be located spatially closer among themselves (0.42 Proxscal units) than remaining industries are (0.89 Proxscal units).

Finally, the comparison of the average distances of all industries in both functional and spatial Proxscal spaces is made. In this analysis, low values in both F-Proxscal space reveal intense functional dynamics, and in S-Proxscal space reveal close spatial clustering of employment. In Figure 5, the average distance of F-Proxscal of all the KBI is 0.63 F-Proxscal units, which suggests intense interlinkages among them, but it seems this does not encourage spatial proximity clustering, since the average distance of S-Proxscal is 0.42 S-Proxscal units. This is due to while government and household-orientated KBI-GH follow population patterns distribution, meanwhile business-orientated KBI-B have special attraction for central locations where network and agglomeration economies are located. Furthermore, the average distances of both functional and spatial Proxscal spaces between KBI and remaining industries' employment are the highest at the whole Catalonian economy, which means poor economic interlinkages and weak clustering patterns among them.

However, a more profound analysis of correlation in position of each industry in both Proxscal spaces could offer more evidence to understand the main issues of the research question of this paper, that is how KBI spatial clustering encourages functional interrelations within them, and conversely, how functional dynamics encourage spatial clustering of those and other interlinked industries. In the next paragraph, this issue is discussed.

4.4 Correlation between Spatial Clustering and Functional Dynamics of KBI

Correlation of the coordinates (x, y) of the two Proxscal matrices using the Pearson correlation index[4] is done. The results reveal a poor correlation *r=0.21* for all industries. However, if only the spatial and functional coordinates of KBI are correlated, this value slightly increases to *r=0.23*. Yet, as has been argued, KBI' employment has a high level of heterogeneity; hence if only business-orientated KB-BI, both local and export-orientated consumption are considered, the correlation between both matrices increases significantly up to *r=0.51*. However, the correlation indexes between the Proxscal matrices of KBI and their interlinked industries reveal a low correlation *r=0.07* for supplier industries and *r=0.32* for buyer industries. In that sense, it could be said that the increasing correlations between KBI' Proxscal matrices seem to confirm the idea about the importance of physical proximity in KBI' employment spatial clustering. Moreover, KBI' input-output relationships with other industries do not appear to be a determining factor for a closer spatial clustering among these industries. Some arguments in this regard are as follows:

- Local business-orientated KBI-LB are strongly linked to whole regional industrial environments; therefore, they have more central patterns in their functional dynamics than in the spatial employment clustering.
- Export business-orientated KBI-ExB show peripheral patterns in both F-Proxscal and S-Proxscal. This is due to the fact these KBI also have long-range interactions at the regional market.
- Government and household-orientated KBI-GH show intermediate patterns between the other KBI groups.It is worth noting that spatial clustering of these is the result of public policies and demographic distributions.

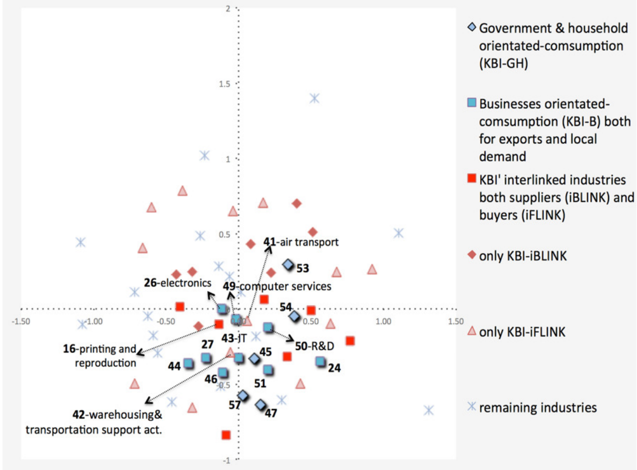

Figure 4. KBI' Spatial Proxscal

Source: own elaboration

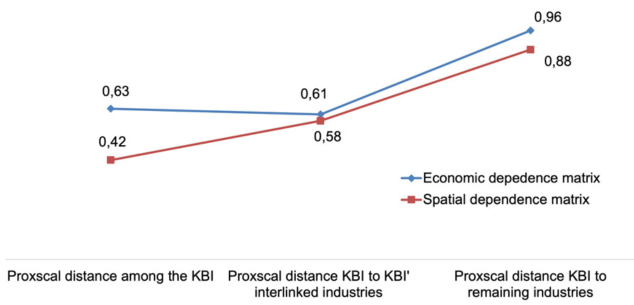

Figure 5. Proxscal distances

Source: own elaboration

4 The Pearson index is a measure of linear correlation between two data sets. It has a value between -1 and 1. The sign of the index means positive or negative correlation.

5. Conclusions

There is a certain consensus in the related literature about the role of knowledge spillovers as well as of social and human capital in spatial clustering of KBI' employment. Face-to-face contacts, which emphasize the importance of physical proximity to develop processes of interpersonal trust for knowledge and innovation production, and network economies derived from externalities created by long-distance interactions between innovative players, emerge as decisive mechanisms for KBI' employment growth. Furthermore, Hirschman's concept about industrial interlinkages both backward and forward states that these links have spatial effects on firms' location.

This paper offers empirical evidence from Catalonia, where Barcelona Metropolitan Region (BMR) is the largest urban agglomeration, of functional dynamics' effects of the knowledge-based industries (KBI) both business-orientated KBI-B and government and household-orientated KBI-GH on spatial clustering of those and other interlinked industries. Complementary, this paper presents a solid data-driven approach, contributing by this way to discussions about implications of data in quantitative urban analyses. In that sense, an innovative approach to the Multidimensional Scale Analysis is made. In this paper, this technique is used in order to relate an economic dependency matrix, which explains the relationship between all the economic sectors including the KBI, with a spatial dependency matrix, which shows the relative geographic distances that exist between employment locations of KBI and remaining industries in Catalonia.

Results reveal that KBI, especially those business-orientated, have large functional interlinkages with each other and tend to be clustered close together, especially in metropolitan Barcelona. In fact, KBI' employment decentralization processes reveal a distinctly inertial tendency to move to the Barcelona's outskirts. This fact confirms the importance of face-to-face contacts that central areas promote, even for temporary spatial proximity, as well as economic diversity, and accessibility to a wide range of network externalities found in those areas as transport infrastructures and fast internet connections. Furthermore, expectations regarding the spatial close dependence of those KBI' interlinked industries with KBI are no clear. It means that input and output relationships of KBI do not require of spatial proximity, and those functional linkages occur in large and diverse regional employment markets.

At length, the results of this study have important implications for urban planning policies. The results suggest that for many KBI, especially those business-orientated, encouraging land uses for diverse economic activities may be a more appropriate policy option at the regional level, since for KBI' firms it is not sufficient to be specialized, it is also important to be connected with similar and complementary industries. Furthermore, an informed policy regarding KBI' employment clustering in metropolitan areas needs to consider their preference for central and well-interconnected locations where both physical and virtual interactions are more affordable.

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More Phenomenology Less Visual: A Haptic Narrative and a Proposed Haptic 'Sensemarks' Database of Istiklal Street, Istanbul

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Keywords: phenomenology, haptic, haptic sensory experiences, haptic sensory database, istiklal street

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Over the years, Istanbul's urban places have changed gradually. Istanbul has gone through neoliberal goals and globalisation-based problems, and all of them improved and altered the urban faces in the city. Istiklal Street, a pedestrian way of Istanbul, has had distinctive qualifications that made it specific among the other places over the years. However, the transformation since the 1990s created dramatic physical changes in Istiklal Street. Meantime, some different variables impressed the intangible character of the area effectively besides the physical notions. Significantly, the haptic attributions of the Street have been influenced remarkably, and this motivated us to regard the haptic dimensions of the place. This research mainly asked how Istiklal Street's haptic characteristics come today. The haptic character of Istiklal Street has been issued to promote the distinctive haptic affordances of the urban places. The discussion here told us a haptic re-exploration was necessary to understand the Street's transformed sensory characteristics. The findings showed us that unique haptic characteristics of the Street are still visible. However, some new facades of the buildings have negatively influenced the authentic haptic characteristics of the Street. The study underlined that urban policies and practices need to consider the urban areas' texture, material, and graphic characteristics more efficiently and in new ways.

In this paper, to make the Street's haptic intangible assessments visible and archivable, the possibility of designing a digital and online database was also discussed. The Street's haptic data would be promoted through this sustainable database. The Street's haptic dimensions would open new perspectives in design, architecture, and urban intangible heritage studies. The haptic data of Istiklal Street would provide us with significant affordances to see haptic-based conceptions of the area.

1. Phenomenology of the Haptic Modes of the Place

It is clear; an urban place is more than vision, and a phenomenological understanding needs attention to its intangible sensory dimensions beyond the visual. Haptic is the sense that is closely related to our ability to catch what our surrounding says. The haptic characteristics are the most trustful filtering and enhancing mechanism to understand the place's haptic modes. We know the discussions on the sensory properties of urban places are increasingly being considered. As the sensory experience should be understood as an embodied thinking (Pallasmaa, 2009), we may not comprehend our surroundings without sensory examinations. We know Istiklal Street has embodied highly problematic spatial situations; for years, the Street's tangible and intangible accumulations suffered. The valuable sensory features related to its multicultural past, historical architectural elements, and cultural heritage components penetrated somehow. Many distinctive sensory modes have got risks losing their diversity; they started to be standardised. Nevertheless, some critical sensory elements are still distinguishable on the Street. Istiklal Street's sensory characteristics would be a multi-sensory body practice based on the perception and cognisance of the environment's sensory modes.

The haptic sensations play a vital if often overlooked, role in examining human and world interrelations. The streets are the key laboratories to search for haptic sensory experiences. Therefore, the haptic sensory experiences of the streets are crucial and worth being examined. A place is the product of complex processes; the experiential relationship between the place and user cannot be reduced to one-dimensional and visual examination. Phenomenology

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says a place is multi-sensorial. For the French phenomenologist Merleau-Ponty, our body opens a world to us to approach things and people, so our body is our anchorage in a world (Merleau-Ponty, 2002, p. 167). Merleau-Ponty defines the role of the body as the origin of the experience of place. According to him, we comprehend the world, things, and others through our body (Merleau-Ponty, 2002, p. 182-185). For the notion of Merleau-Ponty, the body inhabits a place (Merleau-Ponty, 2002, p. 172-175); by occupying a place, we capture the place, which based on our bodily experience (Merleau-Ponty, 2002, p. 230-233). He says, *"we are in the world through our body, and in so far as we perceive the world with our body"* (Merleau-Ponty, 2002, p. 239). As we come to the 'haptic experience', the matters related to the haptic sensations issued in the literature; hapticity is considered synonymous with tactile sensations. It may refer primarily to the experience of touching the body. Haptic experience, moreover, provides information about an object's surface, its consistency, and form. Accordingly, the urban places' tactile experience refers to the potential of bodily relations within the environment (Diaconu, 2011). Unlike other senses, haptics enables us to modify and manipulate the world around us (Mclaughlin et al., 2002). We cannot change our environment through hearing, seeing, smelling, or tasting, but we can do it through haptic body movements. Haptic perception involves connections between movement and touch (Millar, 2005), and this strong interaction reveals the importance of touch for experiencing the built environment (Herssens & Heylighen, 2012). Therefore, haptic perception goes far beyond visual-spatial perception and refers to a more complicated experience; it involves integrating many senses, such as touch, positional awareness, balance, and movement (O'Neill, 2006). Touching is the only sense that deals with the three-dimensional world as we experience it (Trejo, 2011); the haptic sense incorporates pressure, temperature, pain, and kinesthetic sensations. The haptic sensation is unlike any other sensory experiences as it may have the ability to alter the environment whilst perceiving it; this is not feasible in other senses such as hearing, seeing, smelling or tasting (Herssens & Heylighen, 2008; Vasilikou, 2016). The haptic system consists of the complex intermingling of subsystems with no specific 'sense organ'; this cooperation turns the whole body into an active organ of perception (Dischinger, 2000). Through the sense of touch, we sense the shape of an object or place and its materiality, weight, resistance, temperature, and lack of it; we may not explore a site efficiently. All the senses are said to be extensions of the haptic sensations; for example, "sight detached from touch could not have any idea of distance, outness or profundity, nor consequently of space or body" (Pallasmaa, 2005). Imagining our surroundings is not possible without ever having felt the texture. Therefore, an urban place could be decoded well by haptic sensations as subscribed (Pallasmaa, 2005, p. 143). Contrary to the hegemony of visual understanding of urban areas, haptic experiences' importance is essential. This research's approach flows the idea that an urban place originates from visual and non-visual sensory experiences, and they combine the sensory character and distinctiveness of the site. Although the haptic approach has been still in its infancy, it can open a wide range of intimate understandings of the place.

2. The Changing Hapticity of Istiklal Street, Istanbul that Codes the Place

Istiklal Street has been probably the most popular and exciting part of Istanbul with its shops, restaurants, bars, museums, and bookshops. The area characterised by richness and profundity in terms of its history and cultural background (Ertep, 2009). We know the future of urban space based on its self-dynamism, but the latest actions have distorted some intimate hapticity levels in the area. As we know, people experience and judge places following how they sense. There is a mutual and inseparable relationship between sensory qualities and experiencing a place because a human body is a sensory organism and draws advantage from sensory attributes in the experiencing processing of urban areas. Therefore, seeing the haptic experience's mediations would give us a new understanding of the place's sensory characteristics. Istiklal Street is a crucial place for urban sensations in Istanbul; thus, it is a contested concept and summons different images and connotations for different audiences. It is also a paradigmatic place to see how the links between the inhabitants and place established, shaped, and reproduced. The Street witnessed the alterations of the socio-cultural structure, economic and political movements, law regulations, innovative transportation, and communication activities in Istanbul. The process resulted in a controversial modification of the distinctive sensory characteristics of the Street.

After the 1990s, many buildings restored, moved, converted, closed, and demolished. Many of them have been significant elements in terms of the qualitative value of Istiklal Street. The concretisation of the Taksim square, and the construction of the Demirören Shopping Mall, the apparent disregard of public interest in projects such as Narmanlı Han, the clearing out of the Cercle d'Orient building and demolition of the Emek Movie Theater, the forced relocation of İnci Patisserie and Robinson Crusoe bookstore, the closure of Rebul Pharmacy along with the evacuation of century-old second-hand bookseller Librairie de Péra located in Tünel square, of Kelebek corset shop and Rumeli arcade, the closing down of the City Theater, Muammer Karaca Cultural Center, and cinemas such as Alkazar, Emek and Sinepop became the most prominent markers of the transformation taking place. It has been Istiklal Street that ended up negatively influenced by all of this. In the immediate aftermath of the Gezi Protests in 2013, the Street could not retain its liveliness, and the 2016 coup attempt decreased tourists' flow to Istiklal Street. The policies expedited tenants' eviction combined with regulations on outdoor tables and chairs for restaurants and cafes. They caused young and upper-middle classes hanging out in Beyoğlu to shift towards Beşiktaş and Kadıköy instead. The further desertion of places on Istiklal Street resulted in the closure of many places that had become emblematic of the neighbourhood. This process brought about the Street's unique, hybrid constitution's rapid disintegration. The pictures from the good days on the Street dwindled. Istiklal Street has continued to be the only address despite this destruction of its identity and accumulated sensory experiences. A large segment of the society has criticised the changes in the area, unavoidably local voices raised. Except for the field of academic talks, an enormous amount of discourses in social media showed that the multi-layered socio-cultural and architectural structure of Istiklal Street has been changing controversially (Adanalı, 2011a, 2011b; Güney, 2015; Tekin & Akgün Gültekin, 2017). We know nothing more certain than change helps ensure the continued viability of every human-made and natural system. In urban environments, the changes are seen as the lifeblood of economic, social, and political systems that underpin the built fabric that accommodates and facilitates activity, but how about the Street's intimate haptic modes?

This research stressed that the experiences of people in the Street are more than visual experiences. The urban perception is not only understood through the eyes; it is experienced through all the senses of our body as we move through the place and actively interact with it (Pallasmaa, 2005). The predominant sensory informant seems like the visual modality, but this approach may threaten the multi-sensory nature of the human-places interaction. Because the eye's dominating role gradually separates us from a sense of the world, we become spectators on a just visual journey (Theart, 2010). Although visual perception is the primary way of understanding urban places' experiences, the haptic sensations influence the experience and understand authentic and intimate relationships with the Street. This Street, as a composition comprising impressions from different sensory spheres that continuously overlap and complement each other. So, it can only be perceived as a dynamic multi-dimensional holistic, multi-sensorial medium. The Street's haptic senses mediate our interactions within the urban context through the body in a multi-sensorial way (Degen, 2010). The process of sensing the place goes beyond the visual impressions. Istiklal Street's sensory dimensions comprised many multi-sensory features, but hapticity has been the most critical element to shape the area's distinctiveness. The site was filled with late Ottoman-era buildings, mainly from the 19th and early 20th centuries; the buildings have had distinctive architectural styles; therefore, the Street has a recognisable haptic characteristic.

As the haptic transformers, the area witnessed a challenging process since the 1990s that directly influenced Istiklal Street's haptic appearance and sensations. The Street's haptic characteristics are mainly structured by historically and politically significant buildings such as churches, synagogues, mosques, and academic institutions and consulates by various nations. In terms of the haptic experiences of people, the Street has been converted into a new shaped hub. There have been many reseasons. The changes in the area forced the identical shops to leave the Street. While the most distinctive facades have gone on the Street, such as Kelebek Corset Shop and Inci Patisserie, the restored or renovated buildings' facades remarkably transformed the textures haptic characteristics of the area. Many veteran theatres turned into hotels; some important bookstores have abandoned the Street. The exterior design of the buildings followed the new functions of the buildings. Unavoidably new facades of the buildings have risked the area's haptic characteristics; as Tuan says, "touch is the sense least susceptible to deception and hence the one in which we tend to put the most trust" (Tuan, 1993, p. 45). We know Istiklal Street has hosted many passages with various characteristics; these passages have offered different social frequencies and configurations in terms of the usage patterns; specifically, the arcades about the main Street have attracted the users of the place. The strong immediate link between the body and the built environment that the haptic sensations of the place (Vasilikou, 2016) damaged in the area. The Street's haptic characteristic has been normally compiled by the hanging stuff such as dresses, huts, and paintings to get the pedestrians' attention. However, the latest interferences have changed Istiklal's passages' authentic characteristics as they converted into the service places of shop stores and hotels. Istiklal Street afforded many local and tourists opportunities to see the street arts; the inhabitants and shop owners have been very tolerant of artists. In some case, cafes have preferred drawings as a background for their outdoor seating areas. People could share their feelings, their anger, their love and their beliefs with people through the walls' surfaces on the area. So, many graffiti works on the walls as one important part of the Street's texture. The colourful surprises of artworks and images awaited pedestrians on the old walls. They accompanied people as they walked along; this had made it hard to imagine the walls without it. However, the latest renovation process created pure surfaces without any sign of artworks. As the haptic experiences form an intimate sense that conveys messages of the built environments, the newly renovated and restored surfaces could not tell us the buildings' story. As one of the other issues on the haptic characteristics of the area, we need to mention that traffic has been taken down as a part of the region's urban renewal project at the beginning of Istiklal Street in 2013. In 2014, the iconic Taksim Square transformed into a pedestrian area, and the entire area paved by mostly concrete and granite materials. We witnessed the haptic engagements with new objects on the Street allowed us to have less emotionally resonant experiences of our environment. Also, the Street's floor renovated and revamped in 2017, but a green plastic material has been laid on the ground beneath the tram. We are aware that various properties such as "smooth or rough, firm, or soft, matt or reflective, or absorbent, etc." may provide an affordance to identify the place's haptic qualities (Thibaud, 2011). However, the new outlook of the street flooring has not received positive feedback. In the area, globalisation has negatively affected the Street's haptic features; the Street has started to serve the advertisement concepts. Nearly every corner or even on the top of stores designed as branding places such as huge billboards to attract people to shopping. Due to new regulations, nearly all the signboards of stores on the Street started to look nearly similar. All of them resulted in the situation that the local ones have left their facade coverings and signboards. While the colours, forms, and textures have started to be similar, the Street's haptic qualities damaged by the non-specific and non-identifiable features. Our haptic perceptions embrace the sensory interrelations of our eyes, ears, and limbs. It extends our embodied spatial perception, which is simultaneously conducted by our vision, hearing and touch. Therefore, haptic qualities may reflect off the Street's weight, density, temperature qualities. As the Street's haptic features altered following the renovations and marketing actions, we see nearly all haptic components from the facades to the iconic tramway changed somehow. The planning approach is not considered the local and non-local people's preferences, the cosmopolite structure, and the intangible elements damaged with the Street's distinctive haptic composition.

3. The Losing Intimacy in the Street's Haptic Characteristics

This research followed the idea that the intimate role of the haptic sense between the user and place is an undeniable phenomenological fact that deserves to look at as much as possible. It is crucially worthwhile to see the place with a perspective that would be more phenomenology, less visual. The outputs tell us the Street's old and historical buildings have got distinctive outlook and haptic traits. The surface characteristics of the building facades on the area have been eroded and neglected. The annoying presence of the construction stuff above the buildings' faces notably expanded. This situation has related to the wrong implementations of the renovation or restoration procedures in the area. The effects of globalisation-oriented urbanisation have been dangerously visible in the Street's haptic identity. The historical buildings are the essential agents of the Street's haptic presentation. Istiklal Street's haptic features showed us our haptic bodily choices on the environment's texture, material, and graphic sides. The overall result could say the construction works visibly expanded on the area; also, several neglected and damaged pieces of buildings' facades. The lovely Street art examples have gone somehow, whereas the artworks on the walls have been a part of the pedestrian's walking tour on the Street. The outdoor advertisements and big posters started to dominate the facades' representation of the area. However, the unique haptic characteristics -which belong to the Street's old and historic buildings- are still distinguishable among other haptic elements of the Street. The unique facades and texture, material, graphic characteristics of the Street need to be considered more efficient policies and practices.

Exploring Istiklal Street through the haptic experiences has been a way of attending to distinctive sensory features of a place and making an explicit connection with it, communicating with the area in which we live. The Street's hapticity- that we perceive- has spread information about our surroundings back to us. We have known this Street through our haptic perception; our senses have played an essential part in this process. Istiklal Street's urban environment shaped by many elements influencing each other is a heterogeneous system characterised by a mix of multi-sensory features. Hence, a haptic sensation is a perceptive apparatus naturally intertwined with the surroundings (Signorelli, 2015). We continually expose ourselves to the imposition of haptic sensory-scapes that are intertwined and perceived simultaneously; that is why the changing intimate role of hapticity in the area creates many debates.

4. The Proposed Haptic 'Sensemarks' Database of Istiklal Street and its Possible Contributions

Here, we offered to develop a future proposal to turn Istiklal Street's haptic findings into a more sustainable version. This database would be open to the contributions of the users of the Street. The Street's users may upload their individual identified haptic Street's Sensemarks to this database after visiting the area. They may share their haptic sensory experiences on the Street, which they would have previously recorded using technological recording devices. This digital and online database would be a sustainable, sensory qualities archive of Istiklal Street. So, Istiklal Street's haptic sensory experiences would be converted into a 'Sensemarks' archive. Istiklal Street's present and future haptic Sensemarks would be reachable, transferable, and sustainable through the Street's haptic sensory database.

We are aware that the non-visual-centric information about the users' sensory qualities would help overcome the lack of understanding about how people experience the places. The information -which would be gained through the proposed database- would mainly contribute to the knowledge of human and place interactions. We know all the outputs on 'how people sense and experience the place with their haptic sensory qualities' would be worthy in urban design studies, arts, architecture. This database would have a sensory perspective to discover the Street's haptic Sensemarks, so creating attention to Street's environments' haptic features would be possible. The design approaches of the Street's environments would be enriched. The database may create new motivation points on the decision-making processes of the Street. Accordingly, the new urban guidelines would be possible about the haptic sensory features of the Street. In the future, the policies may be improved through the achieved information on the Street's haptic environment.

The database's reflections may also affect the architects, designers, or policymakers; they may benefit from this data on the Street's haptic sensory features. The urban places' haptic features' data would be productive to comprehend new design probabilities, principles, or conceptions. The detections would contribute to the knowledge of architecture, design, sensory urbanism, and heritage studies.

5. As a Conclusion

We know how 'how people sense and experience the urban places' is crucial for urban ethnography, urban anthropology, and urban sociology besides urban studies and architecture disciplines. The haptic sides of the urban area have a crucial position in examining human and world interrelations. In our everyday life, different sensory compositions are integral parts of our environments. Therefore, employing a haptic based approach to study the urban environments we interact with (Pallasmaa, 2005) would be necessary and worthy. Istiklal Street is an important place for Istanbul's history, tangible and intangible heritage, cultural memory, social and community life. Istiklal Street's matters touch the fields of architecture, urban sensory studies, and intangible heritage studies.

The haptic experience should be understood as an embodied thinking (Pallasmaa, 2009, p. 107). We may not imagine our surroundings without ever having felt the texture of wood, the temperature of steel, the sharpness of a corner, the verticality of a wall, or without ever having moved on a ramp (Herssens & Heylighen, 2008). Istiklal Street's haptic characteristics could be read as an extension of our multi-sensory body practices that filter and enhance the environment's haptic modes. We know the area has embodied highly problematic spatial situations. For years, the haptic accumulations of the Street suffered. The valuable haptic features -that link the area to its multicultural past, historic architectural and cultural heritage elements -penetrated in some ways. Many haptic modes have got risks losing their diversity; they started to be homogenised. However, the essential haptic elements are still distinguishable on the Street. Therefore, it may be integrated carefully with the further design applications; the policies and practices may consider the Street's texture, material, and graphic characteristics in more efficient ways. This kind of narratives would create a short - circuit between our perception of vision and sense of touch to support the haptic modes and probabilities on the Street.

The proposed database about Istiklal Street would be worthwhile in terms of many points. Firstly, this database would make public the users' haptic experiences of the Street. The sustainable and archivable data on the Street's haptic features would create new points on the place's haptic characteristics. The new discussion would be possible in architecture, urban design, and intangible heritage about the urban places' haptic sensory experiences' data.

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So Similar, So Different: Diving in the Physical and Acoustic Features of Two theatres. A Case Study

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The study of the acoustic conditions of Concert Halls, Theatres, and Opera House offers the possibility of understanding better the behavior of those spaces. Many researchers

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have dealt with the physical and acoustic characteristics of landmark venues that host live performances, but many of them still need to be characterized and studied.
The present work aims to perform a comparative analysis of two theatres. We have chosen two theatres with similar characteristics except one, the volume of the main hall in this case: the Olympia Theatre and the Talia Theatre, both located in the city of Valencia (Spain). We want to get deeper into the factors that influence how a certain space sounds. More specifically, the ratios between stage area and audience area.
We have collected geometrical data of both spaces, such as room volume, fly-tower volume, audience surface, stage surface, stage opening surface area, acoustical surface area, etc.; and material and architectural detail data to determine the absorption coefficient of the different surfaces of the space. Moreover, we will conduct acoustical measurements surveys in both theaters.
To summarize, we will work in a three-axis strategy: geometric, acoustic absorption and onsite analytic data, to evaluate the influence of the different parameters in the acoustic behavior of the room and the relationships between them.

1. Introduction

Acoustics started to be studied as a science at the beginning of the 20th century (Beranek, 1992). Before that date, the design of acoustic spaces was based on a combination of trial and error and copying the shape and proportions of other previous successful venues. The reverberation time was the first parameter used to analyze the acoustic of a space. The reverberation time depends on the shape and size of the enclosure, the materials used in the construction of the room, and the way they are built. Some designers of the time ignored the influence that the shape and the proportions of the room have. Because of that, they only paid attention to the reverberation time, which has proven to be insufficient for an adequate acoustic design. Between 1900 and 1950 the importance given to the shape of concert halls and theaters decayed. There are some design aspects, especially in proscenium theaters, that are often taken for granted despite their relevance in architectural acoustics. A tight design in longitudinal section with deep boxes keeps the room volume small, providing a low reverberation time and limiting the distance from the last row to the stage, which is desirable, both visually and acoustically (Barron & Foulkes, 1994).

This work is part of a broader investigation carried out in the Centro de Tecnologías Físicas, Universidad Politécnica de Valencia, Valencia, Spain. The research involves performing acoustic measurements in theaters and create acoustic models of them to study the behavior of the determined surfaces. Theaters located in the region of Valencia have been selected mainly due to the quality and number of available spaces, the proximity, and the operability (each measurement takes approximately between 3 and 4 hours).

The region of Valencia has a long musical tradition. Almost every city has at least one musical society, (there are more than 400 concert bands [Ruiz Monrabal, 1993]). It is common for these societies to have their own facilities or even a small auditorium. Sometimes, these spaces are proper musical auditoriums, but usually, they are multi-functional spaces in which it is possible to host other activities related to scenic arts besides music.

In the late 70s, the city of Valencia suffered a decrease in the number of venues for theater exhibitions. That can be explained by a decrease in the public interest in those kinds of artistic representations, and by the rise of other media spaces such as cinemas. Because of that, some theaters were transformed into cinemas, others changed activity, and others were closed. Even so, the city of Valencia has more than a dozen theaters, of different importance. Some of those theaters built in the mid-nineteenth and early twentieth centuries are still functioning today. Some notable examples are the Principal, the Olympia, and the Talía. Some new venues have been built in the last decades, such as the Palau de la Música (music hall), the Palau de les Arts (opera house), and some smaller spaces such as La Rambleta (theater), the Catarroja Auditorium.

We have extensively measured and collected data from several theaters. Among them are three of the oldest and most important theaters that are still operative in the City of Valencia. Those theaters are the Principal Theater, the Olympia Theater, and the Talía Theater. All of them are roughly from the same period. The Principal Theater is the oldest and the largest of the three. The Olympia Theater and Talía Theater share most of their physical characteristics, dimensions, and materials. The main difference between them is the volume of the room. The reason why these theaters have been selected is the significance those venues have in terms of cultural heritage for the city of Valencia. It is also relevant to analyze how the acoustic parameters of those theaters differ and interlink depending on the characteristics mentioned in previous paragraphs.

Researchers presented in the past their criteria to evaluate or classify the quality of a venue (Arau-Puchades, 1999; Beranek, 2004; Knudsen, 1931). Since the main parameters we wanted to compare are related to the dimensions, the Beranek methodology can be considered the most adequate in this case. The Beranek methodology describes several parameters that allow displaying the data of each space in a very concise way that enable the comparison between the differences and similarities of the rooms under study.

The combination of differences and similarities usually leads to the obtention of relevant conclusions in terms of the architectural acoustic design.

The Olympia Theatre was designed by the architect Vicente Rodríguez Martín in 1915 (Fig. 1 and 2). It is located in a building block that also includes commercial spaces. Those commercial spaces and the Theatre itself are set on the ground floor and first floor. The apartments are placed on the upper floors. The composition of the building stands out from the rest because of its formal unity. Its style be-

Table 1. Materials used in Olympia Theater

Zone	Materials
General suspended ceiling	Reed with plaster
Amphitheatre suspended ceiling	Plasterboard on studs with mineral wool
Ceiling under balconies	Plaster
Decorative false skylight	Plumbed glass
Scene pavement	Wooden platform
General pavement	Tongue and groove wooden floorboards
1st floor pavement	Parquet on slab
Circulation spaces pavement (Stalls and GF balconies)	Carpet on wooden floor
Stairs	Marble
Walls (hollow sound)	Plasterboard with cavity
Walls (solid sound)	Plaster on solid ceramic brick
Fabric wall frames and balconies partitions	Fabric with absorbent
Moldings (balconies, stage opening, ceiling perimeter)	Decorative plaster
Access doors	Solid wood
Curtain	Drapes, heavy velour
Chairs	Empty chairs heavely upholstered

longs to what was called the International Decorative style (Colomer Sendra, 2002).

The auditorium has a long shape with a slight slope. It has two floors with balconies on both of them. The access to the ground floor balconies is located at each side of the room. The first floor is accessed through a central marble stair. The side corridors give access to the balconies and the regular seats. It is also worth mentioning that the building in which the Olympia Theater is set was one of the first buildings in Valencia to use metallic riveted structure and smelted columns. The walls that surround the theatre are made of solid ceramic brick. The floors, in general, are made of tongue and groove wooden floorboards. In the stalls, a carpet has been placed on the circulation spaces. Also, while the floor stage is arranged on a wooden structure, the first floor is set on a structural slab. The wall cladding is made with plaster, except for the entrance area on the ground floor, where there are several fabric wall frames, and on the back area of the first floor, which maintains the appearance of plaster but with a hollow wall solution. The suspended ceiling is made of reed with plaster, and the back of the room is equipped with an acoustically treated ceiling. The central area has a false skylight and metal structure, backlit. The ledge of the balconies and the perimeter of the ceiling are decorated with plaster moldings. The list of the materials used in the room can be seen in Table 1.

The Talía Theatre was designed by the architect Javier Goerlich Lleó in 1927 (Fig. 3 and 4). It belongs to the catholic charitable institution "Casa de los Obreros de San Vicente Ferrer (Herreras & Rodríguez, 2008) and it was originally connected to the building next to it: the offices of the “casa de los Obreros”. It has seats on the ground floor and first floor and three levels of balconies. The flooring is made of tongue and groove wooden floorboard on the stalls and stage, and it is covered by carpets on the first floor. The balconies have hydraulic tile flooring. The walls have plaster

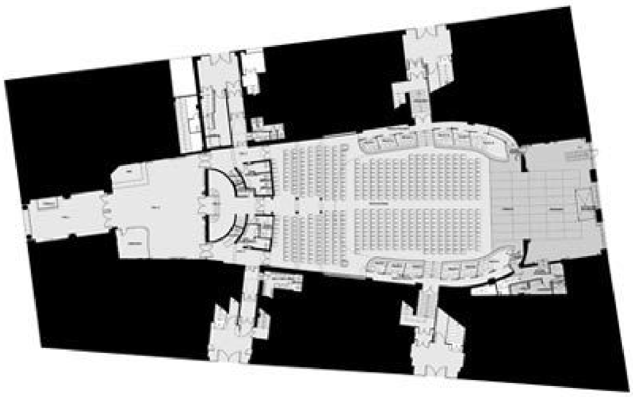

Figure 1. Olympia Theatre. Ground floor plan

Source: (Carlos Montesinos)

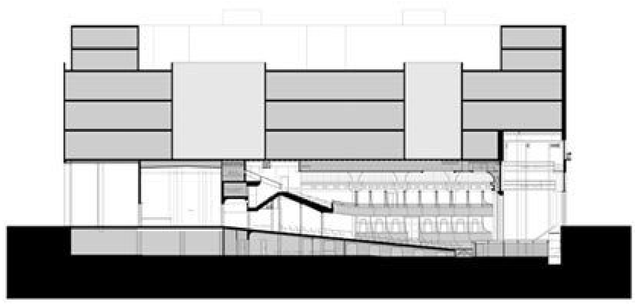

Figure 2. Olympia Theatre. Long section

Source: (Carlos Montesinos)

coatings in general, and near to the room entrance, plasterboard with an air chamber. The ceiling of the theater is made of plaster on fastening strips. The ledge of the bal-

Table 2. Materials used in Talía Theater

Zone	*Materials*
General suspended ceiling	Plasterboard on studs with mineral wool
Ceiling under balconies	Plaster
Decorative light	Small area glasses
Scene pavement	Wooden platform
Ground floor pavement	Tongue and groove wooden floorboards
1st and 2nd floor pavement	Hydraulic tile
Amphitheater pavement, circulation spaces GF	Carpet
Stairs	Marble
Walls (hollow sound)	Plasterboard with cavity
Walls (solid sound)	Plaster on solid ceramic brick
Moldings (balconies, stage opening, ceiling perimeter)	Decorative plaster
Balconies partitions	Partition with cavity
Access doors	Solid wood
Curtain	Drapes, heavy velour
Chairs	Empty chairs heavily upholstered

conies and the perimeter of the ceiling are decorated with plaster moldings, in a similar way as in the Olympia Theater. The list of the materials used in the Thalia theater can be seen in Table 2.

Both theaters were restored by the architect Carlos Montesinos. The Talía Theater was restored in 1995 and the Olympia Theater in 2000 (Fig. 5). The main goal of this paper is to study the influence that the characteristics that differ from one theatre to the other may have on the acoustic parameters of the room. To prevent the cross effect, the interaction of several parameters acting simultaneously, we chose a pair of theaters that share most of their characteristics.

2. Methods

The method chosen to develop the study consists in the experimental field measurement of the acoustic parameters. The main point of the acoustic measurement is to study the most relevant points of the venue with what is called impulse response. An impulse response is able to characterize linear time invariant systems. Any receiving point in the room can be understood as a linear time invariant system. This characterization done by emitting a sine-sweep inside the room, a kind of sound signal that covers all the audible frequency range and measuring how that sound is affected by the intrinsic characteristics of the space. After analyzing that sound, we can not only obtain all the acoustic parameters of the room, but also, we are able to compute the way in which any sound would react in that space. In this specific study, the rooms analyzed were measured using first an omnidirectional microphone and then a bidirectional one. This allows us to define how the sound would be perceived by the auditory system and the influence of the side walls on the localization of the sounds (Sakamoto et al., 2008). The impulse response was recorded in various positions on the audience plane (Figure 6). Additionally, the field measurements were done in two different room conditions, with the curtain open and with the curtain undrawn. By measuring the room in those two different conditions it is possible to better understand the influence of the proscenium, These experimental measurements were conducted in accordance with the ISO 3382 (*ISO 3382-1. Acoustics - Measurement of Room Acoustic Parameters - Part 1: Performance Spaces*, 2009). The sound source used is a Bruel & Kjaer omnidirectional source. The microphone used to record the acoustic signal is a Shore KSM44A condenser microphone.

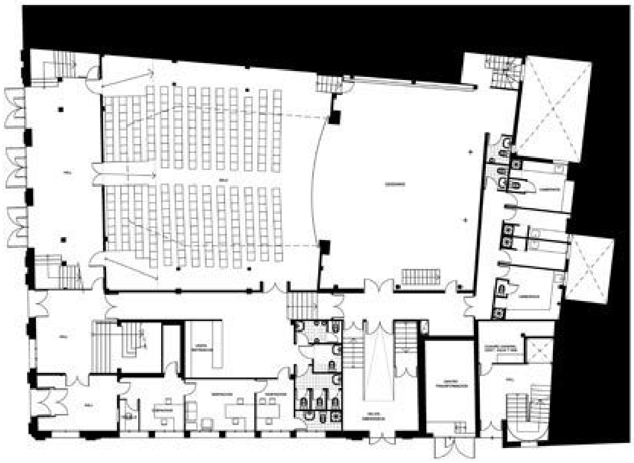

Figure 3. Talía Theater. Long section

Source: (Carlos Montesinos)

An analytic survey was performed on both halls to gather acoustic and geometric data. By visiting the venues, we have collected information about the building materials, specially those that affect the acoustic behavior, and how they have been built. Some onsite measurements were done

Table 3. Coordinates of the source and the receivers set in the Olympia Theater

	X	Y	Z
Source	-1,67	-0,25	2,31
Receiver 1	2,90	-0,13	1,05
Receiver 2	9,83	-0,12	1,73
Receiver 3	17,91	0,00	2,53
Receiver 4	24,33	0,05	3,16
Receiver 5	21,69	6,00	2,90
Receiver 6	9,54	-3,83	2,10
Receiver 7	6,47	-5,12	1,40
Receiver 8	20,31	0,14	6,95
Receiver 9	24,76	0,00	8,65
Receiver 10	25,37	-5,64	9,07
Receiver 11	9,89	-7,46	6,30
Receiver 12	5,83	-7,96	2,84

Table 4. Coordinates of the source and the receivers set in the Talía Theater

	X	Y	Z
Source	1	-0,32	2,51
Receiver 1	-2,63	0,12	1,21
Receiver 2	-9,88	0,72	1,52
Receiver 3	-11,90	3,50	1,60
Receiver 4	-6,51	4,97	1,37
Receiver 5	-2,83	4,92	1,22
Receiver 6	-4,74	-4,48	1,30
Receiver 7	-9,10	-3,71	1,48
Receiver 8	-14,34	0,52	5,13
Receiver 9	-13,46	-1,71	4,83
Receiver 10	-11,59	0,63	4,23
Receiver 11	-9,35	5,04	4,23
Receiver 12	-5,18	5,15	4,23
Receiver 13	-8,90	-3,95	4,23
Receiver 14	-4,29	-4,45	4,23
Receiver 15	-7,00	5,37	7,38
Receiver 16	-2,80	4,79	7,38
Receiver 17	-10,30	-3,62	7,22
Receiver 18	-7,06	-4,25	7,38

to complement the information collected prior to visiting the theaters.

The number of receivers set in each theater was conditioned by the configuration of each of the spaces: number of floors, the differentiation of spaces (stall, balconies, amphitheaters) and the lack of symmetry (due to that in the Talía Theater a larger number of receivers were set). The receiver points were distributed uniformly and non-symmetrical in relation to the room axis. Placing the measurement points in a non-symmetrical way is crucial to avoid the influence of eigenmodes. The source was placed in the center of the apron, which allowed us to maintain its position in the closed curtain measurement procedure.

To define the (x, y, z) coordinates of the source and receivers (Table 3 and Table 4), we have set the origin in the center of the apron at the lowest point, where it joins the stalls. The analysis was conducted without audience.

A series of acoustic parameters were obtained after computing the impulsive response, the early decay time EDT, the reverberation time RT30, the objective clarity C_{80}, the definition D_{50}, and the speech transmission index STI. These parameters are considered the most relevant when studying the acoustic behavior of theaters and music halls.

The Early Decay Time, EDT, is the time (in seconds) in which the first 10 dB fall of a decay curve multiplied by a factor of 6. The reverberation time of a room, RT30, is the time it takes for sound pressure level to decay by 30 dB multiplied by 2. In unoccupied halls, the EDT is also a way of measuring the reverberation time (Long, 2005). The EDT gives a more accurate representation of the subjective impression of the reverberation time than the RT30. The lower the EDT is compared to the RT30, the more intelligible the spoken voice is in that space (Arau-Puchades, 1999).

The Clarity of a room (C_{80}) describes the relationship between early sound reflections and late sound reflections. In general, it is inversely proportional to the reverberation time (Beranek, 2004). A room would have a clear and precise sound when the clarity values are high. The Definition (D_{50}) is the ratio of the early received sound energy to the total received energy. It is directly proportional to the Clarity. Both parameters are related to intelligibility.

The reverberation time in mid-frequencies (RT_{mid}) is the average value of the RT30 at 500Hz and 1000Hz. The recommended RT_{mid} for venues in which intelligibility is an important factor is between 1,2s to 1,5s, assuming the presence of an audience. Those values would differ with an empty room. (Carrión Isbert, 1998).

The Speech Transmission Index (STI) is an indicator of the intelligibility of a room. An STI between 0,50 and 0,64 would be considered adequate (Carrión Isbert, 1998).

Besides the already mentioned parameters, some other characteristics of the theaters were accounted for to complete the analysis. Those characteristics are the number of seats N, the volume of the room V_R, the volume of the fly-tower V_F, the acoustical audience area S_A, the proscenium curtain area S_P, the acoustical absorbent area S_T (which is the sum of the prior two and refers to the amount of absorbent surface of the enclosure), the surface of the stage SS, the average height of the theater H, the average width of the space W, the average length of the room L, and the distance from the front of the stage to the most distant listener D.

The ratio between some relevant parameters was assessed to compare the influence of the architectural characteristics in both theaters. In the case of the volume of the room, it is interesting to take into account its ratio with the acoustical absorbent area (V_R/S_T), the volume of the fly-tower (V_R/V_F), and the number of seats (V_R/N). In addition, the ratios between average height, width, and length have been calculated, H/W, L/W.

As mentioned in previous sections, the materials, the absorption coefficient of the enclosure surfaces, and almost every physical characteristic except volume are very similar in both cases. Therefore, the differences in acoustic behavior between the rooms seem to be due to the volume of each venue.

3. Results

The results obtained after processing the data acquired during the field measurements can be seen in Table 5. As it was mentioned in previous sections, the measurements were conducted both with the curtain opened and undrawn.

The correlation between EDT and RT30 (Table 5) is an indicator of the intelligibility of speech. The percentual difference between the EDT and the RT30 at mid frequencies in the Olympia Theater is about 11%. In the case of the Talía Theater, it is above 14%. These values do not differ very much between them, which indicates a good level of intelligibility.

As can be observed in Table 5, the Olympia Theatre has higher values of C_{80} and D_{50}, which indicates a greater level of intelligibility and clarity than Talía Theater.

Given that the theaters were measured without the pres-

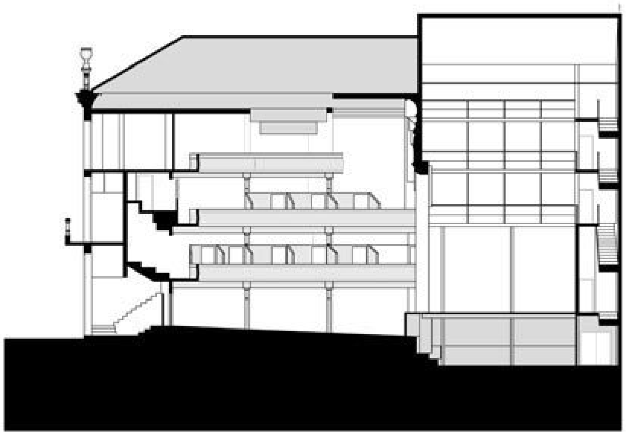

Figure 4. Talía Theater. Long section

Source: (Carlos Montesinos)

Figure 5. Olympia Theater (left) and Talía Theater (right)

Source: Author

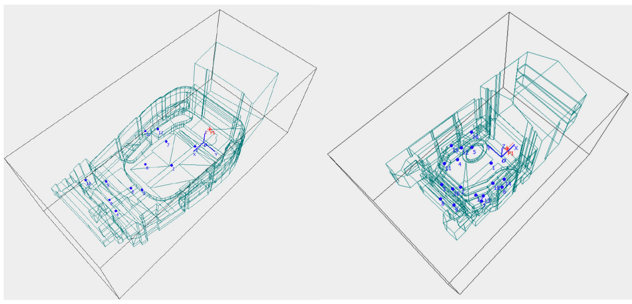

Figure 6. Situation of the microphones in the Olympia Theater (left) and the Talía Theater (right)

Table 5. Measured objective attributes: EDT, RT30, C_{80} and D_{50} of Olympia Theater and Talía Theater with opened and undrawn curtain

Acoustic parameters*	Theater	Stage Opening	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
EDT(s)	Olympia	Undrawn	0,895	0,814	0,937	0,936	0,937	0,844
		Opened	0,914	0,768	0,908	0,933	0,882	0,789
	Talía	Undrawn	1,453	1,409	1,279	1,173	1,079	0,911
		Opened	1,359	1,26	1,225	1,141	1,028	0,859
RT30(s)	Olympia	Undrawn	1,031	0,977	1,056	1,069	1,017	0,928
		Opened	1,014	0,957	1,017	1,057	1,006	0,911
	Talía	Undrawn	1,596	1,528	1,458	1,375	1,273	1,064
		Opened	1,579	1,49	1,437	1,345	1,258	1,055
C_{80}(dB)	Olympia	Undrawn	2,13	4,93	4,35	4,24	4,71	5,35
		Opened	2,93	5,32	4,48	4,69	5,25	6,04
	Talía	Undrawn	1,22	2,01	2,83	2,76	3,71	5,11
		Opened	1,64	2,88	3,14	3,41	4,32	5,77
D_{50}	Olympia	Undrawn	0,39	0,55	0,56	0,56	0,59	0,61
		Opened	0,41	0,54	0,56	0,58	0,63	0,66
	Talía	Undrawn	0,39	0,46	0,50	0,5	0,55	0,62
		Opened	0,40	0,51	0,51	0,54	0,58	0,65

*Early Decay Time, Reverberation Time, Clarity, Definition

Table 6. Mid-frequency reverberation time, RT_{mid}; Mid-frequency Early Decay Time, EDT_{mid}, and EDT_{mid} – Rt_{mid} ratio, of Olympia Theater and Talía Theater with opened and undrawn curtain

*Acoustic parameters**	*Theater*	*Stage Opening*	
EDT_{mid}(s)	Olympia	Undrawn	0,94
		Opened	0,92
	Talía	Undrawn	1,23
		Opened	1,18
$RT30_{mid}$(s)	Olympia	Undrawn	1,06
		Opened	1,04
	Talía	Undrawn	1,42
		Opened	1,39
EDT_{mid} - $RT30_{mid}$ (%)	Olympia	Undrawn	11,86
		Opened	11,23
	Talía	Undrawn	13,45
		Opened	14,95

ence of an audience, the EDT_{mid} and RT_{mid} results observed in Table 6 would be higher with the seats occupied. The volume of the fly-tower seems not to influence the results of the reverberation time nor the early decay time in either theater. Between them, the Olympia Theater appears to have a very low mid-frequency reverberation time, which produces a subjective effect called “dead room”. It would be desirable to increase the reverberation time of the venue to avoid it. On the contrary, the Talía Theater has an adequate reverberation time. Despite it being near the upper limit, it is still at a point in which intelligibility is not affected.

A proper diffusion level is guaranteed when values of EDT_{mid} are similar to those of RT_{mid}. The ornamentation and irregularities of the surfaces contribute to an increase in the sound diffusion of a particular room. The ornamentation also adds a homogenizing effect to the reverberant sound (Beranek, 2004). In this case, the EDT_{mid} is similar to its correspondent RT_{mid}. For that reason, both theaters have a good diffusion level.

The STI of both theaters can be considered “Acceptable”

Table 7. Speech transmission index

*Acoustic parameters**	*Theater*	*Stage Opening*	
STI male	Olympia	Undrawn	0,62
		Opened	0,63
	Talía	Undrawn	0,59
		Opened	0,6
STI female	Olympia	Undrawn	0,62
		Opened	0,64
	Talía	Undrawn	0,6
		Opened	0,61

(Table 7). Although the Olympia Theater is a bit more intelligible than the Talía Theater. This is consistent with the data of clarity and definition.

The physical parameters measured in each theatre are shown in Table 8.

The calculated ratios can be seen in Table 9.

In order to evaluate the magnitude of the similarity between the parametric data of both theaters, a Brainerd-Robinson (Brainerd, 1951; Jiménez-Puerto, 2018) analysis has been carried out. This analysis yields a percentage of similarity between the data packages involved. In this case, the percentage has been 85%, which validates our initial hypothesis regarding the choice of two very similar spaces.

The ratio between the volume of the room, V_R, and the total absorbent area, S_T, should satisfy the expression: $RT_{mid}=0,14(V_R/S_T)$ to ensure a good acoustic behavior in the room (Carrión Isbert, 1998). Table 9 indicates that since both theaters share the V_R/S_T proportion, this ratio would be 1,21; which compared to the values of RT_{mid} in Table 6 shows that both Olympia and Talía theaters are more or less equally distant from the target (between a 14 % and 17% of variation) and within an acceptable distance.

4. Conclusions

The design of venues, and other spaces with live acoustic performances, requires keeping in mind acoustic, structural, and design aspects. These aspects that sometimes seem to be isolated from each other, are closely interrelated. With this work, we wanted to investigate how some of these relations could affect the performance of a specific room.

In the case study, it was interesting to observe and study why despite the theaters sharing all its physical characteristics, except one, and many of its absorbent characteristics, the acoustic measurement gave slightly different results. The main goal, therefore, was to dive into the possible causes of those differences.

The Olympia Theatre doubles in size the volume of the main room of the Talía Theater and almost triples it in capacity. That explains why the V_R/V_F ratio is directly proportional, while the ratio between V_R/N is inversely proportional. The acoustical absorbent area, S_T, is double in the Olympia Theater, but the volume of the room vs the acoustical absorbent area, V_R/S_T is equal. That means that both spaces have the same percentage of absorbent surfaces proportional to each volume. If only the amount of absorbent areas were enough to determine the acoustical behavior of a room, the different acoustic parameters we have studied would be very similar for both rooms. However, the proportions of both theaters do differ quite a bit. In the Olympia Theater, the length of the room predominates over the rest of the dimensions, width, and height, even the width is significantly larger than the height. The Talía Theater is practically cubic (height, width, and height are similar).

Table 8. Physical parameters of the Theaters

Theater	*N*	V_R *(m³)*	V_F *(m³)*	S_A *(m²)*	S_P *(m²)*	S_T *(m²)*	S_S *(m²)*	*H (m)*	*W (m)*	*L (m)*	*D (m)*
Olympia	1.055,00	4.965,54	1.367,98	522,13	52,15	574,28	103,40	9,50	16,66	29,26	34,35
Talía	378,00	2.238,68	1.314,56	209,14	49,12	258,26	102,70	11,82	13,75	14,65	16,67

Table 9. Physical parameters ratios

Theater	*V_R/S_T (m)*	*V_R/V_F*	*V_R/N*	*H/W*	*L/W*	*0'14 x V_R/S_T (m)*
Olympia	*8,65*	*3,63*	*4,71*	*0,57*	*1,76*	*1,21*
Talía	*8,67*	*1,70*	*5,92*	*0,86*	*1,07*	*1,21*

As we have seen prior, the acoustic parameters EDT, RT30, C_{80}, take higher values in the Talía Theater. Meanwhile, the D_{50} is very similar in both of them. Also, the study of the acoustic data reveals that acoustic parameters are being affected very slightly by the opened-undrawn curtain measurement set, which means that the contribution to sound absorption of the fly-tower is balanced. In addition, the similarity in the ratio V_R/S_T, related to the field measurements could be an indicator of the independence of the size of the fly-tower in the final acoustic behavior of the room, which was an unexpected result and will need further analysis. For example, adding more diverse cases to the study in order to reach a relevant conclusion.

The acoustic behavior is not determined unambiguously by the volume of the room and the total absorbent area but can be affected by the interrelation of the different dimensions that configure the space.

Both buildings share the same materials, but further analysis of the way the materials of the surfaces are placed would be necessary. It would also be recommendable to make a virtual acoustic model and adjust them, to evaluate the contribution of this aspect in the behavior of the room.

The results of this study emphasize the importance of proportions and building details and diminish the relevance of the amount of absorbent square meters in the design of spaces where acoustic comfort is essential.

To complete the survey, an on-site acoustic measurement with an audience would be desirable, to test the theatre in the standard use conditions.

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ArchiDOCT, 17 (1) DATA

Data Management implementation. New Strategies Addressing Built Assets

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Nowadays, the spread of innovative surveying technologies and tools for digital data management are strongly impacting the discipline of surveying and representation, shifting the discretionary phase of the survey project to the data processing phase.
The paper aims to explore the process that translates reality into digital data, and the methodological processes that guide this transformation, particularly in the field of intervention on existing buildings. The information captured through digital surveying procedures lead to new developments, allowing the parameterization of elements, the standardization of procedures and the replicability of solutions, by applying BIM - Building Information Modelling and Common data environment (CDE).
Within this process, geometric data enrichment through the aggregation of information through semantic and ontological correlations is essential. These correlations are the semantic representation of the relationships between elements that before the digital era could not have been expressed for computational purposes. Digital data becomes a tool for investigation and broadens the horizons of knowledge of the built environment.
The "genesis" of the digital data applied to the As-Built is widely discussed. However, there is still large room for the definition of operational methodologies that deal with translating the complexity of theoretical speculation into standardised processes. The presented research is moving in this direction, starting from a consolidated theoretical basis and aiming at experimenting methodologies by extending procedures now applied to Heritage-BIM also to the widespread built heritage.

1. Introduction

Never before the world of architecture has been producing and consuming data. Data that generate architectures and architectures that generate data. Information from the real world are acquired, aggregated and transformed (approximated) by digital tools that operate by applying a process strongly linked to the subjectivity of those who guide the process (Popper, 1969).

The spread of surveying technologies, allowing the massive acquisition of data, has had a significant impact on the discipline of surveying, partially reversing the traditional process. The new tools available actually shift the discretionary phase of the survey project to the data processing phase. Data are thus collected extensively, reducing or withdrawing the primary phase related to the interpre-

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She is involved in several research activities and she is the author of more than two hundred publications in the field of Heritage Documentation, Survey and Representation. Since 2006, she has been a speaker at national and international conferences, in particular on integrated methodologies between 3D survey, documentation and representation for heritage conservation.

tation by the surveyor, and are instead configured as raw data ready for multiple interpretations (synchronic or diachronic). Moreover, the current evolution is leading to a large application of BIM - Building Information Modelling working in a parametric environment, and fostering standardization and the replicability.

Within this process, geometric data enrichment through the aggregation of information is essential, giving entities that go beyond the mere anatomical representation (Centofanti, 2010) and making explicit semantic and ontological correlations that allow a full understanding of the architectural organism (Maietti et al., 2020).

Opening up to multiple interpretations of the surveyed data, requires the definition of a structured methodology (Bianchini, 2014) that drives the process according to rules that allow defining (according to a case-by-case degree of approximation) the level of reliability (LoR) of the represented three-dimensional geometry. To the data is then added the "Paradata" (The London Charter[1]), which traces the choices made by each operator during all the processing phases.

The geometric information collected and processed, organised in a parametric spatial matrix, act as a synoptic basis for the aggregation of further information levels. Born-digital data or digitised data find their own location in a discrete environment that combines them and makes explicit their correlations, creating a "complex representative model" (Centofanti, 2018).

Complexity, made usable by its organisation within a discrete model, comes in a shared digital environment that allows multiple actors to access and act on the information collected punctually and selectively, expanding investigation opportunities.

The research aims to propose a possible methodology for data management able to foster digitisation processes in the intervention on the existing building stock in Emilia-Romagna.

The digitisation of processes has been a widespread trend in the construction field for a long time (Negroponte, 1972), extending from the planning phase to cover the whole construction life cycle. This is even more the case when working on new buildings, where regulations[2] (European, national, or regional) recommend or impose intervention guidelines to achieve EU objectives regarding land consumption, sustainability, and energy saving.

Limited to the Emilia-Romagna region, the research context is rich in a very extensive 20th-century building heritage.[3] Nevertheless, it requires adaptation works such as restoration of materials and components, plant upgrading, roofing systems renovation, or structural reinforcements due to age or need (for instance, subsidence or seismic risk).

Working in terms of digitisation of processes applied to existing buildings requires the definition of procedures that consider the needs of all the operators involved, either being owners, officials, contractors, component manufacturers or technicians.

To support the implementation of innovative processes in a sector such as construction (OICE[4]) in the Emilia-Romagna territory – mainly made up of small and medium-sized enterprises historically unwilling to adopt a particular type of technological shift –, it is necessary to provide tools and methodologies simplified in use, immediately adoptable and able to help operators understand what added value they can gain from them.

The *digital* component in architecture is supported by the expanding availability of hardware and software tools offered at increasingly favourable costs. These tools' output represents a data source widely used during all phases of a building's life.

For instance, a network of temperature sensors (RICS, 2014) housed in interconnected thermostatic valves (*Wired/Wireless*) semi-autonomously regulate the temperature inside a building. Such sensors collect data processed by a control unit that operates according to sets of instructions created using unique calculation models to maintain constant indoor comfort when external conditions vary while containing costs. Like much more complex ones, similar automation processes are becoming increasingly popular as being supported by the value they generate compared to the investment for their implementation (*energy efficiency in this case*).

The data management and use become value. Processes that previously would have required the efforts of several professionals are now carried out semi-automatically, in real-time.

Unfortunately, devices (*e.g., Sensors*) interconnected via infrastructures (*Wired/Wireless - E.g. A wi-fi network connected to a data collection system*) are necessary to generate data. Such infrastructures require to adopt architectural arrangements which should be planned in the design phase (in case of new constructions), otherwise obtained during the redevelopment process as in the case of intervention on existing buildings.

2. State of the Art

In the field of intervention on the built environment, the data defining state of the art are "*created*" through a multidisciplinary investigation process (Fig. 1). This analytical method aims to create multiple datasets (even of a very diverse kinds) handled through specific processes aimed at transforming data into information.

Besides dealing with the conversion of a large amount of data into information, this process generates information itself. This information, called paradata,[5] represents the *trace* of the discrete method used for the transformation and lays the foundations for the ontological organisation of

1 The London Charter. Available at: http://www.londoncharter.org/ (Accessed: 14 May 2021).

2 UNI EN ISO 19650, UNI 11337:2017

3 Ance, Osservatorio congiunturale sull'industria delle costruzioni – January 2020, www.ance.it

4 OICE, Annual report on the 2018 BIM competition for public works

the collected information, guiding the process towards the correct understanding of the object (De Luca et al., 2007). Thus, the obtained information is used to define a synthesis model representing the characteristic elements of the building and all the components that define it (*structural, HAVC, to name a few*) as accurately as possible (Fuller et al., 2020).

The data collection tools are now advanced technologies, constantly being developed by manufacturers, focusing on performance values and ease of use. Ease of use is a crucial factor, which is essential for broadening the user base and making their application possible in new fields.

For instance it is possible to mention the evolution of the terrestrial laser scanner, which has gone from being a complex object (Tucker, 2002) to a portable object that could be sold in an Apple store and controlled through an App[6] in the space of twenty years.

The SfM (*Structure form motion*) (Luhmann et al., 2013) procedure is also widely used. Considered to be one of the most promising technologies, it uses algorithms capable of sampling a series of two-dimensional images to generate a three-dimensional point cloud. This system makes it possible to use hardware developed for other purposes (e.g., DSLR cameras, Smartphones, or Action Cams, among others) and properly developed commercial software. This technology has such promising development horizons that even producers of traditional laser survey tools invest in the acquisition of the companies that develop these algorithms.

The two technologies described above provide a 'point cloud' as output. These points, described in a three-dimensional environment, include spatial information (X, Y, Z) and additional information such as the intensity value or the RGB value of each point. The limitation that does not currently allow the superimposition of the two technologies lies in the accuracy of the generated data. Today, the workflow of a survey carried out using laser scanner technology is still more reliable than a SfM (but also usually slower and more expensive) (Fig. 2).

A strength that can be attributed to SfM technology is using images acquired by consumer SAPRs (drones), which allow investigations in areas that are difficult to inspect with other technologies (roofs, crumbling buildings, large portions of land) with relatively low costs.

The laser/SfM survey makes it possible to obtain the data necessary to create an aggregate "point cloud" with a degree of accuracy defined according to the purpose, which is indispensable to creating a synthesis model of the object. The data accuracy and reliability become essential information for the subsequent phases (Fig. 3).

In addition to the morphological aspects, other effective data for in-depth knowledge of the case study are also collected. Stratigraphic data, thermographic data, temperature, or humidity trends (to name a few) contribute to defining not secondary informative levels, depending on the specific object needs. Heterogeneous in terms of output,

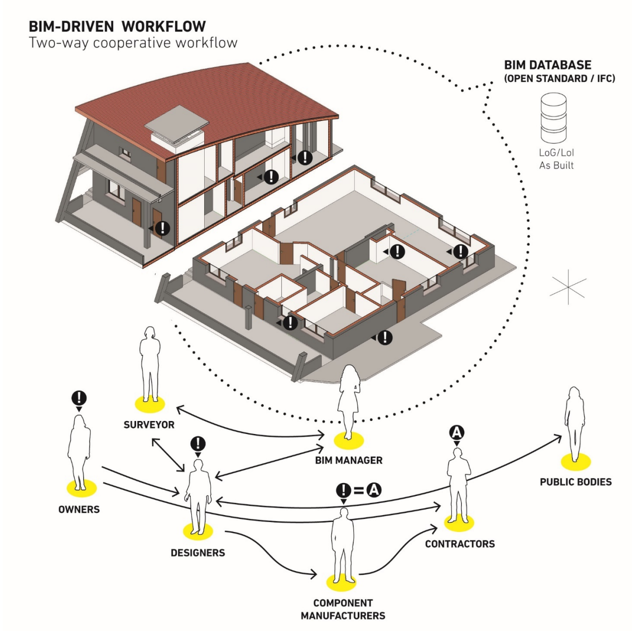

Figure 1. Guided workflow through the use of a shared parametric model allows actions to be shared among stakeholders, avoiding on-site problem solving. The geometric, diagnostic and additional information that defines the "subject of intervention" are created, processed and managed by several operators. The sharing phase is organised in such a way that each operator uses the collected data at the level of detail specifically designed for the specific function in the process

Figure 2. Quality check of the collected data, in this case the point cloud has a sufficient density and distribution of points to describe the elements that define the building

Collected data are assessed to see if the information are sufficient to describe the construction elements, materials and issues affecting the case study. In this case, a "cheap" survey process such as Structure from Motion provides sufficient geometric and chromatic information for further activities

these data require specific methodological steps to be converted into information (often through databases) to be

5 The London Charter, version 2.1

6 Leica BLK2GO

used within a three-dimensional digital model.

The technologies used and the methodological process of required elaboration contribute to the definition of more or less substantial "intervention budgets". Therefore, it is necessary to carefully examine which, when, and how to employ one of these technologies or more during the planning phase of the survey campaign.

Thus, the digital model becomes a synthetic container, created using a discrete method, set up to be as close as possible to the needs for which it was created (Bolognesi & Fiorillo, 2019). A massive data collection is not always a good practice. Excessive data (thence excessive information) can undermine computational systems that operate on technological apparatus based on limited resources. A too dense and heavy cloud is unusable by most workstations, just as a set of data from sensors can provide misleading indications.

3. Case Studies

The methodological process proposed by the research will be tested on case studies belonging to the existing built heritage in Emilia-Romagna. Among the indicators used to identify kinds and number of case studies, some criteria emerged from the ANCE[7] reports on the regional heritage that shows quite evident quantitative and qualitative trends in describing the building stock. Key indicators are linked to the period of construction, building technology and intended use. Identifying case studies belonging to these groups can contribute to the definition of a detailed methodology, covering a significant number of buildings with the same features and needs in terms of documentation, upgrading or adaptation. Once again, data collected and organised in databases[8] using filters can provide helpful information for decision-making.

Among the key elements needed to identify the case studies, it was decided to opt for buildings with a low number of co-owners. Difficulties in obtaining the required authorizations to carry out the necessary building surveys could have lengthened the research timeframe and undermined its effectiveness.

Therefore, it was decided to select case studies belonging to the Azienda Casa Emilia-Romagna (Acer). This crucial regional stakeholder owns several buildings whose characteristics perfectly cover the selected research criteria. Not of secondary importance the stakeholders' willingness (Acer) to invest resources (dedicated staff time, infrastructure) for the heritage digitisation.

The COVID-19 pandemic slowed down the phase of defining individual case studies under the needs of the stakeholders. The restrictions imposed by the pandemic made any survey inside inhabited buildings impossible. Sample buildings (Fig. 4) were identified and used to define and test research methodologies to overcome this issue. The temporal uncertainty linked to the emergency duration

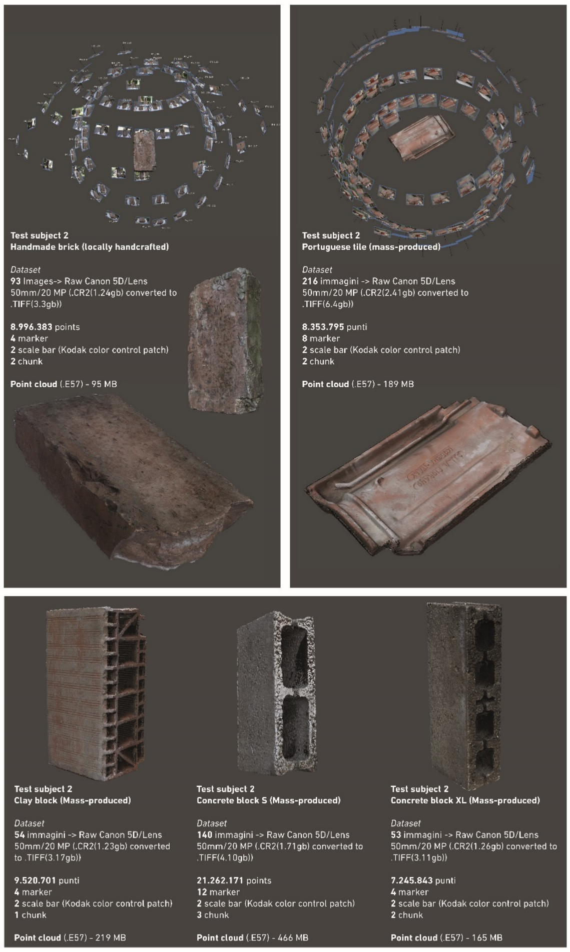

Figure 3. Extensive data collection

Creation of specific information sets to support the cataloguing of the building elements used in Emilia-Romagna during the 20th century. We can find handmade elements or the result of mass-production processes

highlighted how a working method based on the massive acquisition of data (*point cloud*) allows an operator to carry out synthetic modelling without the need to go to the site physically.

4. Research Methodology

The methodology adopted for this research is empirical/deductive, based on the validation of the process through a repeated approach.

In this research, the analysis of currently available methods for the data creation, management, and the definition of valuable procedures for their transformation (information/knowledge) represents the basis on which to articulate a methodological process that analyses and discretises the possible approaches helpful in solving the problem of technological permeability (fig. 5).

The main areas of investigation are closely linked to the

7 *Scenari regionali dell'edilizia*, Centro studi ANCE. Available at: https:// www.ance.it (Accessed: 14 May 2021).

8 *Dati statistici per il territorio: Regione Emilia-Romagna (2019)* Available at: https://www.istat.it (Accessed: 05 Apr 2021)

technological maturity of the tools, infrastructures, and operational practices currently in use. Such technologies – even those coming from different fields (*e.g., AR/VR, Digital Fabrication, or Blockchain*) – must be sufficiently mature to guarantee short and medium-term effects without running the risk of proposing attractive solutions linked to the "fashions" of the moment, which in practice would require indefinite time for widespread adoption.

Of no less importance are the aspects arising from applying regulations (*European, national, regional*) and their effects on operational practices. Developing a theoretically high-performance methodology, which contrasts with the current practices, partly defeats the "ready-made" concept that lies at the heart of the research.

4.1 Scope and Survey Campaign

Defining the purpose of data collection is an essential step in planning the field intervention. Knowing the purpose makes it possible to structure the a priori process and define which technologies and methodologies to use, thus setting its budget. The purpose may be purely documentary, or it may be an analytical investigation phase in the broader process involving subsequent intervention actions. Depending on the reasons governing the intervention, it is possible to decide on planning punctual activities (*a single survey, more or less integrated*) or envisaging medium-long term scheduled activities that return data describing a trend over time (Brusaporci, 2015). Indeed, different types of intervention require specific tools and related acquisition methods.

4.2 Equipment and Methodologies

The tools needed to pursue the research objectives are those effectively collecting information during an integrated digital survey campaign. They are tested and analysed to define which aspects help plan the survey campaign.

The final purpose of the survey defines the whole process from data collection, through processing, to the modelling phase. Therefore, it is possible to say that the purpose of the survey defines the budget (economic and time) allocated to the various work phases at the outset. The use of more accurate instruments, which produce higher quality data and require adequate economies, will only be envisaged for those interventions where they are truly sustainable. On the other hand, other interventions will foresee using less accurate yet exhaustive tools following the purpose envisioned in the planning phase. In this direction, previous experiences of protocols or workflows aimed at guiding the processes of digitization, respecting needs, requirements and specificities of heritage assets to be surveyed have been analysed (Di Giulio et al., 2017).

The instruments foreseen can be divided into dimensional and morphological survey instruments and diagnostic instruments.

Among these technologies, it is possible to list Camera 360, DSLR, SAPR, Traditional direct survey instruments, Digital survey instruments (*Disto, Disto 3D*), Total station, and Laser scanner.

Figure 4. The two case studies accessed during the pandemic by COVID-19, used as a test-bench for the stage of testing technologies and procedures

These are two similar but different processes, where in the first case, we have a historic building that required almost 900 photographs to be taken for representation. While in the second case, a 1980s building required less than a third of the pictures to achieve the same level of detail

On the diagnostic side, Georadar, Active sensors (*Sensor and data taker*), Endoscopy analysis, Thermography, Spectrophotometry, IR images.

The data obtained by these instruments are collected, processed, and stored using hardware and software equipment duly dimensioned in terms of calculation and storage capacity. The final objective of the research is to share the information acquired and conveyed by the synthesis model.

The technologies used are all available and have advanced levels of technological maturity.

4.3 Data Process and Analysis

Once the data collection process has been completed on-site, a preliminary check is carried out to assess the compliance and quality of the material collected. Many unforeseen hardware and software issues can save much time if handled on-site. Today's digital tools make it possible to check the quality of collected data in real-time and make redundant copies to guarantee its integrity.

At the end of the on-site activities, it is possible to proceed to the data processing and analysis phase. In this phase, paradata are created in addition to the information (Apollonio & Giovannini, 2015). The raw data is processed using specific procedures optimised for each type of data (geometric, two-dimensional, and informative, among others) to obtain ontologically structured information. This process requires a meticulous data storage management structure. At least one unaltered copy of the original data is kept as the data processed in each subsequent stage of the process.

In addition to data in its phase-specific form, the activ-

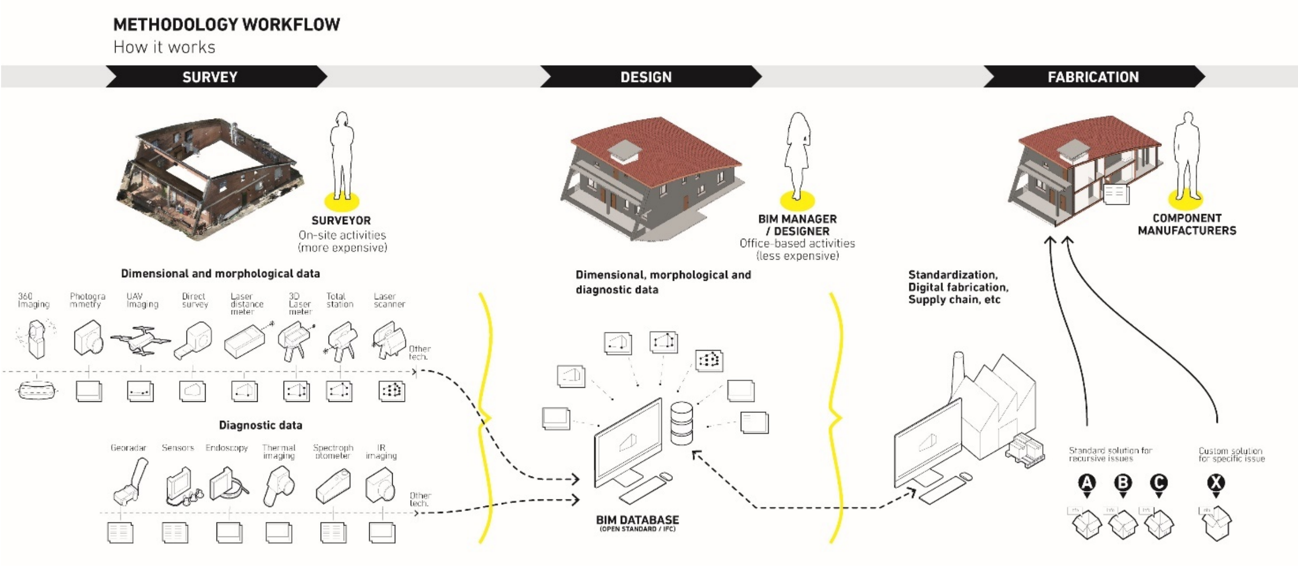

Figure 5. Methodology workflow. Surveying and diagnostic tools produce data that are processed and collected in a parametric BIM model

The information obtained can be used for redevelopment interventions based on innovative technologies such as smart fabrication

ities carried out by the operator who processed it (paradata) are also recorded. Each information set requires specific software applications, which alter its conformation at each step, to be processed. It may happen during the processing phase to realise that some procedure has been done wrong, and it is not always possible to undo the operations carried out (considering data sets of tens of GB). Therefore, having a copy of the starting data and the record of the carried-out operations is not an excessive scruple but a fundamental requirement. The material collected, processed, and all the information created throughout the process is organised in special storage facilities[9] with a standardised organisational structure. It is accessible and usable by the involved operators and has a certain level of redundancy to guarantee security (local copies for daily operations and cloud for long-term storage).

4.4 Data Aggregation (Modelling)

After the processing phase, the information collected is aggregated and contributes to creating the model. The model is produced according to the purpose and gathers and integrates information into a kind of knowledge tool. The parametric model (Fig. 6), which is created by employing specific commercial applications, makes it possible to aggregate and superimpose sets of information belonging to different disciplines, cataloguing them ontologically (Olawumi & Chan, 2019).

The parametric elements aggregation makes it possible to create a questionable knowledge model, useful both as an information container and a tool for analysing the whole. The model is created to share information among the actors involved in the process (Daniotti et al., 2021). Therefore, it is converted from a proprietary format (specific for each software) into an open format that allows it to be used by all stakeholders.

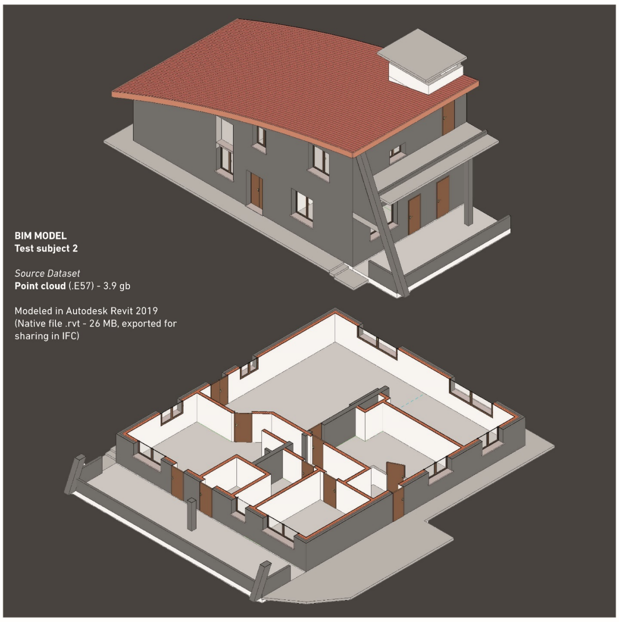

Figure 6. The gathered data are translated into information which are used to populate a parametric BIM model

The model organizes ontologically all the elements that constitute it and allows the operators to carry out data analysis

9 IT infrastructure for data collection and management (UNI 11337-5:2017)

4.5 Data Sharing

Provided by law as a "*common data environment*"(CDE/AcDAT), the management system (*storage/repository*) described above is used to share all available data. The person in charge of data protection will provide the targeted sharing of information since not all data can be freely shared or easily used by anyone. Targeted data sharing is essential when working with a considerable amount of data where there is a risk of unnecessarily overloading the system. It is the responsibility of the administrator of the sharing system to ensure that the dedicated material for each activity is available to the operators. The local sharing system can be hosted by a dedicated workstation or server, adequately set up to perform redundant backups both locally and in the cloud. Data security issues are a topical concern.

5. Conclusions and Further Activities

Data is the most valuable raw material of the future. European projects such as Gaia-X[10] show how data sovereignty will be a commercial battlefield in the not-too-distant future, where Europe (Autolitano & Pawlowska, 2021) owns less than 5% of the companies involved.[11] The data created today are stored in facilities that operate outside the European regulatory framework and over which there is no jurisdiction whatsoever.

Having established these first two points, it is still possible to consider it correct to operate towards digitising processes.

The current state of the construction industry in Italy, which has been in crisis for the last twenty years, does not allow to not take advantage of the digital revolution as a driver for the growth and relaunch of the entire sector.

Developing digital ecosystems, in which all stakeholders in the supply chain (public/private) can work together, acting on a shared model that connects all areas of the construction process, can be a privileged starting point to solve some of the critical issues in the construction process.

The methodology under development is limited to investigating the intervention needs supported by digital data sharing in the built environment. Likewise, it aims to provide operational tools for professionals who will have to evolve in methodology, adopting innovative technologies that allow a competitive advantage in a constantly evolving market.

Future research developments may see employing the created models as tools for collecting data (e.g., energy consumption, maintenance statistics) to be applied to automated management Blockchain protocols (Carson et al., 2018) or as digital bases for the more or less automated integration of construction technologies used in restoration processes based on digital fabrication, in a supply chain/industry 4.0/Supply chain perspective.

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10 *GAIA-X - Home*. Available at: https://www.data-infrastructure.eu/GAIAX/Navigation/EN/Home/home.html (Accessed: 14 May 2021).

11 *Market Trends: Europe Aims to Achieve Digital Sovereignty With GAIA-X. Gartner*. Available at: https://www.gartner.com/en/documents/3988433/market-trends-europe-aims-to-achieve-digital-sovereignty (Accessed: 14 May 2021).

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