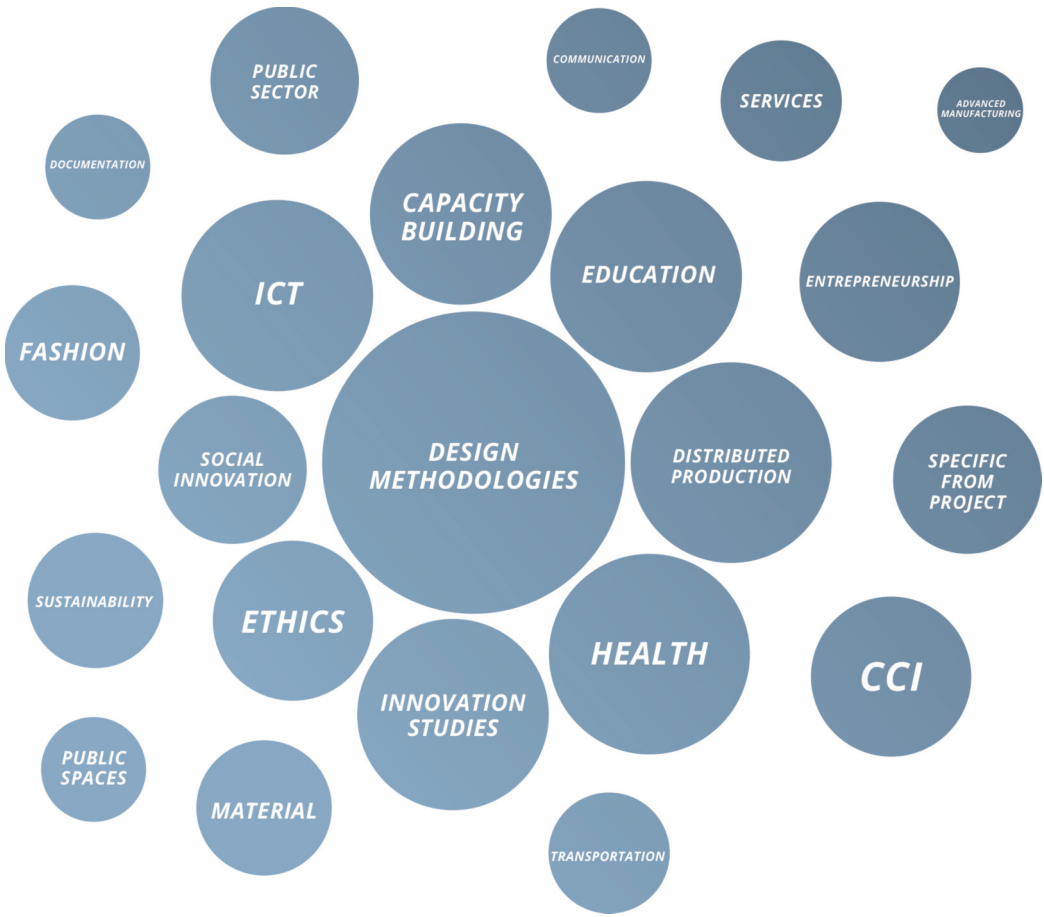
SEVEN YEARS OF DESIGN RESEARCH AT POLITECNICO DI MILANO

Analysis of the funded research projects

edited by Francesca Rizzo



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The Design International series is born in 2017 as a cultural place for the sharing of ideas and experiences coming from the different fields of design research, becoming a place in which to discovering the wealth and variety of design, where different hypotheses and different answers have been presented, drawing up a fresh map of research in international design, with a specific focus on Italian design.
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Francesca Rizzo
Department of Design, Politecnico di Milano

1.1 Design as a research discipline in the context of EU funds

The evolution of the Design in an academic field of study has followed a common trajectory in diverse academic environments from a practitioner's discipline dealing with the form and function of products and communications into a research area characterised by a circular process of knowledge development in experimental projects and through reflections on projects' outputs and impacts. This designerly way of knowing assumes the fundamental design practice of generating prototypes and solutions for and in real contexts as epistemological apparatus to produce new knowledge (Cross, 2006). It then emerges as a new and complex discipline that applies to real problems (instead of technological or scientific ones) and on people with the aim to produce those needed transformations where the problem exists in order to solve it. Designerly way of knowing can be then defined as a fundamental impact research working on addressing complex and persistent real challenges and by doing this creating and developing/sharing concepts, theories, approaches, methods and practices about transformative ways of researching, educating and engaging with society.

Topics that have emerged during the last 40 years of research have dealt with socially responsible design practices, taking a systems-thinking approach to problem solving, and focusing primarily on issues of education, health, sanitation, social justice and environmental stewardship towards a new paradigm involving new models of interaction and understanding of systems dynamics. It has emerged as a strategic impact discipline where people's interactions, collaborations with stakeholders and other disciplines (stretching far beyond the boundaries of any single organisation or discipline) are informing the future.

At a European and international level, due to a series of contingent and structural factors, in the last ten years there has been a significant growth in interest in design research which, in turn, has generated a quantitative and qualitative growth in the demand for design research skills, which are recognized in new application areas and allow greater possibilities for integrating design in multidisciplinary areas. This growth was accompanied by a significant increase in the places and moments of disciplinary confrontation. There has been an expansion of the circuit of sector conferences and the birth of several scientific journals, such as the International Journal of Design in 2007, She Ji: The Journal of Design, Economics, and Innovation and the Journal of Design, Business & Society, both in 2015. The relationships and presence of design in other disciplinary fields were also strengthened (Management & Entrepreneurship, Innovation Studies, Computer Science, Materials Science, Service Design and Management, Social Sciences and Humanities, etc.), and the demand for design-related skills in European and international research programs has increased. At the same time, the number of actors and international competitiveness in teaching and research have grown strongly.

Evidence of this growing interest is the inclusion in the 2015-2020 National (IT) Research Program which has identified in the cluster "Design, creativity and Made in Italy"[1] one of the 14 areas of specialisation of applied research and the European Agenda of the Horizon 2020 program which, through the 2013 Action Plan for Design-Driven Innovation (European Commission, 2013), has funded 9 collaborative research projects all focused on the study of design as a lever for innovation and on experimentation with design driven innovation methods to support the competitiveness of European production systems.

Supporting the more strategic dimension achieved by design as an approach to innovation was the document produced by the European Commission in 2012, published by DG Enterprise and Industry, Design for Growth and Prosperity, and included in EU research, development and training programs such as: H2020, HEurope, COSME, Creative Europe, ERASMUS.

The document clarifies how design-led innovation represents a competitive advantage for Europe compared to other models of innovation development, since it carries the ability to include social, quality of life and sustainability needs in the development processes, of preservation and development of human capital, which are essential to promote products and services that are competitive on the market.

[1] https://www.clusterminit.it/

"Design as a driver of user-centered innovation contributes to getting good ideas to market. It enhances agile and focused product and service development, strengthened and made more effective and desirable through good design management. It facilitates the development of better, transparent and more effective public services and contributes to social innovation, thereby raising the quality of life for all the citizens of Europe. And for complex societal problems, design offers people-centered approaches that can achieve better solutions" (European Commission & Directorate-General for Enterprise and Industry, 2014, p. 19). The Commission itself defined design not only as the set of knowledge and skills to define the shape of the products, but also as the discipline that determines the functioning of the products themselves (as well as of the services). Design creates value and contributes to competitiveness, prosperity and well-being in Europe.

For these reasons, since 2012, the Commission has aimed to accelerate the adoption of design in industrial and innovation activities at European, national and regional level through the explicit recognition of the role of design, including the flagship initiative launched among the levers in 2012 entitled "Europe 2020 Growth Strategy" (Commission, 2010).

Through these actions, the Commission in the period 2013-2020 aimed to:

- broaden the application of design for innovation and growth in Europe;
- spread awareness of how design-led innovation can improve the efficiency of public services and drive economic growth;
- create skills and competences for the application of these policies.

With regard in particular to the last point of the 2013-2020 Design agenda, the Commission has set up its Policy Lab at the Joint Research Center in Brussels which has adopted the design thinking approach as a method for the innovative development of policies, as it is more suitable for the development of innovative solutions that meet the needs of citizens according to a collaborative approach based on co-design between all the stakeholders involved.

The pluralism and disciplinary breadth described above represent the richness of design but also its limits for research. In fact, its multiple nature makes it extremely difficult to evaluate research projects concerning design, now that the boundaries of design have widened from the traditional ones to respond to the complexity of the needs of contemporary society.

1.2 Basic and applied design research at the Department of Design

Basic research in the Department of Design has been traditionally organised into two macro areas: the first, which can be defined as generative in nature, deals with designing, studying and experimenting processes, methods and tools for the development of human centred innovation; the second, of an analytical nature, deals with studying the relationships and impact of design in different application domains from a historical, socio-cultural, technological and economic point of view.

The goal of the basic research for design is twofold: to produce knowledge for the continuous application of the designerly way of knowing unprecedented domain; to produce knowledge to frame and analyse, from a historical and cultural point of view, design as a model / paradigm to define socio-cultural and technological systems of production and consumption.

The 2015-2020 National Research Program had also placed the area of Design, creativity and Made in Italy among those of high potential skills, those areas for which "Italy has distinctive assets or skills, which must be supported with the goal of increasing its industrial impact" (*2015-2020 National Research Program*, n.d.).

Despite the many strengths, basic design research in the Department has been heavily penalised by the scarcity of the national funds as evidenced by the fact that in the last two rounds of assignment of PRIN funds (2018, 2020) no projects have been assigned to the responsibility of a principal investigator belonging to the department of Design.

There are several causes for this poor support from the national level (which is also reflected at European level with respect to ERC funds), among which it is worth remembering the absence of the design discipline from the classification of disciplines used by the ERC (European Research Council) to funding for basic research. In particular, the de facto unification of the discipline with other ERC sectors such as SH5_5 (Visual arts, performing arts, design) or the PE8_11 Industrial design sector (product design, ergonomics, man-machine interfaces...) produces, as a serious consequence, the fact that the evaluation of basic research projects coming from design is entrusted to panels of expert evaluators of art, production engineering and economics.

In light of this framework, the basic research topics in the Department of Design from 2014 to 2022 can be summarised as follows:

- studies on new models of open, collaborative and distributed production;
- studies on processes, methods and tools for people-centered innovation (co-design, participatory design, ecosystem activation);

- studies on the role of design and the impact of design skills on the competitiveness of our country system (including studies on the culture of design and its diffusion in the fundamental production ecosystems of our country system);
- studies on new materials and sustainable production technologies;
- studies on the potential of design for public sector innovation.

Basic research on Design feeds industrial research in the development of product, process and service innovations for the continuous improvement of people's quality of life in a sustainable way with respect to the cultural and productive ecosystems in which they live and work.

Industrial and applied research has the role of verifying on a large scale the hypotheses, knowledge, methods and tools produced by fundamental research with particular reference in the following domains of application: Made in Italy; Territory, society and culture; Environmental sustainability and new economic paradigms; Digital revolution and the frontiers of innovation.

Made in Italy

There is a progressive change in manufacturing processes, crossed by digital transformation. On the one hand, completely new scenarios are opening up, such as those of the open and distributed manufacturing experimented by FabLabs and Makerspaces; on the other hand, peaks of advanced experimentation emerge in traditional sectors, such as Med-Tec and Fashion-Tech. This is generating an important impact on the Italian production system, redefining the processes of conception and materialisation, through models of organisational change, the ability to control and manage the production process and integration with the communication-distribution system.

In this sector, specific lines of research are:

- digital manufacturing and industry 4.0 (3D printing, rapid prototyping, customization);
- new production and distribution models (innovative technologies for the customised production of consumer goods with high added value);
- new entrepreneurship models and development strategies driven by design between global networks and reconfiguration of industrial districts (startups, incubators, accelerators).

Territory, society and culture

European policies support culture and creativity as assets for competitiveness and sustainable and inclusive growth. The growth of Creative and Cultural Industries (CCI) in Italy is particularly significant.

Design is a creative competence and a tool for the enhancement of culture in all its expressions, creating innovative services and products in the tourism, food and wine supply chains, the use of artistic and museum assets, territories and quality manufacturing.

In this sector, specific lines of research are:

- safeguard and enhancement of the territory and culture (cultural and creative industries, cultural heritage);
- social innovation and urban regeneration (human smart cities, social inclusion, living labs, urban and territorial incubators);
- collaborative services, creative communities, public engagement (mobility, health, environment, energy).

Environmental sustainability

The Commission on the New Climate Economy recently estimated at 26 trillion dollars the induced activity that will be generated by the fight against global warming alone, with over 65 million new low-carbon jobs, equivalent to over a third of the employment of the entire European Union at 28.

Over the last five years, over 345,000 Italian companies have invested in products and technologies to reduce environmental impact, save energy, contain carbon dioxide emissions, and the result is that these companies have proved to be more competitive and innovative, attracting investments and increasing hiring.

The economic and environmental sustainability of the ecosystems in which we live depends critically on the design phase of the products and services that fill them.

In this sector, the specific lines of research are:

- methods and processes for optimising the resources used and recycled (energy consumption in production and use, presence of punctual systemic failures that affect the duration) along the entire supply chain;
- tools and processes for collaborative services (circular and collaborative economy);
- advanced manufacturing (digital and fast prototyping, 3D printing).

Digital transition and the frontiers of innovation

The products of daily use are increasingly integrated by technologies that make them interactive in the relationship with people, with other objects and with services (Internet of Things – IoT, open platforms, wearables). Through intelligent products, people become an active part and co-producer of data and services, contributing to the culture of open innovation in sectors that are fundamental for the missions that characterise the new EU research program

Horizon Europe, such as open science, health, climate change, social inclusion, energy consumption, among others. The complexity of smart products today represents one of the most relevant factors for social inclusion (digital divide). Design can apply to the development of intelligent products that are sustainable and compatible with the characteristics of the people who will use them.

In this domain specific research lines of the Department are:

- quality of user-technology interaction;
- communication and visualisation of data, big data accessibility (citizen science and public engagement of scientific data, monitoring, consumption, access data);
- quality of life of people and living environments (home automation, IoT, AI; biotechnologies);
- innovation in public services (digital transformation of public administration, accessibility and usability of services).

1.3 A deeper view on the sources of the funded projects from 2014 to 2020

Funded research in the Department of Design has been traditionally concentrated on national and regional funds especially for the long period of time included between the department foundation in 2000 and the launch of the Horizon 2020 programme in 2014.

During these 14 years researchers of the department mainly attracted funds for the collaboration with the "industry" of design which is particular flourish in the Lombardy region where the furniture, fashion and luxury districts have represented natural partners especially for all those research activities linked with the education programs and the system of labs in support of the research and education.

In this period another relevant channel of funds is the national program in support of the basic research (PRIN projects) where the department, also for its uniqueness on the national landscape (it is still the only italian Department of Design) shows capacities of attraction funds in the domains of made in Italy and cultural heritage including artisanship and craftsmanship. The funds from EU programmes are still limited to 4 projects for basic and applied research (7th framework programme) and a couple of projects under DG Growth and Marie Curie programs.

This configuration of resources in that period has depended on three main reasons: the strong connection between the department and the communities

of studios, practitioners and companies working on design in the area of Milan and the Lombardy region; the availability of funds at the national level not yet based on the ERC classification; the limited awareness at the EU level on the potentiality of design as a research discipline.

It is since 2014 that the Department starts to become competitive at regional, national and EU level.

In particular the Department shows capacity in attracting 37 regional funded projects; and 41 EU funded projects, between EU projects 14 are funded by H2020 while the remaining 27 are funded by Marie Curie, Creative Europe, EACE, Interreg programs (see fig. 1.1).

In particular, with respect to the H2020 projects it is interesting to notice the following data:

- Out of 111 professors (full professors, associates, researchers) 39 presented H2020 proposals (35%);
- Out of 39 active researchers 11 at least have one 1 project;
- For each of the 39 applicants it is possible to say that 1 additional researcher is engaged in the proposal preparation. This means that at least 78 people from the department have been involved in a EU proposal;
- For each of the 14 projects won under H2020 at least 3 researchers have been involved; this means that at least 42 researchers from the department have been involved in the development of an EU project;
- 3 coordinated projects out of 14;
- 175 partners along the 14 H2020 projects and 34 nations across the world.

Beyond the numbers it is interesting to notice and reflect about what relevant role funded projects may have played in the development of the Department between 2014 and 2020 (and this is one of the goals of this book). Here it is possible to introduce some explanations on the remarkable shift from projects supported by the regional and national level (and few projects at EU level) to many projects supported by regional and EU level.

To include this picture within a proper framework 3 circumstances must be considered: first the introduction in the EU research framework H2020 of the work programme "Europe in a changing world – Inclusive, innovative and reflective societies" and the corresponding societal challenges as objects of research thorough pilots; the adoption of this model by the regional research programmes as they basically pursue applications and concrete solutions; the adoption of the ERC classification by the national program as grid of application to fund the basic research. These 3 facts have configured a new space of opportunities for the department of Design to become partner in EU col-

Fig. 1.1 – European, national, and regional funds attracted.

laborative projects under the framework H2020 thanks to the design scope as a research discipline to serve basically people and (society) with solutions oriented to meet the unsolved issues for the people and the society; the barrier that the lack of a ERC panel or set of ERC keywords on design has posed between the department attempts to gain funds for basic research and the real opportunity to been properly evaluated under this strand of funds.

Moreover it seems that the introduction in H2020 of the "pilot" oriented methodology to conduct research in real contexts and with and for society has represented an not expected space of application for the design as a that research discipline that better fit with this new approach for its intrinsic characteristics and its ways of knowing by testing prototypes in real contexts, i. e. by piloting and reflecting on projects (pilots) impacts.

As a counter verification of this new opportunity design research can have in the context of EU research programmes last data tells that in the first 2 years of the HEurope program the department of Design has won 9 projects out of 37 applications reaching a success rate of 24.32%.

1.4 Conclusions

This book explores the thematic areas addressed by the research in the Department of Design, obtaining a snapshot of the issues addressed through funded research, their dimensions and results achieved, as well as their interconnections to the basic design research topics. The ambition is to build the research landscape explored by the researchers of the Department through the access to competitive funds (regional, national and EU) and vice versa to gain some insights about how themes supported by funded research affect the basic design research. Starting from the data emerging from the qualitative analysis of 32 projects (see chapter 2), two are the relevant questions the book discusses (i) the interactions between the funded research and the Department research profile and identity and (ii) the interactions between the funded research and the basic design research topics.

To answer the interrogations, the analysis of 32 projects has deepened their keywords, outputs, outcomes and impacts as described in chapter 2 where the methodology for the projects' investigation is introduced.

Data from the analysed projects reveal the presence of 11 transversal clusters and 12 vertical research vertical clusters.

Transversal clusters are those that do not show a unique link with an industry area, rather they apply to different sectors such as design methodologies or ICT. Vice versa vertical clusters are strictly linked with specific productive sectors or represent specific domains of application and development such as: health, public sector, social innovation among others: that often are widening the scope of the basic design research and nurturing still under- or unexplored research directions especially in a multidisciplinary perspective, while the same clusters are also challenging the design curricula asking for competences that historically never entered the profile of the designer.

In terms of transversal topics, nevertheless the varied nature of the projects, design methodologies and tools development are a common thread, showing a relevant tendency towards participatory practices and codesign with a different variety of actors (not only end users), hands-on experimentations, context-based and situated and action research. A direction further represented by the knowledge transfer, which outlines how the sharing and disseminating of knowledge often reaches out to highly interdisciplinary scholarships. A second transversal area is the one of capacity building (different from design education), where the first concern is the application of design knowledge to support the development of design oriented skills and mind setting to deal with innovation processes in different working contexts. Thirdly, ethics emerges as another relevant topic which is specifically ad-

dressed as a topic. Going beyond prior attitudes that mainly looked at ethics in terms of research processes and results, the research investigates trajectories such as Responsible Research and Innovation, shedding light on how design can contribute and impact the environment.

As a result of the analysis, both the vertical and the horizontal clusters show an ongoing amplification of disciplinary boundaries, with an inherent proneness to apply design knowledge-driven approaches and research to new or formerly "non traditional" considered far-away domains like for example, themes previously often enquired by urban scholars and architects and currently reclaimed, are that of public spaces as objects of investigation and design on the one hand, and policy design, policy-making and governance on the other. The reasoning extends to the public sector, which poses growing challenges regarding the development of new approaches to service design, delivery and provision, to the definition of its governance, and the capacity to effectively engage citizens in its processes.

Next to this first insight it is quite relevant to notice how even when funded projects deal with traditional design themes as, for example, design education, the contribution of the design is reorientated toward an unusual theme for the discipline like how to deal with education of employees in public or private organisations to support the development of new competences. This specific reorientation testifies the application of design knowledge to deal with processes of organisational transformation/change.

The final aim of the book is to individualise the continuity/discontinuity and deviations between the funded research and the basic design research that characterises the Department of Design of the Politecnico di Milano and to discuss the interactions between them especially in the period from 2014 to 2020 when the funded projects especially from EU level have significantly increased with some important role played also in affecting the topics and the modalities of the basic design research.

The chapter 2 describes methodology that has been applied to analyse the projects' sample.

The chapter 3 introduces a perspective on design research and which is the current landscape at the international level, and it provides an overview of the research keywords used to describe the research activity carried on in the Department of Design. Then the clusters as they emerged from the analysis of the funded research project keyworks are synthetically introduced and described.

The chapter 4 elaborates and discusses the data obtained from the extraction of the outputs produced by the analysed projects. The chapter 5 reflects the projects' outcomes and finally the chapter 6 reconnects through the use of

the impact pathway tool, elaborated by the EU Commission in the new HEurope template, outputs and outcomes to the impacts archived at the scientific, technological and socio economic levels.

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2. Context of the analysis and methodology

Ilaria Mariani, Patrizia Bolzan, Annalinda De Rosa, Venere Ferraro, Marzia Mortati, Xue Pei, Francesca Rizzo, & Davide Spallazzo
Department of Design, Politecnico di Milano

The book aims at picturing the funded research of the Department of Design of the Politecnico di Milano, building the research landscape explored by its researchers through access to competitive funds (regional, national and EU). For this scope, the study qualitatively analyses the research projects coordinated or participated by principal investigators from the Department of Design, funded and concluded in the timeframe 2014-mid 2021. The ambition is to gain insights into the topics addressed, the dimension of such strands of investigation, and the relationship with the Department's basic research, capturing the results achieved in the short, medium, and long term. Ultimately, the intent is to also reason on upcoming directions of design research.

The methodology applied to return such a picture that reads the multi-level features of the Department's funded research relies on the construction of a knowledge basis composed of project descriptions with the same structure to grant a robust and reliable comparison among them.

The methodology has three phases:

1. Project sample definition
2. Knowledge base development
3. Data extraction and interpretation

The study initiated in June 2021 and ended in September 2022, and its methodology is depicted in fig. 2.1 and detailed below.

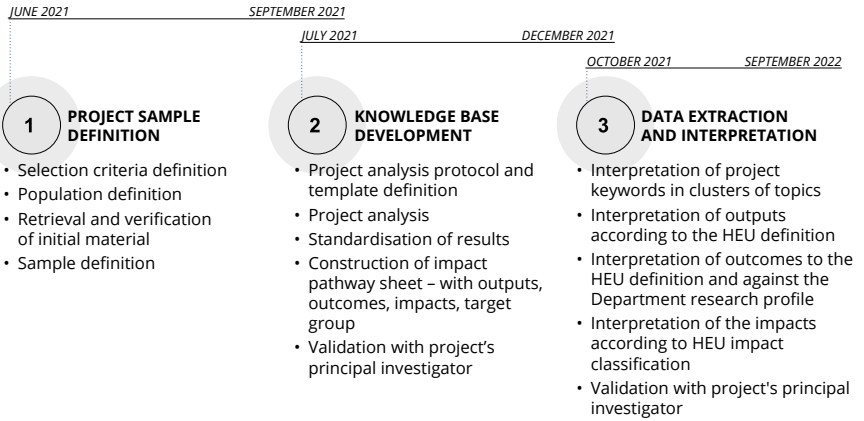

Fig. 2.1 – The phases and steps of the research process of the study.

2.1 Phase 1: Project sample definition

The first phase of the study concerns the sample definition. It started in June 2021 and ended in September 2021. The activity began setting the selection criteria, followed by the definition of the study population, the retrieval and the verification of relevant material for the qualitative analysis, which determined the final sample definition.

Selection criteria definition. This study uses a holistic model with research projects as single units of analysis. The criteria of selection are identified according to the scope of the study and the need to build a qualitative knowledge base. They are:

- Timeframe. The analysis only captured projects funded and concluded in a specified timeframe: from 2014 to mid-2021, when the study started. The snapshot, therefore, does not capture projects completed from the second half of 2021 and beyond or still in progress.
- Typology. Coordinated and participated in European and national competitive research projects, coordinated regional competitive research projects, and funded research projects identified to grant a diversity of topics.

Population definition. A total of 96 research projects answered the selected time frame (85 competitive funded research projects as in Fig. 1.1, plus 11 funded research projects selected to grant a diversity of topics), of which 45 also answered the typology selection criteria, constituting the study population.

Retrieval and verification of initial material. Given the nature and scope of the study, evidence for the analysis is collected through multiple sources and then triangulated (Rothbauer, 2008). In particular:

1. Documents. The collection consists of data and material from principal investigators, such as the description of action, the proposal submitted, the technical/final report of the project. Additional data is collected from scientific publications of the project and dissemination material.
2. Archival records. Additional available resources are collected through other sources, such as project websites and documents uploaded on EU platforms.
3. Open-ended interviews. Conversations with the Department's principal investigators of the projects provided further first-hand material.
4. Artefacts. Ultimately, material and data derived from eventual artefacts produced by the research projects.

The aim is to gain an extensive understanding of the projects analysed. Therefore, several projects were excluded due to two preconditions to the development of in-depth analysis:

- Availability of material. Availability of sufficient and relevant data and documentation, such as project documents and reports, to build a qualitative analysis.
- Availability of principal investigators. The analysis requires continuous discussion with the principal investigators, primarily to participate in interviews to gain first-hand knowledge, and ultimately to validate the analysis developed.

Sample definition. The previous steps cut the overall population to 32 projects. The sample is composed of 19 European, 1 national, and 12 regional, as detailed in tab. 2.1.

2.2 Phase 2: Knowledge base development

The second phase took place from July 2021 to December 2021, and regards the development of the knowledge base. The phase begins identifying the analysis model as a standardised tool to build an analysis template that frames the evidence and data in a structured manner, allowing to identify relationships between future trajectories of European research and the projects implemented so far.

Tab. 2.1 – The study sample.

Scale	Program	Project name	Year	POLIMI Role	Case ID
EU	Connecting Europe Facility	C-ROADS Italy	2017	Partner	14
	Creative Europe	DDMP	2018	Partner	19
		Human Cities	2014	Partner	22
	Cultura	DigiMooD	2018	Coordinator	03
		MaDe	2018	Partner	11
	Easme-Cosme	DEFINE	2018	Coordinator	07
	Erasmus+	Edu4FT	2017	Partner	08
		FashionSEEDS	2018	Partner	09
		LeNSin	2015	Coordinator	10
		PUDCAD	2017	Partner	18
	Home Affairs	FIRE	2014	Partner	25
	Horizon 2020	BRIEFING	2018	Partner	06
		CIMULACT	2015	Partner	26
		CREA	2015	Coordinator	04
		DiDIY	2015	Partner	31
		NESTORE	2017	Coordinator	15
		SDIN	2015	Partner	29
		SISCODE	2018	Coordinator	30
	Interreg	CO-CREATE	2016	Partner	05
NAZ	Eranet-Safera	POD	2015	Coordinator	16
REG	Accordo di Collaborazione	Eupolis	2017	Partner	27
	Bando Ora! 2018 / Fondazione San Paolo	Tango-Down Athena	2018	Coordinator	24
	Enea	LDI	2014	Partner	12
	Fondazione Cariplo	Cascina 9	2018	Coordinator	23
		Includi.MI	2017	Coordinator	28
		WeMi	2015	Partner	32
	Polisocial	CampUS	2014	Coordinator	21
		TAMBALI FII	2017	Coordinator	20
	Progetti di ricerca applicata per la valorizzazione del patrimonio culturale lombardo	L'architettura in Lombardia dal 1945 ad oggi	2014	Coordinator	01
	Regione Lombardia	DesFromIdeasToMarket	2015	Partner	17
		DIGIKNIT	2017	Partner	02
		NUVOLE	2017	Partner	13

To capture the non-linear causal relationship that links research activities and impacts, this study relies on a **conceptual model** that derives from the notion of *impact pathways* or *pathways to impact* (Bruno & Kadunc, 2019, p. 66). First introduced for the research quality assessment in the British context, the concept is currently adopted by the Horizon Europe (HEu)

framework, where it is associated with a *Key Impact Pathway Indicators* approach. As it emerges from the HEu programme, the research and innovation funding strategy of the European Commission is soundly built on the impact pathways concept, which is defined as the "Logical steps towards the achievement of the expected impacts of the project over time, in particular beyond the duration of a project. A pathway begins with the projects' results, to their dissemination, exploitation and communication, contributing to the expected outcomes in the work programme topic, and ultimately to the wider scientific, economic and societal impacts of the work programme destination" (Horizon Europe Programme. Standard Application Form (HE RIA, IA), 2022, p. 29).

Building on this, the study pivots around four elements: (1) *outputs* as the direct result of an implementation action, (2) *outcomes* as short and medium-term effects related to the use and/or exploitation of a project output, and (3) *impacts* as long-term effects on society, the economy and science. Such results are then described through (4) *impact pathways*, which link outputs, outcomes and impacts in a causal sequence of activities, giving a comprehensive picture of the change processes caused by research initiatives (Bruno & Kadunc, 2019) (fig. 2.2).

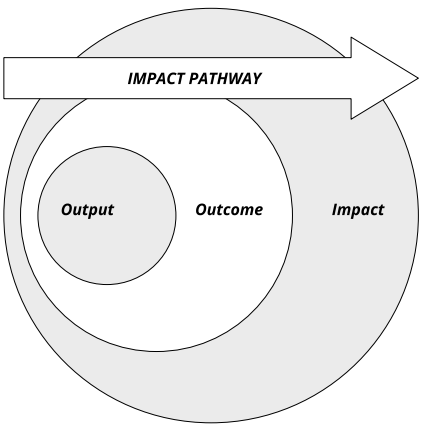

Fig. 2.2 – The impact pathway as the causal sequence of outputs, outcomes and impacts.

On the basis of the impact pathway model, the projects serve as a knowledge base to extract qualitative evidence regarding direct results, effects achieved in the short term, scilicet during the project period, and impact trajectories as long-term effects. The phase unfolds from the design of the

project analysis protocol and its template to its filling, the normalisation of the results, and the elaboration of the impact pathways as a causal sequence of project outputs, outcomes, and impacts.

Project analysis protocol and template definition.
The step starts with the definition of the analysis protocol with the relevant dimensions to consider while observing all the projects, considering the need to build a replicable model to analyse the entire sample. The analysis protocol includes general information about the project, embeds the concept of impact pathway adopted by the HEu programme, and looks into connections to current strategic directions. The protocol is structured in three sections, as shown in the schema (tab. 2.2, column Analysis protocol).

The protocol is then turned into a device, the template, for analysing the sample of research projects and collecting data. Aiming at collecting comparable data, the dimensions identified by the protocol are turned into a set of questions to be addressed during the project analysis (tab. 2.2, column Template). These questions serve as a framework during the desk research as well as during the verbal interviews with the Department's principal investigators (after proper translation for maximising understandability in the framework of a conversation).

Project analysis. The template is applied to each project to extract information on the different dimensions identified by the analysis protocol. Data is gathered (i) analysing the project description of action, application, deliverables, technical report, and websites relevant to the project, and (ii) interviewing the principal investigators – even multiple times if needed. Once compiled, the analysis is sent to the project's principal investigator for review and validation.

Standardisation of results. The standardisation consists of uniforming and codifying the data collected by the team involved in the study, especially regarding jargon, linguistic style, and detail level of the analysis. The step grants coherence in the analysis in terms of higher uniformity and comparison. The aim is to gain an extensive understanding of the projects analysed.

Construction of impact pathway sheet. The construction of the impact pathway sheet is aimed at grasping the project's impact pathway. The sheet is jointly reasoning on the three dimensions of the impact pathway – as previously described in this chapter – and the key elements of the Impact Section as they are identified in the Horizon Europe Programme Standard

Application Form (Horizon Europe Programme. Standard Application Form (HE RIA, IA), 2022, pp. 37-38). The form identifies six relevant dimensions: (i) specific needs, (ii) expected results, (iii) dissemination, exploitation and

Tab. 2.2 – Analysis protocol and template.

	Analysis protocol	*Template*
Section	**Dimension**	**Description**
Section1: Project information	Title	Title
	Duration	Duration
	Program & specific program	Program & specific program
	Links	Links
	5 keywords	5 keywords
	Consortium	Consortium
	Abstract	Abstract as a synthesis from the DoA/ application/website or a mix of these to provide the best synthesis for our purpose
Section 2: Scope and results	Strategic objectives: • issues/challenges and disciplinary areas	Strategic objectives: • Which are the identified issues/challenges and the disciplinary areas in which the research project is situated?
	• key idea and scope	• What is the key idea and scope of the project?
	Department's expertise • Principal activities, role in the contributions	Focus on the Department's expertise: • Provide a brief description of the principal activities in which the Department has led and/ or was involved in, specifying the role it played in terms of tasks and specific contributions
	• Link activities and outputs	• Link the activities with the outputs developed
	• Complementarity or synergy of expertises	• Are the Department expertises complementary or in synergy with those of the other partners?
	Impact • Project outcomes and impacts	Impact • What were/are the outcomes and impacts of the activities in which the Department was involved?
	• Impact within the research group: opportunities and inputs	• Which is the impact within the research group able to produce future research and amplify knowledge? Did the project open up opportunities and inputs in other/forthcoming projects?
	• Impact on future research	• How did it impact the research of the group involved in the project or/and the Department? Did it nurture new or further know-how/ reflections/areas of investigation?

(continued)

	Analysis protocol	*Template*
Section	**Dimension**	**Description**
Section 3: Strategic contribution	Contribution to knowledge	Which is the main contribution to knowledge brought?
	Link with HEU, Missions, PNRR as strategic documents	Possible emergencies and common trajectories to the three relevant strategic documents (HEU, Missions, PNRR)
	Expertise not fully exploited	Are there areas in which the Department could/ should bring expertise but are not yet/fully exploited or recognized as its strengths?
	Contribution to the Department research lines	Did this project contribute to the Department's research line(s)?

communication measures, (iv) target group, (v) outcomes, (vi) impacts. Beyond the dimensions already included in the analysis template, the inclusion of the target group is considered relevant, since it zeroes in on who will benefit from the project's results and who will use or further up-take them. The resulting template consists of a further synthesis device aimed at extracting and causally linking the project outputs, outcomes, and impacts, together with the target group of the project. The information collected in the analysis template is revised including the fourth dimension of the target group, derived from the key elements of the impact section of the HE proposal format. The result is a sheet gathering data on (i) output, (ii) outcome, (iii) impact, (iv) target (fig. 2.3). To fill the impact summary sheet template a second round of data extraction from the given documents is necessary, often also requiring further interviews with the project's principal investigator.

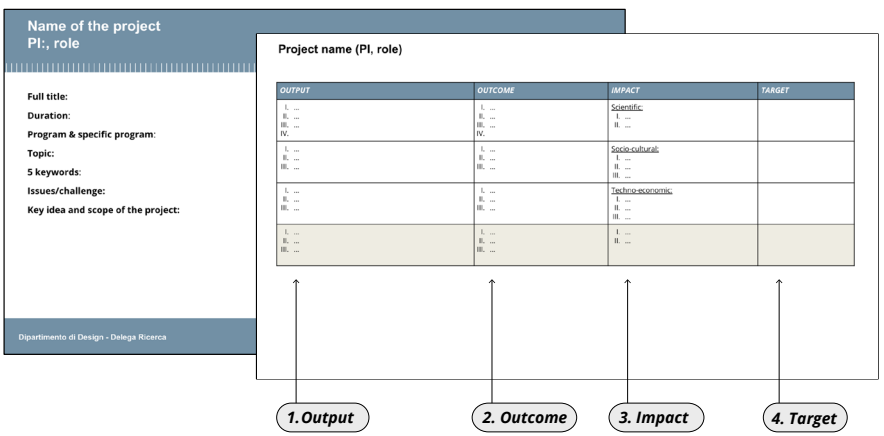

Fig. 2.3 – The impact pathway sheet.

Validation with project's principal investigator. The new round of data compilation is followed by a further review and validation of the pathways to impact with the project's principal investigator.

2.3 Phase 3: Data extraction and interpretation

Finally, the third phase of the methodological approach, running from October 2021 to September 2022, focused on interpreting the projects through the three dimensions of the impact pathway: outputs, outcomes, and impacts. Each dataset is characterised by a specific procedure to address the interpretation, being the object of a specific analysis. Although their detailed description is presented respectively in the chapters 3, 4, 5, and 6 of this book, in the following it is briefly described their development.

Interpretation of project keywords in clusters of topics. The analysis elaborates and clusters the 159 keywords used to describe the research projects in the 32 project analyses, gaining a comprehensive picture of the topics addressed by the funded research project of the Department. Following an iterative process of refinement and polishing, the dataset of 159 keywords is analysed to build thematic clusters through a bottom-up approach. 22 clusters identifying common trends and macro-topics are mapped: 21 thematic clusters plus "Specific from project". These keywords and topics are then interpreted against the 113 keywords and topics elaborated in 2015 on the delivery of the new Department website and describing its research. On this occasion, a bottom-up process was launched, and each researcher of the Department contributed with their keywords. After validation, the process produced 113 keywords as a sort of self-portrait of the Department's basic research. By identifying continuity, discontinuity, and differences between the set of keywords, the analysis provides a landscape of the Department's competitive research, providing evidence on how funded research subjects affect fundamental design research. The analysis unfolds from the elaboration and clustering of keywords describing the 32 research projects, obtaining a comprehensive overview of the themes covered. Clusters of topics stemming from funded research have then been confronted with the keywords used to describe the Department research profile and the basic research themes.

Interpretation of project outputs according to the HEU definition. In this step, all the outputs presented in the 32 impact pathway sheets are extracted. The original list of outputs, worded as reported in the proposal and

validated by the principal investigator, is standardised. The result is a list of 54 outputs. Different clustering methodologies coming from relevant frameworks and programmes are applied to interpret the outcomes. However, they were discarded since they could not fit the depth and extension of the objects analysed. As a result, the list of outputs collected from the study is interpreted through a two-level operation: firstly, a bottom-up operation identifies output clusters; secondly, a top-down operation revises and identifies the final clusters through a qualitative validation phase. The bottom-up clustering identifies 6 output clusters: Analytic, Educational, Instrumental, Performative, Scientific, and Tangible. Outputs are then attributed to these categories.

Interpretation of project outcomes to the HEU definition and against the Department research profile. The outcomes described in the 32 impact pathway sheets are extracted and interpreted against two relevant grids of analysis: 113 keywords of the Department of Design, organised under 3 typologies; and a selection of 45 ERC keywords representative of the Department research. Both these lists are a portrait of the Department's research activity, produced through bottom-up approaches that saw the researcher of the Department actively contributing respectively to their definition and identification among the overall set of ERC keywords. The list of outcomes depicted in the impact pathway sheets is then interpreted and mapped against these two lists of keywords, with the Department Keywords providing an inside perspective, and ERC Keywords relevant to the Department providing an outside perspective.

Interpretation of the impacts according to HEU impact classification. The projects' impacts, as depicted in the 32 impact pathway sheets, are extracted and standardised to maximise formal coherence. For the purpose of interpretation, the list of impacts is analysed according to the study methodology, namely the framework proposed by the European Commission to monitor and measure the impact of research and innovation projects. Therefore, the list of impacts is interpreted against the 3 impact categories of scientific, social, and economic/technological impacts, and the 9 Key Impact Pathways of the Horizon Europe Program (European Commission, Directorate-General for Research and Innovation, 2022).

Validation with project's principal investigator. The interpretation is validated and iterated through direct interviews with the project's principal investigator.

To conclude the methodology, it is fundamental to point out that the development of the Impact Pathways took place ex-post and, despite validation with the project's principal investigators, carries with it an important element of interpretation due to the researcher running the study.

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3. The funded projects of the Department of Design and their interactions with the basic design research

Francesca Rizzo & Ilaria Mariani
Department of Design, Politecnico di Milano

The chapter first describes what is design research and which is the current landscape at the international level, providing an overview of the research activity carried on in the Department of Design to then look into the topics addressed by its funded research. The ambition is to depict the research landscape that emerges from the research projects accessed through competitive funds, gaining insights into how the funded research influences the basic research. In this framework, the chapter faces two relevant dimensions: (i) the interactions between the funded research and the department research profile and identity, and (ii) the relation between the funded research and the basic design research topics, exploring the continuity, discontinuity and interactions among the two strands. The analysis shows discrepancies between areas that the Department covers with its basic research and topics on which it obtains funding and vice versa. The funded research highlights, on the one hand, the occurrence of new areas which go beyond the thematic clusters of the basic research. On the other hand, it also reveals the disappearance of traditionally established domains of investigation, opening the discussion on how the research reached advanced levels of conceptualisation and specialisation. Ultimately, the chapter discusses how the attraction of funds impacts the Department's research, refocusing some strands and strengthening its capacity to influence ongoing transformations, leveraging the potential of design.

3.1 The basic design research landscape and the position of the Department of Design

Design and, consequently, design research are featured by disciplinary promiscuity as an inevitable result of its inherently interdisciplinary na-

ture (Friedman, 2003). It also shows the unceasing tendency to explore and weave new connections, expanding and blurring its boundaries. As a topic, design has been the subject of analysis from multiple disciplinary perspectives, producing as many insights into the subject. It is a multifaceted and complex phenomenon featuring a variety of dimensions which ranges from artefactual, processual, social, economic, technological, and environmental, which are addressed by reaching out to a multi- and inter-disciplinary array of methods and theories, often adopted and adapted from neighbouring fields (Cash et al., 2022). This is whereby design research has the duty to capture and reflect the discipline's interconnected nature, making its orientations and directions explicit.

The design research landscape involves a variety of academic communities researching the topic from various viewpoints. Its inherent diversity fundamentally defines the distinctiveness of the discipline whose work impacts far beyond its boundaries, nurturing the potential of design research, and constituting a pressing challenge in terms of identity and processes (McMahon, 2012). Such diversity has made it challenging the achievement of a consistent and comprehensive view of the research in this field. In mapping this miscellany and heterogeneity, Cash and colleagues (Cash et al., 2022, p. 1) identify various threads of discussion surrounding diversity and scope (Clemente et al., 2020; Horváth, 2004; McMahon, 2012), construction of knowledge (Briggs, 2006; Cash, 2020; Love, 2002), and methodologies (Blessing & Chakrabarti, 2009; Krogh et al., 2015; Reich, 1995).

Through its areas of investigation, design research gives a valuable glimpse of how the domain unfolds through specific studies, from the emergence of new research questions, methodologies and applications, to the crystallisation of certain concepts and insights. As it is recognised within its community and despite the recent significant advances, design research remains vulnerable, presenting fragilities compared to other fields (Margolin, 2010). With a contribution indeed scattered across the literature (Horváth, 2004), with well-known flaws and limits in terms of methodological development, validation and standardisation (Cash, 2018), it often fails to receive wide recognition in terms of impacts and relevance. Its insights still struggle to turn into convincing evidence for other disciplines, where there are common standards, and to bring an effective change of practices and culture (Dorst, 2016). A condition that underlines the need to strengthen its impact and avoid stagnation (Clemente et al., 2020).

Over fifty years of developments in design research, an extensive number of topics have been touched and resonate through the discipline, showing a series of 'waves' (Cooper, 2019), from design methods to design thinking

(Dell'Era et al., 2020) within innovation and its application throughout society, industry, and education. More specifically, fundamental design research has moved from methods and processes to services and systems (Cooper, 2019), while extending to neighbouring disciplines such as management and business, health sciences and IT (Christensen & Ball, 2019), showing an evident tendency to be cross-disciplinary and trans-disciplinary beyond multidisciplinary. Being conducted for, into, and through design (Frayling, 1993), over the last decades, the discipline witnessed an increased expansion of interest that opened up an abundance of novel areas of investigation. Consequently, the design domain has expanded from user interaction (Park & McKilligan, 2018) and system design (Jones & Kijima, 2018), to management (Micheli et al., 2019), ethics (Sweeting, 2018) and sustainability (Ali et al., 2016; Rocha et al., 2019), while exploring matters related to cross-sector innovation, adoption and adaptation from and to other disciplines, development and codification of design knowledge, understanding and framing of design problems as well as qualitative aspects of design. However, this proliferation of topic areas and the resulting cross-fertilisation that the design discipline encountered are often imputed to have exposed the domain to fragmentation and a possible disciplinary loss of focus (Christensen & Ball, 2019; Cross, 2018).

Although the progressive widening of the investigation areas is demonstrated by the growing contexts in which the design discipline can bring its contribution, the literature still lacks a current mapping and review of the basic research in design and its main topics. With this in mind, this chapter does not pretend to capture and provide the state of the art of design research in general. On the contrary, it intends to draw a map with precise and clear-cut boundaries, investigating in detail the topics of funded research taking place in the Department of Design. The relevance of the analysis lies in the role of the Department of Design of the Politecnico di Milano in the international context. Recognised as one of the leaders of design research in the world – ranked 5th in the QS World University Rankings by Subject 2022 "Art and Design"[1] –, it has been the main actor in many of the most advanced and controversial issues that have characterised the design research debate during the last two decades.

In the following are the keywords elaborated in 2015 on the delivery of the new Department website to describe its research, and validated during the Department production conference. The keywords are the result of a bottom-up process through which each researcher of the Department contributed with their keywords. The list obtained was later systematised and validated, resulting in 113 keywords as a sort of self-portrait of the Department.

[1] topuniversities.com/university-rankings/university-subject-rankings/2022/art-design

The keywords used by the Department to depict its basic research activities provide a vivid picture in terms of (1) contents, (2) approaches, and (2) subject areas (tab. 3.1).

Contents. In terms of contents, the work of the Department is outlined through nine areas, framing a multi-layered and extensive contribution on design matters. "Arts & Humanities" portrays the contribution in terms of design history, visual arts, cultural heritage, with a focus on museum studies, and cultural and creative industries. It also includes studies related to aesthetics, semantics and semiotics. "Design & Management" gathers, on the one side, explorations on change management and design policy; on the other, product performance, service assessment, and competitive advantage. "Health & Safety" represents the investigations related to design for older people, subjective well-being, safety and prevention converge, extending to fundamental research on risk evaluation. The research in this area also includes investigations on wearable technologies and smart systems such as sensors, home automation, control systems. "Knowledge Management" contains studies on communication process and information design, with specific focuses on data visualisation, as well as on digital archives and platforms. "Production Models" pictures the Department's inquiry on (new) craftsmanship, digital manufacturing, distributed and open microproduction, with focuses on local craft and made in Italy. The research related to production processes is then completed with studies in the two directions of materials and networks. "Representation Systems" points out the investigation on the role of drawing in the design process, as well as the Department's contribution in terms of computer aided design, researching on augmented reality, virtual reality, and virtual models, as well as design methods and processes such as reverse modelling and parametric design. "Responsible Development" reports studies on environmental and life cycle design, zeroing in on comprehensive matters of sustainable energy and lifestyle. "Social Innovation" is portrayed as an extended area looking at the matter in terms of collaborative services, corporate social responsibility, welfare, also including games for social change. The Department's contribution on the matter is further enriched by specific research on perspectives on disintermediation and gender issues. Ultimately, "Urban Landscape" mirrors the advanced studies on smart city and urban spaces, with explorations on the two directions of mobility and traffic management, and spatial design and temporary living.

Approaches. The Department's contribution unfolds through three areas: design approach, process and methods, and design research. "Design approach"

Tab. 3.1 – Keywords gathered grassroots from the community of the Department of Design in 2015 to describe its research.

Typology	Topic	Department Keywords
Contents	Arts & Humanities	Aesthetics Cultural and Creative Industries Cultural Heritage Design for Cultural Heritage Design History Museum Studies Semantics and Semiotics Visual Arts
	Design & Management	Change Management Competitive Advantage Design Policy Product Performance Service Assessment
	Health & Safety	Design for Older People Design for Subjective Well-Being Risk Evaluation Safety and Prevention Smart Systems Wearable Technologies
	Knowledge Management	Communication Process Data Visualisation Digital Archives Digital Platforms Information Design
	Production Models	(New) Craftsmanship Digital Manufacturing Distributed and Open Microproduction Local Craft Made In Italy Materials Networks
	Representation Systems	Augmented Reality Computer Aided Design Drawing(S) Parametric Design Reverse Modelling Virtual Models & Virtual Reality
	Responsible Development	Environmental Design Life Cycle Design Sustainable Energy Sustainable Lifestyle

(continued)

Typology	Topic	Department Keywords
	Social Innovation	Collaborative Services Corporate Social Responsibility Deintermediation Games for Change Gender Issues Welfare
	Urban Landscape	Mobility Smart City Spatial Design Temporary Living Traffic Management Urban Spaces
Approaches	Design Approach	Co-Design Creativity Cross-Cultural Research Design Driven Innovation Design for All Design Thinking Emotional Design Experience Design Metadesign Strategic Design User Centred Design
	Design Process and Methods	Case Studies Decision Making Envisioning Ethnography Interdisciplinarity Mapping Product Development Prototyping Scenarios Storytelling Transmedia Practices
	Design Research	(Design) Education Design Theory Epistemological Research Phenomenological Research Reflective Practice

(continued)

depicts the research that explores design thinking and its application, design driven innovation, user centred design, metadesign and co-design, showing the presence of studies focusing on creativity, cross-sectoral and cross-cultural research. It also highlights how the Department leads research on design approaches, such as strategic design, experience design, design for all, and emotional design. "Design process and methods" reports on the variety of meth-

Typology	Topic	Department Keywords
Subject Areas	Communication	Basic Design Brand Communication Communication Design Game Design Graphic Design Interaction Design Media Studies Movie Design Packaging Design Synesthesia
	Interior	Exhibition Design Hospitality Design Interior Design Lighting Design Private and Public Spaces Retail Design Urban Design Yacht Design
	Service	Product Service System Service Design Transportation Design
	Fashion	Fashion Design Jewellery Design Knit Design Textile Design Texture Design
	Product	Car Design Colour Design Ergonomics Furniture Design Lighting Product Design Product Design Usability

odologies investigated by the Department. The research on methods ranges from prototyping, ethnography, case studies, scenarios, mapping, storytelling, showing extended application, such as to processes of decision making, product development, transmedia practices, envisioning. Here it is noteworthy to notice that interdisciplinarity emerges as a specific area of research. Finally, "Design research" draws attention to reflective practice, (design) education, design theory, epistemological and phenomenological research as typologies of research on which the Department contributes to create knowledge.

Subject area. To conclude the exploration, the Department participates in building knowledge through its basic research on five subject areas, which

are the five umbrella domains through which the Bachelor of Science of the School of Design executes its educational offer: Communication, Interior, Service, Fashion, and Product. "Communication" pictures how the Department plays a role in advancing research related to basic design, communication and interaction design, graphic and movie design, packaging and game design. The research unfolds through various domains, such as brand communication, media studies, and synesthesia studies. "Interior" points out the contribution on interior and urban design, exhibition, lighting, and retail design, hospitality design, yacht design, and research on private and public spaces. The participation in the discourse on "Service" is depicted as related to product-service-system design, service design, and transportation design. In the area of "Fashion", the Department advances knowledge on fashion and knit design, textile and texture design, and jewellery design. Ultimately, "Product" describes the contribution in terms of ergonomics and usability, product design, furniture design, colour design, lighting product design, and car design.

This chapter explores the **topics and areas addressed by the funded research** in the Department of Design, obtaining a snapshot of the issues addressed, their dimensions and results achieved, as well as their relation to the research of the Department. The relevance of the study lies in the fact that rather than individual studies, research programmes are ultimately accountable for progress, igniting advances in knowledge by generating new contents and opening up new problems (Koskinen et al., 2012). Given this premise, the chapter ambition is to build the landscape of the competitive research the researchers of the Department are carrying on and to gain some insights about how topics supported by funded research influence and orient basic design research by individualising continuity/discontinuity and deviations between the two.

3.2 Data collection and analysis

To answer the interrogations, the analysis unfolds from the elaboration and clustering of keywords describing the research projects[2], obtaining a comprehensive overview of the topics covered. For this purpose, the research projects are here specifically explored through the keywords used to describe them. The dataset consists of 159 keywords, validated through the

[2] Methodological note: as described in chapter 2 the funded research projects are analysed as qualitative case studies. As a consequence, when speaking of funded research projects, the reference is to the case studies developed on them.

project's principal investigators and analysed to be thematically aggregated through a bottom-up approach. The clustering process started from analysing the keywords aiming at identifying common trends and macro-topics, which allowed the identification of preliminary thematic clusters. Through an iterative process of refinement and polishing, 22 clusters are mapped: 21 thematic clusters plus "Specific from project", which contains keywords so specific to the project that they could not be included in other groups. Tab. 3.2 reports the clusters and the quantity of keywords belonging to each of them, while fig. 3.1 displays the 32 research projects, the reference to their funding program, and their descriptive keywords coloured according to their cluster of belonging.

Tab. 3.2 – Thematic clusters and number of keywords belonging to each of them.

Cluster	Keywords
Advanced manufacturing	2
Capacity building	9
CCI	7
Communication	3
Design methodologies	25
Distributed production	11
Documentation	3
Education	10
Entrepreneurship	7
Ethics	7
Fashion	5
Health	11
ICT	10
Innovation studies	10
Material	5
Public sector	6
Public spaces	3
Service	4
Social innovation	6
Sustainability	5
Transportation	4
Specific from project	6
Total: 22	**Total: 159**

Acronym [Program]	Keyword 1	Keyword 2	Keyword 3	Keyword 4	Keyword 5	Keyword 6	Keyword 7
L'architettura in Lombardia dal 1945 ad oggi [REG / POR FSE]	Design for cultural heritage	Digital archive	Art and architecture catalogue	Design history	Digital platforms		
DIGIKNIT [REG / BANDO CREATIVITÀ]	Cultural Creative Industries	Knitwear design	Digital archive	Capability building			
DigiMooD for CCI [EU / CREATIVE EUROPE - MEDIA]	Digital Entrepreneurship	Fashion Industry	Creative industries	Educational module	Design-led research		
CREA [EU / H2020 - INDUSTRIAL LEADERSHIP]	Innovation and Entrepreneurship	Design thinking	ICT	Educational model	Creative industries		
CO-CREATE [EU / INTERREG MED]	Cross-fertilization	Design-driven innovation	Creative industries	SMEs and entrepreneurship	Knowledge transfer		
BRIEFING [EU / H2020 - FET]	Future and Emerging Technologies (FET)	Training	Business value creation	Innovation ecosystem			
DeFINE [EU / COSME]	Design and Entrepreneurship	Fashion-Tech	Creative industries	Design-led research			
Edu4FT [EU / ERASMUS+ / KA2]	Fashion-Tech	Design Process	Creativity and Culture	Digital Technologies	Innovative Curricula		
FashionSEEDS [EU / ERASMUS+ / KA2]	Fashion Design Education	Transformation	Fashion Design for Sustainability	Design thinking	Innovative Curricula		
LeNSin [EU / ERASMUS+ / KA2]	Design for sustainability (DfS)	Open access learning resources	Curriculum development	Sustainable Product-Service Systems	Distributed Economies (DE)		
MaDe [EU / CREATIVE EUROPE - CULTURA]	Materials knowledge	Material interpretation	Material narratives	Circular economy	Speculative design		
LDI [NAZ / Accordo di collaborazione]	Industrial lighting	Sustainability	Well-being	Visual comfort	Working fatigue		
NUVOLE [REG / BANDO CREATIVITÀ]	Yacht design	Ergonomics	Advanced manufacturing technologies	Modern materials	Aesthetics		
C-Roads Italy [EU / INEA - CEF]	Mobility	Connected and automated transport	Cooperative intelligent transport systems (C-ITS)	Vehicle to everything	Impact assessment		
Nestore [EU / H2020 - SC]	Healthy ageing	Virtual coaching system	Co-design	Intelligent decision support system	Multi-domain monitoring system		
POD [NAZ / INAIL - ERANET - SAFERA]	Environmental monitoring	Personal protective equipment	Respiratory diseases	Wearable device	Working environment	Behavioural change	
DesFromIdeasToMarket [REG / BANDO CREATIVITÀ]	Hands-on experimentation	Interactive furniture	Technological upgrading	Making	Local SMEs		
PUDCAD [EU / ERASMUS+ / KA2]	Universal Design	New learning and teaching methods	Disabilities and special needs	Open and distance learning	Game-based learning		
DDMP [EU / CREATIVE EUROPE]	Distributed design	Designers	Makers	Indie innovators	European Fab Lab network	Openness	Emerging creatives
TAMBALI FII [REG / POLISOCIAL]	Start-up incubation	Technological-social	Additive manufacturing technologies	DIT materials	Training		
campUS [REG / POLISOCIAL]	Social innovation	Community-centered design	Knowledge transfer management	Co-design	Participatory action research		
Human Cities [EU / CREATIVE EUROPE - CULTURA]	Participatory design	Co-design	Design for social innovation	Community-centered design	Public spaces		
Cascina 9 [REG / Fondazione Cariplo]	Action-research	Capacity building	Social innovation	Participatory design	Storytelling		
Tango-Down Athena [REG / FONDAZIONE SAN PAOLO]	Participatory design	Storytelling	Context-based research	Situated research	Design futures		
FIRE [EU / MIGRATION & HOME AFFAIRS]	Illicit firearms trafficking	Policy	Fighting crime	Prevention	Mapping	Data knowledge	
CIMULACT [EU / H2020 - SWAFS]	Public engagement	Participatory/ Participation	Responsible Research and Innovation	Public participation			
Eupolis [NAZ / Accordo di collaborazione]	Public administration	Digital transformation	Organisational change	Digital strategy	Educational programme		
Includi.MI [REG / FONDAZIONE CARIPLO]	Social innovation	Social entrepreneurship	Design for policy	Milan	Social impact investment		
SDIN [EU / H2020 - MSCA-ITN]	Service design	Service innovation	Training framework	Interdisciplinarity	Doctoral program		
SISCODE [EU / H2020 - SWAFS]	Responsible Research and Innovation	Co-creation	Policy-making	Innovation ecosystem	Design-driven innovation		
DiDIY [EU / H2020 - INDUSTRIAL LEADERSHIP]	Open Source hardware and software	Ethics of digital transformation	Do-it-yourself technologies	Individual and social creativity			
WeMi [REG / Fondazione Cariplo]	Communication Design	Welfare	System of variable identity	Physical-Digital services	Hybrid territories		

CLUSTER

- Advanced manufacturing
- CCI
- Capacity building
- Communication
- Design methodologies
- Distributed production
- Documentation
- Education
- Entrepreneurship
- Ethics
- Fashion
- Health
- ICT
- Innovation studies
- Material
- Public sector
- Public spaces
- Services
- Social innovation
- Sustainability
- Transportation
- Specific from projects

Fig. 3.1 – The research projects, their funding program, and their descriptive keywords, coloured according to the cluster of belonging.

3.3 The topics of the funded research

The topics have been first organised into a polarisation that distinguishes between specific sectors of investigations as *vertical topics* of inquiry and *horizontal topics*, transversal domains of inquiry as they refer to research that can inform different vertical sectors. The 22 thematic clusters have been positioned depending on such polarisation and then further displayed according to their relatedness, using proximity to indicate how close or distant they are from one another (figs. 3.2 and 3.3), and size to indicate their populousness. The side of the polarisation of the *horizontal topics* contains 10 clusters and 82 keywords, while the side of the *vertical topics* includes 12 clusters (11 thematic clusters plus "Specific from project") and 77 keywords.

3.3.1 The horizontal topics

This set of topics taps into two of the design research typology that Frayling (1993, p. 5) individualises, as they focus both on the process of design and design approaches and tools (Research into Design); as well as on design as a research method for gaining knowledge, using it as a way of thinking and addressing matters beyond design itself (Research through Design). In general, horizontal clusters show a certain degree of continuity with the Department's basic research as they include design methodologies, design education, public spaces, sustainability, and ethics, which represent historical themes of investigation within the large context of the discipline of design. However, in the framework of funded research, the continuity gives way to more discontinuous practices, since projects quite often reorient established research scopes beyond the need to serve the discipline per se toward a role of collaborating with and supporting other disciplines (as testified by the use of the outputs of research). Horizontal clusters also include emergent research areas such as innovation studies and entrepreneurship. Even though they testify a tradition, more in the practices than in academia, of design to collaborate with entrepreneurs and the world of industry, here they underline an innovative scientific collaboration that has emerged during the last decade: the one between design and management (S. Colombo et al., 2017).

Design methodologies. Nevertheless, the varied nature of the projects, design methodologies are a common thread, representing the most prominent area through which the Department contributes with its funded research. As such, the area reveals the Department's ability to attract funds that require the

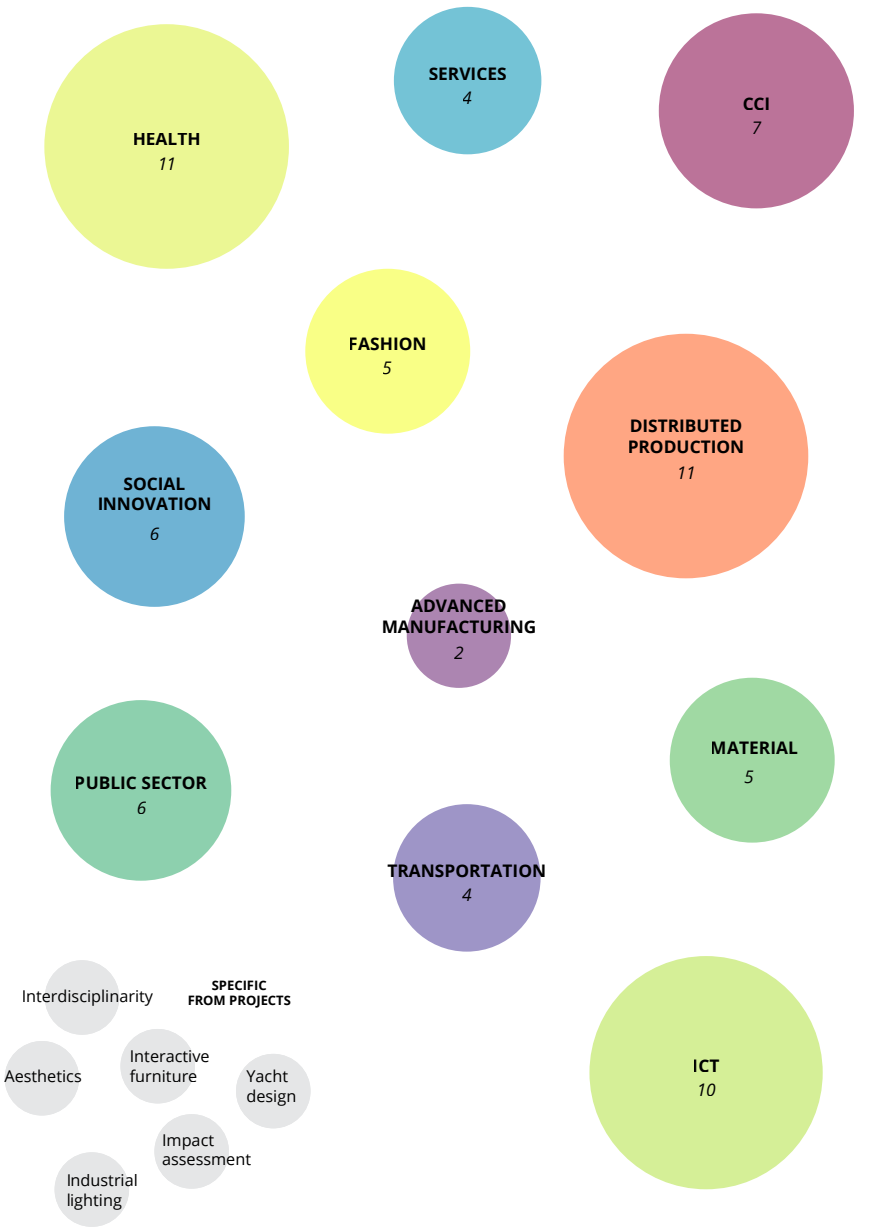
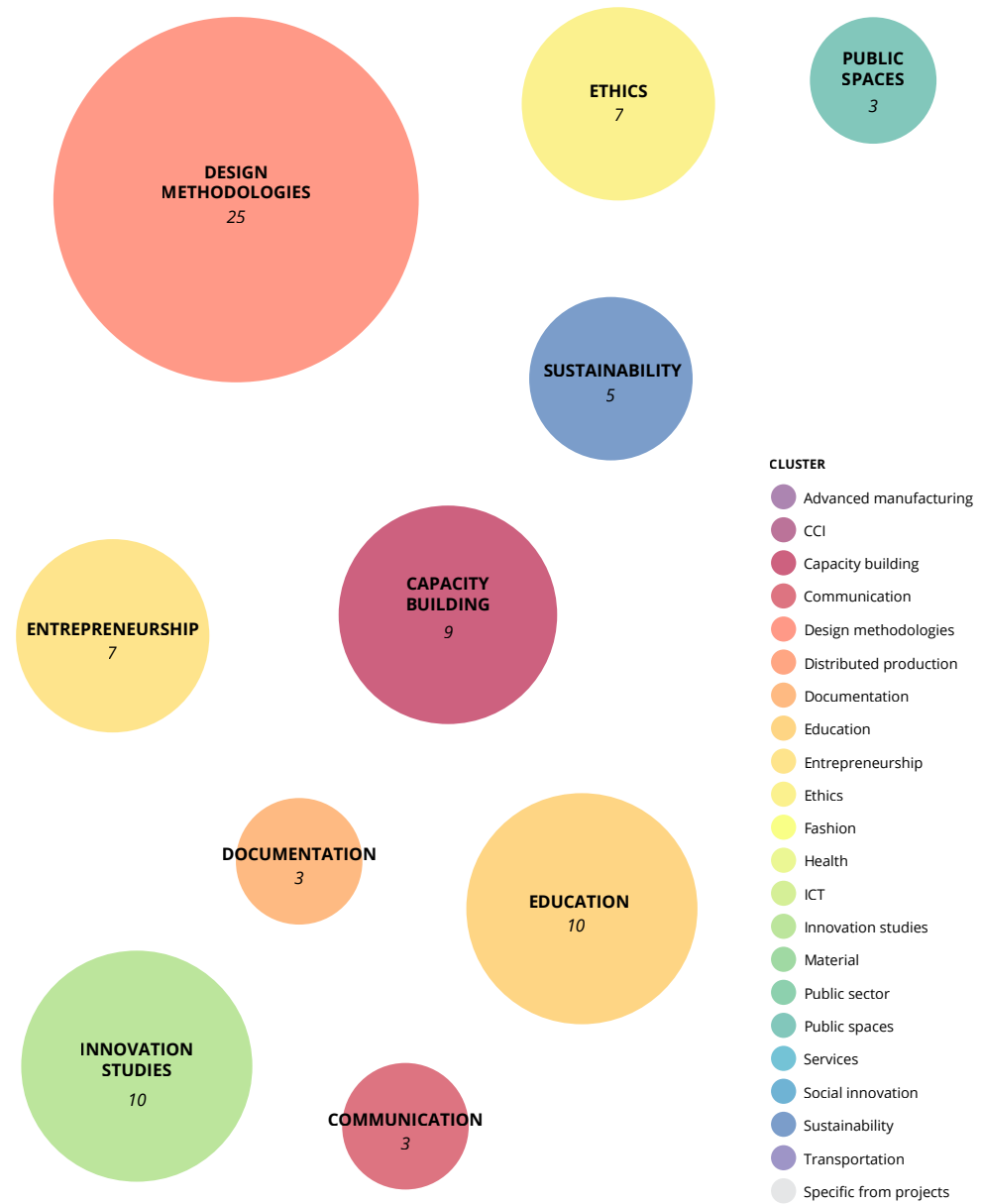


Fig. 3.2 – The 22 topic clusters displayed according to their polarisation and relatedness.



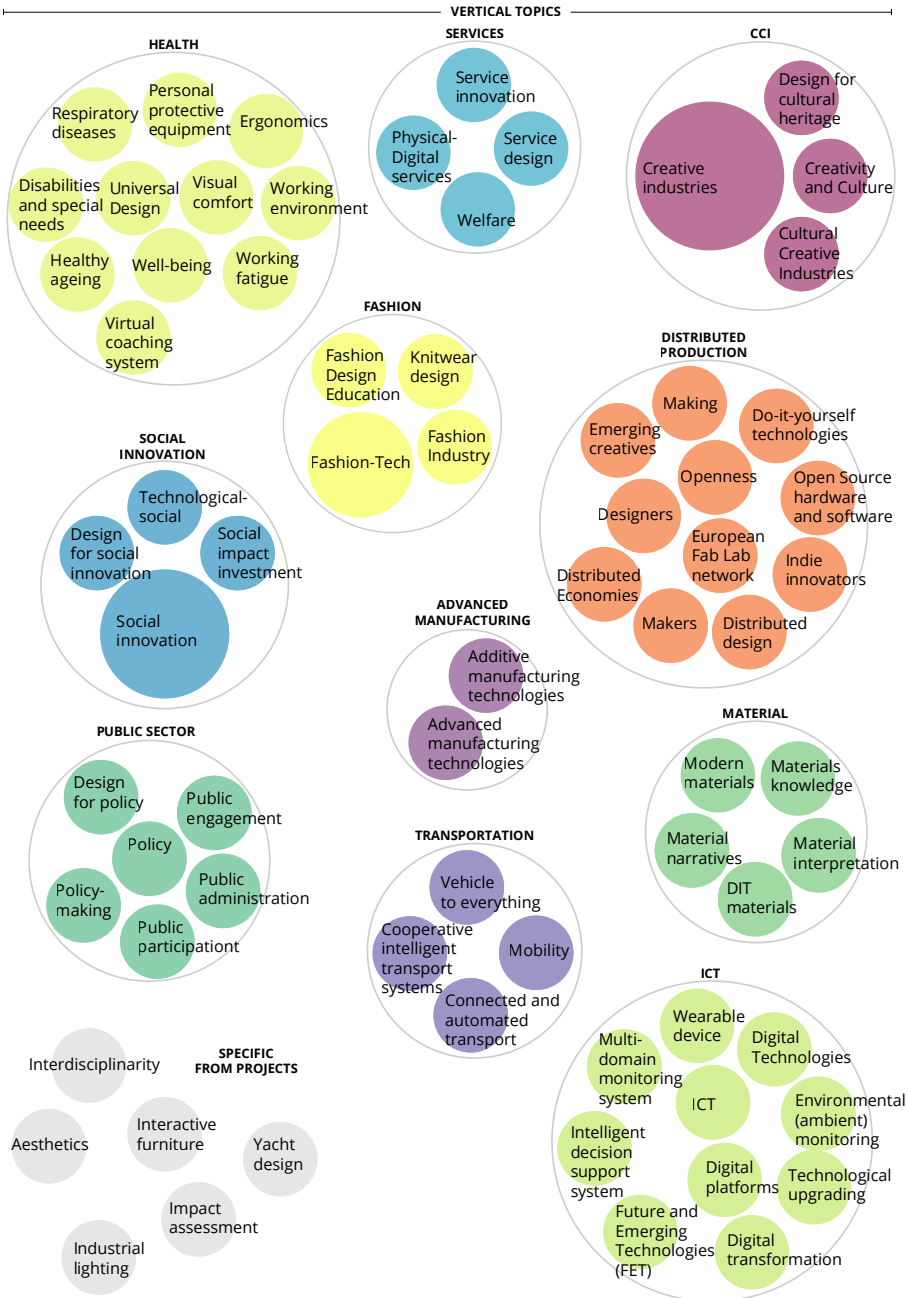
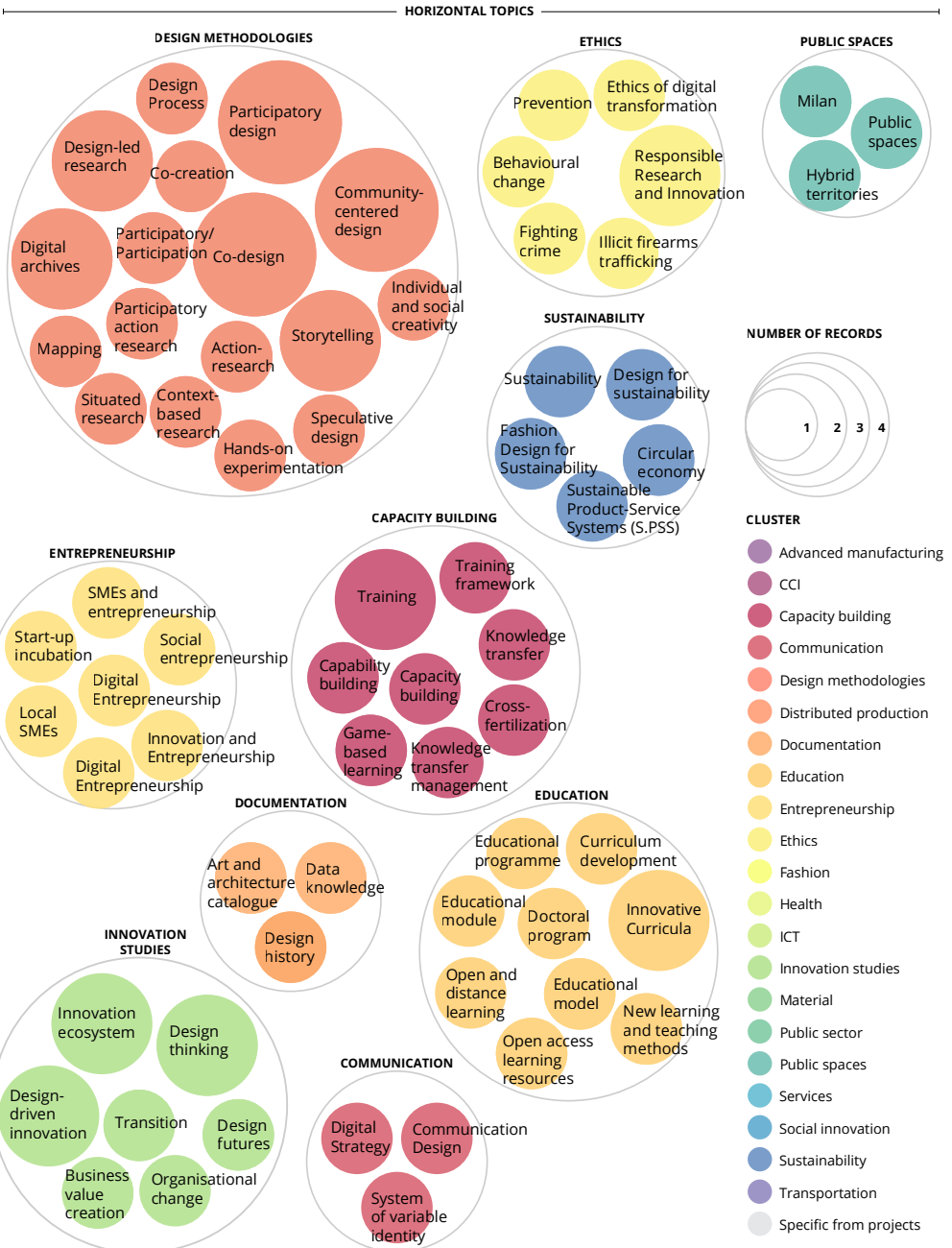


Fig. 3.3 – The keywords constituting the 22 topic clusters and those specific from projects.



application of design methodologies and processes. From participatory design and citizen engagement practices, co-design and co-creation (Deserti et al., 2019; Rizzo & Deserti, 2022), to action research and hands-on experimentation, speculative design, and situated research, the area shows the Department's tendency to highly take into account the context in which the research takes place in terms of features and communities. Moreover, it specifically points out the presence of an established and systematic value-centred approach committed to involving final users and stakeholders in processes to shape a better and more desirable future. The area is cross-cutting in terms of scale and subject matter: from the local to international scale, design methodologies are applied to address challenges ranging from the social to the technical domains.

Education. The cluster highlights a research area that concerns the design of innovative training curricula and frameworks, showing an active commitment toward shaping a new generation of designers as agents of change on matters of relevance, extending from traditional and cross-cutting topics to urgent and pioneering ones (Deserti et al., 2018; Buratti et al., 2018; Maffei & Villari, 2004; Parisi et al., 2017). Among the others, sustainability and circularity, responsible innovation, technology applied to fashion, health, materials and new production processes (Carulli et al., 2017; D'Itria & Colombi, 2022; Zhou et al., 2021). The analysis also points out how education extends to policymaking, aiming to favour innovation shaped by synergic social, cultural, and economic strategies rather than being mainly technology-driven. In particular, it emerges how the Department is able to bridge with industry (Bertola & Vandi, 2020) and the public sector, timely addressing and even anticipating their needs. In this landscape, design research and design methodologies are employed and appropriated to train for designing valuable products, services, and systems, while ensuring social and economic sustainability and desirability (Bertola & Colombi, 2021; Bucchetti & Casnati, 2022; Canina et al., 2018; Ferraro & Pasold, 2020). The analysis also points out how the research on education is profoundly multidisciplinary, with a predominance of design-driven approaches that engage relevant stakeholders to build more effective and systematic activities and strategies. The projects report on different education modalities (synchronous, asynchronous, open and distance learning) (Bertola et al., 2020), mainly engaging learners in problem-based learning and learning by doing.

Capacity building. The cluster shows an interesting shifting of the focus of research on design education: from the designers' curricula to capacity building on design knowledge (processes, methodologies, and tools) to

deal with innovation management and implementation in private and public organisations. The clusters show the fundamental Department's contribution in connecting the innovativeness of the design approach firstly to education (historically bonded to the notion of learning by doing and learning by projects) with the most advanced scenarios. Secondly, to better bridge education and industry (Bertola & Vandi, 2020; Taverna et al., 2019; Vignati & Carella, 2018) or answer the unmet needs of capacity in industries and the public sector in order to develop innovation in real contexts instead of in laboratories. The cluster of capacity building precisely demonstrates the Department's ability to enter into specific contexts with a design-driven approach and provide contextual and situated training on design-related competencies through their implementation in the project. The cluster also contains keywords on knowledge transfer that refer to projects focused on how the Department of Design transfers its knowledge, namely by cross-fertilization and management (Fassi et al., 2019; Casciani, Colombi, Chae et al., 2021). Beyond simply transferring insights or technologies among sectors, attention is drawn on capitalising, systematising, and operationalising design thinking, cross-fertilisation and knowledge transfer management to pollinate other innovative and traditional domains. Ultimately, the analysis shows how through its projects, the Department's contribution also orients toward unusual themes for the discipline, as for instance, how to deal with education of employees in public or private organisations to support the development of new competencies.

Public spaces. The cluster is currently a relevant thematic area, previously mostly enquired by urban scholars and architects and currently reclaimed. The re-entry of the area in the design research specifically points out the need to address public spaces as services and/or service-related context of interaction on the one hand (Concilio & Rizzo, 2016), and policy design (Mortati & Maffei, 2018), policymaking and governance on the other. The topic is addressed at various scales and levels, corroborating that the Department manages to attract funds that intercept the need to profoundly innovate the public sector at different levels: services, culture of service design, as well as with a very close relationship to the physical context where it is located, as well as with other cities and networks of cities to experiment in the urban space. Confronting challenges that communities, society, and institutions face, the Department proves to be able to include and work with the socio-cultural city assets, involving multi-level stakeholders from the framework of the quadruple (Galvao et al., 2019; Peris-Ortiz et al., 2016) and up to the quintuple helix (Carayannis et al., 2012; Carayannis & Campbell, 2010) – academia, industry, public sector, civic society, and natural environments of

society. In so doing, the Department demonstrates to be able to successfully address environmental aspects for a more sustainable socio-ecological urban and twin transition (Muench et al., 2022). Relying on action-research and participatory design, it achieved a win-win situation that put the foundation of the design for public spaces at the intersection of ecology, knowledge and innovation, encouraging crucial synergies between economy, society, and democracy. Among the most relevant implications, considering and transferring cultural values oriented to innovation and change, and developing urban strategies able to sustain innovation at multiple levels.

Innovation studies. This cluster emerges from keywords related to the intersection between design and discipline, such as management, sociology and psychology, from one side, and engineering from the other, striving to investigate the role and relevance of emerging innovations in addressing societal problems. Innovation studies constitute a long-preserved content area which emerges as one of the Department's competitive features, demonstrating its ability to compete with other disciplines that historically preside over it – such as management. The main contributions resulting from the cluster regard design-driven innovation and design thinking, the study of favourable conditions to create value and support the development of innovation ecosystems, the experimentation of how design-related practices and methodologies can contribute to transformation and organisational change (Deserti & Rizzo, 2014), and ultimately how design methods can support envisioning practices. Although studies on innovation have been present in the field of design theories for a long time, this cluster shows the recent capacity of design to attract funding connected to applied research.

Entrepreneurship. The cluster of entrepreneurship mirrors how design can bring and add value to entrepreneurial activity of various natures in its different phases (S. Colombo et al., 2017; Dell'Era et al., 2020). Central is the strategic role of design practice in supporting entrepreneurship and fostering business, recognising the contribution of design-driven entrepreneurship. Acknowledging the challenges and opportunities of embedding design within different entrepreneurial contexts (Telalbasic, 2021), the cluster maps the multiple ways design research enables, activates and sustains innovative, cross-cutting, and also provocative and new ideas (Vignati & Carella, 2018). Design is applied in projects that aim to create new value and business models as a core for establishing new enterprises, favouring innovation through cross-pollination among disciplines and sectors. The cluster includes research projects often based on practising the design process with

an application that extends from local SMEs and start-up incubation to activate multi-level entrepreneurial ecosystems, to digital entrepreneurship for the creative and creative industries, up to social and sustainable entrepreneurship, hence supporting social, cultural, and environmental enterprises.

Ethics. Another cluster which more consistently surfaced in the last decade is ethics. There is evidence of appropriation and streamlining that is denoted by a move beyond the usual and traditional exploration of the topic in terms of ethics of the process or the design act in the strict sense, in favour of a deeper and more transversally focused approach. The cluster shows how the research in the Department investigates the topic in terms of Responsible Research and Innovation (RRI), involving society in science and innovation to involve multiple actors, including civil society, in science and innovation to better align scientific practices and results to real needs (Rizzo & Deserti, 2022; Wetter-Edman et al., 2014; Meroni, 2007). It focuses on the transformative potential of design (Sangiorgi, 2011) in terms of behavioural change (Ferraro et al., 2018; Perego et al., 2020), vetting into how persuasive technologies and information design can persuade toward more ethical behaviours on the one hand (Ferraro et al., 2017; Bruno et al., 2021), and provide access to more understandable and usable information on the other (Mauri et al., 2017). The ethics of digital transformation is also specifically considered, and revolves around principles and practices to responsibly develop and implement digital technologies while driving innovation able to better respond to needs and emergencies (Mariani et al., 2023). Ultimately, the topic extends to prevention, looking at how data and their visualisations can be exploited to generate knowledge to prevent or restrain crime. Therefore, going beyond prior attitudes that mainly looked at ethics in terms of research processes and results, the research investigates novel trajectories, shedding light on how design can contribute and impact the society and the environment.

Sustainability. Instead, although sustainability is a world-wide burning and pressing topic particularly addressed by the Department, it is not as represented as expected, considering the Department interest on the topic. The cluster shows that specific attention is drawn on the issue of evaluating the impact and possible application scenarios of technologies and innovation in order to improve the everyday life impacting on people, their products, and environments. Through applied research, sustainability is explored in terms of how improved product-service-systems can positively impact productivity and comfort, reducing the risk of accidents and increasing efficiency and wellbeing. The collaborations activated through research projects often

entails relevant national actors able to generate impact on national policies and regulations. In terms of circular economy, the topic is also covered in terms of materials and responsible design (Pollini & Rognoli, 2021; Romani et al., 2021), investigating how designers can play as agents of change, able to design, redesign, reform, reuse, and redefine materials giving them new purposes, and therefore advising, educating and communicating their possibilities towards positive social, economic, political, and environmental change across all sector. Ultimately, the topic of design for sustainability is also addressed in terms of education, playing an active and frontline role in training and promoting a new generation of designers and design educators able to effectively support and drive the transition towards a (more) sustainable society for all (Brown & Vacca, 2022; Santulli & Rognoli, 2020).

Communication. The cluster depicts mainly projects that are targeting the public sector and its administrations. Projects in this area focus on the development of communication digital strategies to support the digitalisation and digital transformation of Public Administrations. Design practices as the assessment of citizens' sentiment are introduced to orient the design and implementation of marketing and communication strategies for digital media (Piredda & Ciancia, 2022). The research activities are oriented to investigate design-driven approaches and project-based learning, engaging the public administration personnel and private sector field experts to build more effective and systematic activities and strategies. They specifically highlight how such a cross-fertilisation among triple-helix actors has been a fundamental trigger for organisational and institutional change in terms of digital transformation. A second application is that of communication design for eradicating access barriers to public services and their spaces, favouring inclusivity by design (Bucchetti, 2017b, 2017a). Active listening and involvement of multi-level stakeholders lead to systems of variable identities that reconsider the role of services and their spaces for creating value through inclusive service-management logics.

Documentation. Ultimately, the cluster documentation refers to funds that support the reconstruction, systemisation, study and analysis of documents. The funded projects in this area provide a picture where traditional dimensions of art and architecture catalogues and design history coexist with contemporary and creative modalities of data knowledge and management. Documentation also regards heterogeneous, visual and location-based data produced by humans and machines, such as collections of user-generated contents, web imaginary, and geo-based data (Bach et al., 2018; G. Colombo et al., 2017).

3.3.2 The vertical topics

This set of clusters overlaps with the third design research typology identified in literature by Frayling in 1993 (Frayling, 1993, p. 5) as Research for Design. The clusters cover the funded research the Department conducts on knowledge-finding and evidence-based analysis to support the design as innovation of products, processes, services, and systems. Looking at these vertical topics, it is noteworthy to highlight the relevant presence of new and emerging topics of research, and the absence of those keywords that define the historical Department subject areas (see tab. 3.1), such as product, interior, communication and fashion design. Specifically, the clusters' description, in the following, shows a new formulation and dimension of the area of product. It disappears as a term or cluster per se, being inflected in other clusters such as advanced manufacturing, and distributed production. Similar reasoning occurs for the area communication that is mainly investigated through research funds under the clusters ICT and service. For the subject fashion, even though a cluster is still present, the funded projects testify new interests toward circular economy and new and more sustainable ways of producing and consuming. Finally, the subject interior is partially covered through funded research in the cluster Creative and Cultural Industries even though the transversal nature of the CCIs areas cannot allow for a strong identification with the notion of interior design.

Alongside the discontinuity and reorientation of the classical subject areas the set of vertical clusters also include new research topics on which, in the last decade, the Department of Design has played a strong leadership both for the capacity to orient the design research agenda as well as basic and to attract especially EU funds, these are: services, public sector, social innovation, ICT, transportation, health, Creative and cultural industries.

Services. Strictly speaking, the cluster is explicitly represented in the analysed case studies through four keywords. The direction is that of supporting systematisation and operationalisation at the intersection between service design and service innovation with multidisciplinary approaches that leverage creativity to foster innovation across the various areas of the public and private sectors, from physical to digital and hybrid services. The analysis of the cluster specifically highlights that the design of (complex) service systems is inherently and traditionally addressed by the Department valuing co-creation. The constant engagement of highly dynamic, complex, and heterogeneous constellations of stakeholders opened crucial reflections on how to address and manage the participation of multi-level actors featur-

ing various goals and motives, power dynamics and capabilities. Acknowledging this condition that further challenges innovation processes and their outcomes, the contribution of the Department of Design to funded projects is twofold. On the one hand, it addresses and supports the design of complex services favouring a user-centric and ecosystemic perspective for an intuitive and immediate access to services for all (Deserti et al., 2022; Meroni & Selloni, 2022; Rizzo et al., 2018). On the other side, specific attention is drawn on education and training programmes that at various levels shape designers and researchers as agents of change in the area of service design for innovation (Patricio et al., 2020; Sangiorgi et al., 2019). Even if the representation through projects that directly mention service/s as keywords is limited, it is necessary to emphasise how the area of service design and innovation spreads across several clusters, from health to social innovation.

Public sector. The cluster includes projects that pose growing attention to challenges regarding the development of new approaches to service design, delivery and provision, to the definition of its governance, and the capacity to effectively engage citizens in its processes. In these terms, the analysis of the funded research shows the extension of the notion of design to that of policy as a new design object is an object of design investigation and experimentation, which is often faced with the inclusion of end-users and stakeholders to create value and effectively respond to real needs (Meroni & Selloni, 2022). Public and citizen engagement thus emerge not only as a third mission to create new relationships with the territory and value to the society through public engagement activities, but rather as a specific area of research where co-design approaches are applied (Campo Castillo & Rizzo, 2020; Selloni, 2020). Consequently, it specifically demonstrates the ability of design to bring its specific value through the implementation of its methodologies and methods, in a manner which is often complementary to contributions from related disciplinary fields, such as policy design. The analysis also shows research activities to support the local administrations to improve the welfare conditions of its communities, supporting the development and growth of territorial support networks through the strengthening and involvement of social entrepreneurship in policy making processes. The application extends from design thinking and strategic planning upto service design, assessment and monitoring activities (Bianchi et al., 2022), often exposing the public administration to design practices and mindset, with significant implications such as the ignition of organisational and institutional change (Deserti & Rizzo, 2014).

Social innovation. The cluster social innovation pops up as rich and populated with practices by nature interdisciplinary. Specifically conducted applying participatory approaches, the funded projects highlight how the Department of Design is active and committed to support the development and Social Innovation solution from one side, and the other side to study this new area of application as a specific area of service design devoted developing collaborative solutions that should be sustainable in their contexts and that should answer to specific societal challenges stemming from bottom-up and unmet needs (Deserti & Rizzo, 2020; Meroni, 2019; Maffei & Bianchini, 2018). A distinguished feature that emerges is the deep bond with the neighbourhoods and territorial areas involved and the various actors engaged (Fassi et al., 2019, 2016; Fassi & Sedini, 2018; Deserti & Rizzo, 2020). Beyond the impact on the spaces, with actions that foster their resilience and development, facilitating the interaction, integration and social cohesion, the Department of Design brings specific methodological and procedural contributions (Deserti et al., 2022). This contribution is brought in two different manners, both explicitly meant to empower territorial actors by encouraging the acquisition of skills and competencies, consolidating the social capital of the multiple and multi-level actors involved, strengthening the connection and opportunities for collaboration (Meroni et al., 2018; Maffei et al., 2018; Menichinelli et al., 2020). Secondly, the contribution regards the design and implementation of training formats about design for social innovation (Piredda & Ciancia, 2022), for policy and for social impact investment, often supported by digital learning hubs, lessons learnt and handbooks, MOOCs, Interactive Guidebook for citizens, practitioners, and policy makers showcasing design-based learning frameworks and capacity-building courses. The training formats are built to favour knowledge sharing and transfer among multi-actors and multiple levels of governance, drawing specific attention on how diversities among stakeholders can positively impact the creation of value/innovation.

Creative and cultural industries (CCIs). Among the verticalities, another relevant cluster is that of creative and cultural industries (CCIs). Recalling that the timeframe of the case study analysis regards funded research projects is the period 2014 mid-2021, the area of CCIs mainly stands as distinguished from that of cultural heritage, with which it was originally and traditionally bound, following an Italian historical convention to include artisanship in the field of CCIs. The contribution of the Department that emerges from the projects concerns the support to sectors which suffer a lack of innovation by bringing strategic innovation to strengthen their competitiveness

in domestic and international markets (Zurlo, 2019). Specific attention is drawn to the definition of replicable and scalable learning models that jointly introduce creativity and ICT developments as drivers to ignite specific structural changes and arrangements in stagnant entrepreneurial tissues, favouring social and service innovation, and technology driven innovation, and leading to the development of innovative products for new and old markets (Cautela et al., 2022). The contribution presents an educational perspective that is supported by the development of a curriculum that links cross-cutting challenges (Bertola et al., 2020; Taverna et al., 2019).

Fashion. Partly overlapped with the former, the cluster of fashion is a specific sector in which the Department of Design conducts research. The analysis highlights a diversified approach to innovation in the fashion domain that extends from the contents to processes. Besides research to preserve and conserve heritages of technical knowledge and style through their digitisation, paramount are the areas of fashion-tech and sustainability (Bertola & Teunissen, 2018), underlying the Department's capacity to be a key player in bridging the fashion field with that of innovative technologies (Bertola, 2021). Fashion emerges as a mature sector embedding enabling and disruptive technologies such as digital fabrication, advanced manufacturing, wearables, sensors and embedded systems (Casciani, Colombi, Chae et al., 2021; Ferraro & Pasold, 2020); this is renewing fashion business models, service systems and consumption habits meaningfully intersecting creativity, technology, and entrepreneurial skills. Innovative and interdisciplinary educational modules (Casciani, Colombi & Vacca, 2021; Colombi & Tenuta, 2020) are designed to train digital entrepreneurship for the creative industries (Bertola & Vandi, 2020), with a specific application to the fashion field, in a context of social, civic and environmental responsibility (Brown & Vacca, 2022; Pal et al., 2022). Cross-cutting and cross-disciplinary training pathways aim at breaking the barrier between technologies and creative communities.

Advanced manufacturing. The cluster reports on advanced research on cutting edge manufacturing technologies, exploring materials for promoting entrepreneurial opportunities, product and process innovation. This trajectory complements growing research on new materials created through self-production practices, both creating new materials and building on existing ones (Romani et al., 2021). The analysis of the projects outlines a rooted interest in the topic, which is addressed through fundamental research as well as experimentations for technological, social, and economic innovation. Following circularity and sustainability principles, the basic research on new, bio, and

Do It Yourself materials (Romani et al., 2021) is accompanied by training and real-life implementations at various scales for transferring knowledge. The contribution of the Department of Design is wide and varied, with cross-sector field applications that go from advanced industrial and high-tech sectors to underdeveloped or developing countries. Additive manufacturing technologies and Do It Yourself materials are exploited to generate virtuous ecosystems that prompt synergies among multi-level local actors. Value is created by empowering people, strengthening the local supply chains, and promoting entrepreneurial opportunities that fuel social and economic growth (Canina & Bruno, 2019b). Specific explorations regard the enabling conditions and dynamics that develop in creative and innovative ecosystems that explore additive manufacturing and new materials actively engage quintuple helix actors (Carayannis et al., 2012). Design methodologies and material research are employed and appropriated to develop approaches and techniques for designing valuable products while ensuring social and economic sustainability.

Materials. The cluster portrays materials design and making as a striking cross-sector driving force behind innovation, capitalising on creativity to provide better circular economy solutions through the ideation of new materials (Karana, Barati et al., 2015; Karana, Pedgley et al., 2015; Ferraro, 2020). The case studies analysis highlights how the Department research on material contributes to advance knowledge on the topic of materials featuring innovative properties and qualities in terms of interactivity, connectivity and intelligence,Interactive, namely Connected, Smart Materials (Rognoli & Ferraro, 2022) providing methods, tools, and guidelines. The basic research on materials is deeply intertwined in the higher education context (Parisi et al., 2017). A specific contribution from the Department regards indeed the training of future material designers as future agents of change (Clèries et al., 2021), as well as with experimentations in the field to positively impact social, economic, political, and environmental change. On the one hand, the Department partakes in creating knowledge on the role of new materials and material designers as an emerging but crucial figure in an industry keen on incorporating a circular economy approach. On the other hand, material experimentation is applied to improve living conditions. Beyond the fine-tuning of design methodologies and developing techniques for innovating design products, material and do-it-yourself material design (Rognoli et al., 2015) is applied to generate a virtuous system that prompts entrepreneurial opportunities, fostering a process of social growth and economic independence. The transfer of consolidated training models is deeply intertwined with technological and social innovation, ensuring innovation and sustainability at different levels.

Distributed production. A related cluster is that of distributed production, which unfolds at the intersection of the two global trends of the maker movement and digitisation of design. In the last decade, the research of the Department of Design has particularly presided over the topic (Menichinelli et al., 2020), contributing to various extents to the development of the network, and supportive platforms, as spaces where microfactories, in the shape of makerspaces, Fab Labs and Living Labs, are mapped, community building and social inclusion are favoured, knowledge sharing takes place, project development is supported (Carulli et al., 2017; Menichinelli et al., 2017; Zanetti et al., 2015). The Department played a central role in enabling cross-sector fertilisation among design, production activities of designers and manufacturing SMEs. Particularly relevant is the support provided to creative common development (Bruno & Canina, 2019), such as open source hardware and software which are based on the concepts of sharing, reuse, and improvement (Bianchini et al., 2019). Pursuing a synergistic approach between craftsmanship and digitalization, prototype experimentation is put at the centre, together with relevant actors and stakeholders from the context (Maffei et al., 2018). Acknowledging that distributed manufacturing is prevalent on small scales, specific investigations enquired possibilities and conditions for multi-level scaling. The Department is proven to bring specific knowledge to embed in the practice the dimensions of sustainability and circularity, social desirability and responsibility, social equity and cohesion (Canina & Bruno, 2019a).

ICT. The cluster of ICT is a wide group that gathers the various contributions of the Department in relation to information and communications technologies, with studies that spread from future and emerging technologies and transfer of early stage development technologies among domains, to their extensive cross-sector applications. Instances are digital transformation (Ronchi & Ciancia, 2019), individual and environmental monitoring (Andreoni et al., 2022; Ferraro & Pasold, 2020; Studer et al., 2015; Ferraro, 2015), and intelligent decision support systems (Angelini et al., 2022), sustainable energy and transportation technologies, communication technology techniques for strategic planning, design and monitoring. The Department's contribution extends across the triple helix actors (Ranga & Etzkowitz, 2013). It favours cross-sector fertilisation, bridging ICT development, innovation and creativity in the entrepreneurial, public, and educational contexts, prompting exploration and exploitation in novel as well as traditional fields.

Transportation. A related cluster is transportation. It unfolds exploring the topical matter of ICT applied to mobility and connected and automated

transport in particular, concerning effective data exchange through wireless communication technologies between components and actors of the transport system to improve road safety and efficiency of transport. The cluster depicts ongoing research on testing and implementing cooperative intelligent transport systems (C-ITS) in a harmonised and interoperable way on specific applications such as highway chauffeur and truck platooning. Exploiting the vehicle-to-everything technologies, the Department of Design is involved in testing the technology and its implementation across Europe, zeroing in the evaluation of the impacts of such technology and alerts generated from the increased information available on mobility in real traffic conditions (Agriesti et al., 2019, 2020), bringing specific assessment expertise (Agriesti et al., 2018; Studer et al., 2018). Truck platooning is one of the major topics in transport science and freight transport. Parallel to the abrupt acceleration, the need to account for possible risks on the European network. In this landscape, fundamental field-tests are complemented with traffic simulation that reproduce truck platooning and allow reasoning on critical and best driving strategies (Agriesti et al., 2021). Beyond comfort of driving, the relevance of the cooperative and interoperabile aspect concerns its expected impact on traffic road safety, efficiency and fluidity, leading to a more efficient use of the infrastructure, energy efficiency decreasing and related emission reduction. Such a broad impact related to safety and environmental issues gathers the interest of public and private stakeholders, which are directly engaged to better support responsible and desirable innovation. Moreover, the economic impact implies considerations in terms of supply-chain logistics and management (Marotta et al., 2018).

Health. The cluster health covers different aspects of design in the context of wellbeing, from the scale of the individual to that of the work environment and everyday spaces. The analysis of the case studies highlights three main directions: better ageing, improved work environment, and universal design for disabilities and special needs. In a context where the ageing population is growing fast, health and wellbeing are strategically addressed to reduce the economic burden on welfare systems. The Department's contribution focuses on persuasive technology for behavioural change (Ferraro et al., 2017, 2019), and on the promotion of preventive policies for both healthy ageing and personal protective equipment. Extending from the physical to the virtual domains, the research explores the potentialities of tangible and intangible objects, wearable and environmental distributed sensors and system platforms providing situated and contextualised data, as well as software and apps enabling monitoring (Perego et al., 2020) and personalised coaching (Angelini et al., 2022). Secondly, the Department actively explores wellbeing in the working environ-

ment to contribute lessening work-related exposures which are estimated to account for occupational diseases (Sigsgaard et al., 2010) and accidents. The last strand of investigation taps into how universal design should be applied to provide inclusive and accessible environments for everyone, preventing isolation of vulnerable groups such as persons with distinct forms of impairment or limited motor functions from society (Costa et al., 2019). A topic addressed as part of the design education, engaging students in problem-based learning to trigger better awareness of accessibility (Buratti et al., 2018).

3.4 Continuity, discontinuity and interactions between the funded and the basic research of the Department of Design

To introduce the discourse springing from the comparison between funded research topics and basic research topics, further explored in the following discussion (fig. 3.4), the analysis portrays the presence of new entries together with topics that can be considered as outsiders. Namely, topics traditionally and formally far or not covered by the research lines of the Department of Design, which are becoming more and more present and pivotal. The following discussion builds on the interactions between the Department's research profile and the topics of its funded research over the last decade to

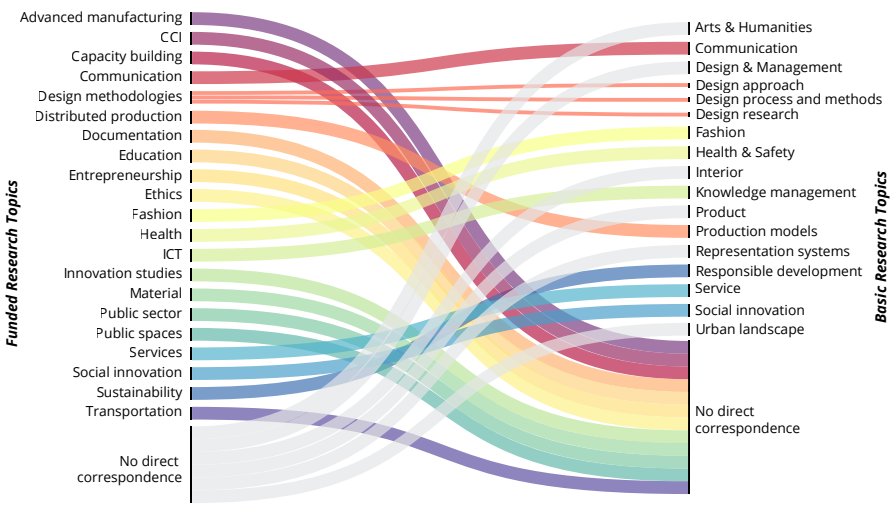


Fig. 3.4. – Relatedness between Department of Design's funded research topics and basic research topics.

gain some insights on their relationship, fuelling a fundamental reflection on the Department's research identity.

The continuity on the topic of methodologies and tools is not surprising, considering how the topic has historically always been present in the Department's research. The Department is indeed nationally and internationally recognised for its relevant contribution to scientific knowledge on methods, processes, tools and their domains of application, extending the domain of design to bring cross-sector innovation. Both in terms of funded and basic research, the analysis highlights a constant effort in the amplification of the disciplinary boundaries, demonstrated by the application of design-driven approaches and research methodologies to new or formerly considered far-away domains. As a consequence, design methodologies can be considered as a Department's competitive and distinguishing feature. Analogue consistency between the clusters of funded and basic research regards the topics of **Health & Safety**, **Production models, Sustainability/Responsible development, ICT/Knowledge management** and **Social Innovation**, although they articulate themselves very differently when exploring the keywords that constitute the clusters.

On the other hand, the basic research cluster of **Design & Management** gathers studies on change management, design policy, and assessment, which are consistently present in a distributed and transversal way across the funded research. Analogous situation concerns the basic research cluster **Urban landscape** that groups studies on mobility, smart city, urban spaces and temporary living, which are jointly objects of funded research depicted under the clusters of **Public space** and **Transportation**.

Both the vertical and the horizontal clusters show an ongoing amplification of disciplinary boundaries, with an inherent proneness to apply design knowledge-driven approaches and research to new or formerly "non traditional" considered far-away domains like for example, topics previously often enquired by urban scholars and architects and currently reclaimed, are that of public spaces as objects of investigation and design on the one hand, and policy design, policy-making and governance on the other. The reasoning extends to the public sector, which poses growing challenges regarding the development of new approaches to service design, delivery and provision, to the definition of its governance, and the capacity to effectively engage citizens in its processes.

Delving further into the comparison, it is noteworthy to discuss that the funded research clusters present specific investigation topics that cannot be directly correlated in the thematic clusters of the basic research. Recalling and expanding the reasoning introduced while presenting the vertical topics addressed by the funded research of the Department of Design, it is rele-

vant to emphasise that parallel to the occurrence of new areas, there is the disappearance of traditionally established domains of investigation. While congruence concerns the subject areas of **Communication**, **Fashion** and **Service**, the analysis highlights that domains such as **Product** and **Interior**, from which our educational curricula are also named, are no more thematic areas per se. That said, some clusters of the funded research detail the investigation on related basic research clusters. It is the case of **Advanced Manufacturing** that can be considered related to the basic research cluster of **Product**, providing a higher specificity on the typology of contribution brought by the Department. Among the reasons, the fact that the research in established domains such as product and service design, communication and interaction design achieved advanced levels of conceptualisation, complexity, and specialisation indeed, and they are pervasively present in the overall thematic areas. This condition can be interpreted as a progressive specialisation of the Department of Design on such topics. The research has evolved and articulated towards more specific areas, highlighting an attainment of such maturity and mastering that the topic becomes distributed and articulated in several subdomains of the discipline.

That said, what is particularly interesting to observe is the discrepancy between the areas in which the Department identifies itself through its basic research and the topics on which it receives funding and conducts projects, and vice versa. Although the Department is renowned for its long-lasting basic research and remarkable contribution on the topics of cultural heritage, which are part of the basic research cluster of **Arts & Humanities**, the topics are not explored through funded research. Analogously, the Department conducts relevant basic research on **Representation systems**, which is mostly absent from the funded research. Among the reasons, difficulties with basic research funding through PRIN funds – that are not among the sources of funds through which the Department is able to sustain its research. PRIN funds as well as EU funds use the ERC fields which groups disciplines to facilitate scientific research in the European system. However, design is not part of any grouping, implying that researchers need to submit their project proposals to other ERC sectors for being evaluated by experts not pertaining to the design discipline.

Surprisingly, nevertheless the Department actively researches multidisciplinary, learning-by-doing and problem-based learning methodologies to teach design principles, being word-wide recognised as a relevant player on the matter, the area of **Education** emerges from the analysis of the funded research but is not identified as a basic research topic, if not as the specific keyword of Basic Design, used in the cluster Communication.

The fact serves as an opportunity to open further the reflection on the relation between funded research, basic research, and education. The landscape resulting from the funded research shows diversity of approaches, foci, and philosophy, with contributions ranging from theory-driven to contextualised knowledge. However, it emerges as a matter of fact that, although design research successfully contributes to widening its investigation to new domains, it still struggles to enter and **impact the design curricula**.

Similarly, through its funded research, the Department shows a marked ability to conduct research out of its higher education context. It is quite relevant to notice how even when funded projects deal with traditional design topics as, for example, design education, the contribution of the design is reorientated toward an unusual theme for the discipline like how to deal with education of employees in public or private organisations to support the development of new competences. Rather than sustaining traditional design education research, the funded research has focused and supported the training in the area of innovation management, moving the target from student profiles to adults. Through life-long learning actions, the Department shows to play a key role in bringing design methodologies and approaches to the private and public spheres. This dimension, very pronounced in the context of funded research, is not present in basic research. This specific reorientation testifies the application of design knowledge to deal with processes of organisational transformation/change.

Then, the Department is recognised to be a cultural and creative engine for the local area, as testified by its rooted synergies with the civil society, the economic system, public and private institutions, and its role in supporting the application and transferring of knowledge and research results outside the academic community to sustain social and cultural growth. However, the Department engagement in the Third Mission often overlaps with the research with civil society and the third sectors, which are engaged to foster progress and boost innovation. This trait is vividly highlighted by the funded research that provides evidence of how participatory approaches are established and pervasive in the Department's research.

A further evident trend regards the strong convergence in funded research of design with engineering disciplines, demonstrating the capacity to bridge gaps, hybridise competences, and increase competitiveness. The trend also regards more traditional areas which are influenced by technological transformations, as it occurred for the fashion-tech and health-tech fields. This convergence is progressively redefining the perimeter of the design research,

enlarging its application contexts. Parallel to this strong and evident convergence, the absence of theorising from the Department's basic research and in the funded research. It is recognized that the Department brings new knowledge in terms of methods, processes, and outcomes, but not in the form of theories, opening a reflection in terms of future possible improvement.

3.5 Conclusions

Over the last decade the Department demonstrated an increasing capacity to attract European funding sources, outlining its multi-polar academic science and innovation potential and its role as a relevant player in design research at the national and international level. As discussed, the attraction of funds impacted the Department's research, reorienting some of its directions and making it progressively more capable to influence the ongoing changes, enhancing the potential of design.

Although it contributed to the advancement of scientific knowledge in terms of processes, methods, and tools, it still features theorising difficulties. This although projects and its educational context potentially provide a fertile space for fuelling iterativity and interactivity between theory-generating and theory-guided experimenting.

Ultimately, the comparison between the funded and basic research reported few overlapping of topics, showing difficulties in the spill-over of funded research into basic research. Innovative arguments addressed through research projects which often contribute to widening the topics of the Department's design research, still remain under- or unexplored directions in terms of basic research.

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4. The projects' outputs: the nature and their connection with outcomes and impacts

Venere Ferraro & Patrizia Bolzan
Department of Design, Politecnico di Milano

This chapter presents and illustrates the so-called outputs of the funded research projects, defined as results generated within the project's life span in the form of scientific publications, products, software, services and so on and aimed at meeting the outcomes and the research impact. More in detail, it explores the design research outputs, identifies, through clustering, their nature and discusses them through the investigation of thirty-two (32) funded research projects carried out at the Department of Design of Politecnico di Milano in the period between 2014 and mid-2021.

This analysis was performed to answer three main research questions: (i) which are the main typologies of outputs generated by the projects within the Department of Design? (ii) how the nature of the outputs is somehow related to the nature of design research and to the department's expertise, and finally, (iii) what kind of outputs are directly attributable to the outcomes and impacts? To this end, the text will describe outputs' categories, map the different outputs generated by the projects within the clusters by also presenting them in terms of numbers, and discuss the nature of the outputs connected both to the nature of the design research and the expertise of the Department of Design.

4.1 Defining the outputs of the funded research

The present contribution describes the outputs of the funded research projects within the Department of Design of Politecnico di Milano; identifies, through ***clustering, the nature of these outputs***; discusses the financed research outputs linked to the ***department's expertise***.

Navigating and understanding the panorama of the research projects is a complex task. First, while preparing and executing a research project, a need

for clarification about terminology is posed. In this regard, the Organization for Economic Co-operation and Development (OECD) has developed a glossary to increase the effectiveness of the execution of European Projects and strengthen European cooperation (OECD, 2010).

Three main words are relevant to research projects: ***outputs, outcomes, and impacts***. The correct meaning of each term is not exactly straightforward; there is the tendency to make a mistake between the meaning of outputs and outcomes and to overlap the term results with outputs one.

The truth is that they can be for sure used interchangeably to communicate, prove, and account for what ***has been achieved*** during a project lifespan and create the ***so-called Chain Results***[1] (see figure 4.1).

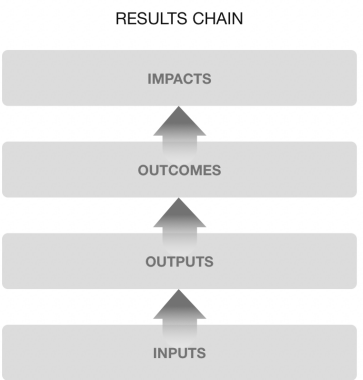


Fig. 4.1 – The Result Chain elaborated by the OECD.

Output, outcome, or impact (intended or unintended, positive and/or negative) are all clustered as results of a development intervention. In this results chain, inputs are used to carry out activities considered actions taken or work performed to generate the delivered outputs. The outputs can trigger changes (outcomes) that might or not activate relevant impact (Intrac, 2015). This means that each affects and influences the consecutive one since they are strongly interconnected and temporarily placed in the chain.

By looking at their meaning, we can define outputs as "*the products, capital goods and services which result from development interventions*".

They are generated by the action to which access can be given in scientific publications, data or other engineered activities and processes such as software, algorithms, protocols, and electronic notebooks.

[1] https://www.oecd.org/dac/results-development/what-are-results.htm

The outcomes are defined as "*the likely or achieved short-term and medium-term change and effects of intervention outputs*" (for further understanding, confront chapter 5).

Finally, the impacts are labelled as "*positive and negative, primary, and secondary, long-term effects produced by development interventions*" (for further understanding, confront chapter 6).

While exploring and deepening the topic of the research's outputs, we need to recognize the different typologies besides the term's meaning.

According to APRE – Agency for the Promotion of the European Research, there are six categories to group the outputs of the European research projects: (1) publications; (2) prototypes, artefacts, research datasets, and software; (3) patents, innovations, product & services; (4) methods & processes; (5) new companies; (6) exhibitions, performance.

The research projects investigated in this chapter are highly diversified. Among the thirty-two (32), we have one (1) national project, nineteen (19) European projects from different programs and thirteen (13) regional ones. Such multifaceted nature of research didn't allow us to use the codified clusters categorized by APRE, so, through a qualitative analysis of the projects, we used interpretative clustering to represent better the granularity of the outputs produced by the Department in the different typologies of projects. As a result, we obtained ***six categories***: analytical output, scientific output, tangible output, instrumental output, educational output, and performative output.

In this chapter, we describe the method used to extract the quantity, typologies of research's outputs and the qualitative approach to cluster them. We will then go through the results of the analysed projects by providing a map of the outputs and the types of outputs that emerged as the most.

In this regard, we will describe four exemplifying research projects chosen for their diversified nature in term of programmes, calls and typologies of outputs: 1) FIRE, Fighting Illicit firearms trafficking Routes and actors at European level – DG Home Affairs within the Prevention of and Fight against Crime (ISEC); 2) Cascina 9, Un progetto collaborativo per lo scambio di competenze, storie e produzioni creative fra attori del territorio – Fondazione Cariplo, Bandi Territoriali 2017; 3) C-Roads – CEF program 2014-2020 (Connecting Europe Facility), and 4) DiDIY, Digital Do-It-Yourself – H2020 Industrial Leadership.

A discussion section will follow dedicated to reason on: (i) the relation between the typologies of the outputs, the nature of design research and the department skills; (ii) the kind of outputs that are directly attributable to the outcomes and impacts**.** The contribution ends with several conclusions aimed at giving trajectories to future projects.

Fig. 4.2 – The sample of analysed projects.

4.2 Extracting the Data: outputs typologies, numbers and clusters

We analysed thirty-two (32) funded research projects (European, Italian, and regional) carried out at the Department of Design of Politecnico di Milano between 2014 and mid-2021. The sample of projects selection followed the methodology and criteria described in chapter 2 and the horizontal and vertical clusters by thematic areas presented in chapter 3 of this book.

The criteria used to select the 96 funded projects within the Department of Design in the time frame indicated above were the following ones:

- projects belonging to competitive research funding programs.
- involvement as coordinators or partners of departmental research groups.
- possibility to access documentation for creating the case study.

The sample of case studies consisted of 19 funded projects (including 4 Creative Europe, 7 H2020, 4 Erasmus+, 1 Interreg, 1 Cosme, 1 Inea Cef, 1 Migration & Home Affairs), 1 national-scale project for the development of digital strategies for public administration, and 12 projects from regional funding (among which 3 Bandi Creatività, 3 Fondazione Cariplo, and 2 Polisocial stand out as the most recurring funding). Figure 4.2 shows the sample of the projects in terms of program scale/typology and thematic clusters. Here we investigate the research projects through the lens of their outputs, more in detail, by looking at their nature and the connection with the essence of the design research and the link to outcomes and impact.

The focus on the research outputs appears to be relevant since, by looking at the results chain of the funded research projects and the impact pathway of the new Horizon Europe Programme (figure 4.3), the project's success stays in the achieved impacts even beyond the duration of a project.

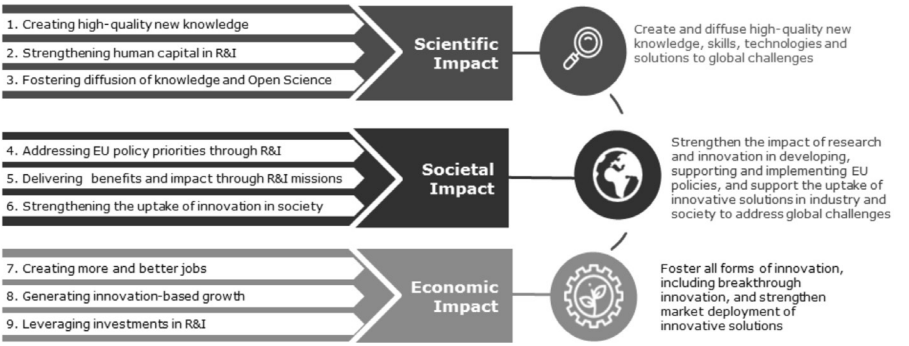


Fig. 4.3 – Impact Pathway of European Project.

The quality and nature of output are relevant for a project to succeed. Indeed, if, for instance, we want to reach a scientific impact, we will focus on specific outputs such as publications, new concepts, training and so on. On the other side, if we aim at having a societal impact, we will set into the project execution the elaboration of different typologies of outputs.

In this sense, the analysis of the 32 projects of the Department of Design, mentioned above revealed diversified samples of research outputs. The setting up of this list resulted from a two-level operation, at first bottom-up and then top-down, with a final qualitative validation phase.

In the first stage, we analysed the project proposal document and the final report of each research project; the research outputs were then extracted with the wording reported by the research groups that executed each project.

Once this stage was completed, we incorporated some subtypes into broader headings for a more consistent typological aggregation across case studies. Afterwards, we investigated the analysis further by confronting the principal investigators of each research project to validate the headings and integrate any preparatory outputs that may not have been evident within the documentation provided. This approach's result is the output list shown in alphabetic order in table 4.1.

The list can be considered as a catalogue of all possible research outputs that, at the year 2019, have been generated through research projects involving the Department of Design. Although the analysed sample included projects of different scales (both European and national/regional), it allowed us to detect the quantity and typologies of research output and its recurrence within the various projects. The elaborated list allowed us to cluster the different research outputs.

4.2.1 Clustering the outputs: a qualitative approach

Concerning the activity of clustering, we found the most structured and internationally recognized one proposed by the Agency for the Promotion of European Research (APRE), which recently categorises the outputs of the Horizon Europe research projects into six categories: (1) publications; (2) prototypes, artefacts, research datasets, and software; (3) patents, innovations, product & services; (4) methods & processes; (5) new companies; (6) exhibitions, performance.

We attempted to break down the multitude of research outputs produced by the Department within these six categories. However, the highly diversified nature of the 32 projects highlighted the limitations of this type of clustering.

Tab 4.1 – The list of research outputs collected through the analysis of the 32 projects the Department of Design conducted (alphabetically, on two columns).

Analysis (Benchmarking/Context Analysis/etc)	Master Courses/Class/School
Award	Matchmaking
Brand Identity	Methodology
Case Study	MOOC
Co-creation Session	Networking
Co-design Session	Online Consultation
Conference	Patent
Construction of Physical Space (Lab&Building)	PhD Thesis
Curricola/Learning Module	Pilot
Data Collection (Repository)	Platform
Dataset	Protocol (Method)
E-learning Course	Prototype
Educational Programme	Publication (Handbook/Booklet/Manifesto)
Evaluation Study	Questionnaire/Survey
Event	Recommendation
Exhibition	Repository
Focus Group	Scientific Publication
Framework	Seminar
Guideline	Software
Hackathon	State of the Art
Impact Evaluation	Technical Report
Innovation Concept	Tool
Internship	Toolkit/Toolbox
Interview	Training Session
Knowledge Base	Usability Test
Lesson Learnt	Website
Literature Review Result	Workshop

While we know that APRE's six categories are highly relevant in structuring the research proposals for the European community, these are not functional in returning the Department's expertise.

In particular, they are not functional, considering that the sample of research projects was dated before the current framing of the Horizon Europe Program. At the same time, some of them responded to the rules of national and regional funding institutions. Moreover, in trying to break down the list of research outputs into APRE's six categories, we found substantial

imbalances: i. e., the category "prototypes, artefacts, research datasets and software" faced very different consistency outputs, while, for example, the category "new companies" was almost completely depopulated.

Consequently, it was necessary to propose an interpretive clustering constructed by referring simultaneously to the types of research outputs collected and the subdivision suggested by the formats for participation in European calls for proposals, which APRE offers.

By studying all the project outputs and confronting the categories proposed by APRE, we proposed an interpretive clustering.

We designed six categories to represent the granularity of the outputs produced by the Department in the different project categories: Analytic, Scientific, Tangible, Instrumental, Educational, and Performative.

Hereafter an exhaustive definition of each of them is reported:

1. **Analytic Outputs**:
   results of the collection, analysis of data and information reporting on the situation (e.g., analysis, state of the art, literature review, case studies results, interview results, triangulation).
2. **Scientific Outputs**:
   output to inform, report, and diffuse specific indications/guides, which could also be used for other actions/activities/studies (e.g., technical reports, guidelines, scientific publications, publications, recommendations)
3. **Tangible Outputs**:
   material or immaterial objects produced by the project (prototypes, spaces, projects, awards, patents)
4. **Instrumental Outputs**:
   tools and instruments with an operational function (e.g., toolkit/toolbox, tools, software, platforms, websites)
5. **Educational Outputs**:
   outputs produced to support educational and training activities (e.g., MOOCs, workshops, courses, internships)
6. **Performative Outputs**:
   physical and/or digital outputs carried out to communicate and disseminate the project (e.g., conferences, seminars, events, co-creation activities, networking).

Table 4.2 shows the detailed breakdowns of all the research outputs. Although there are clusters in which there is a more significant number of outputs, it is important to emphasise that this type of subdivision is much

more homogeneous and representative precisely because it is based on the purpose of the research action that generated the results in the subject. In the next section, the elaborated data will be explained and discussed.

Tab. 4.2 – Adopted categorization of research outputs into clusters.

Analytic Output	**Instrumental Output**
Analysis (Benchmarking/Context Analysis/etc)	Brand Identityv
Case Study	Platform
Data Collection (Repository)	Protocol (Method)
Evaluation Study	Repository
Focus Group	Software
Impact Evaluation	Tool
Interview	Toolkit/Toolbox
Knowledge Base	Website
Literature Review Result	**Educational Output**
Questionnaire/Survey	Curricola/Learning Module
State of the Art	E-learning Course
Technical Report	Educational Programme
Usability Test	Internship
Scientific Output	Lesson Learnt
Dataset	Master Courses/Class/School
Framework	MOOC
Guideline	Training Session
Innovation Concept	**Performative Output**
Methodology	Co-creation Session
PhD Thesis	Co-design Session
Recommendation	Conference
Scientific Publication	Event
Tangible Output	Exhibition
Award	Hackathon
Construction of Physical Space (Lab&Building)	Matchmaking
Patent	Networking
Pilot	Online Consultation
Prototype	Seminar
Publication (Handbook/Booklet/Manifesto)	Workshop

4.3 Analysing the Data

We filtered the data by looking at the typologies of outputs and getting an overview of the number and repetitive factors of the various research outputs. Figures 4.4 and 4.5 show, respectively, the various research outputs in terms

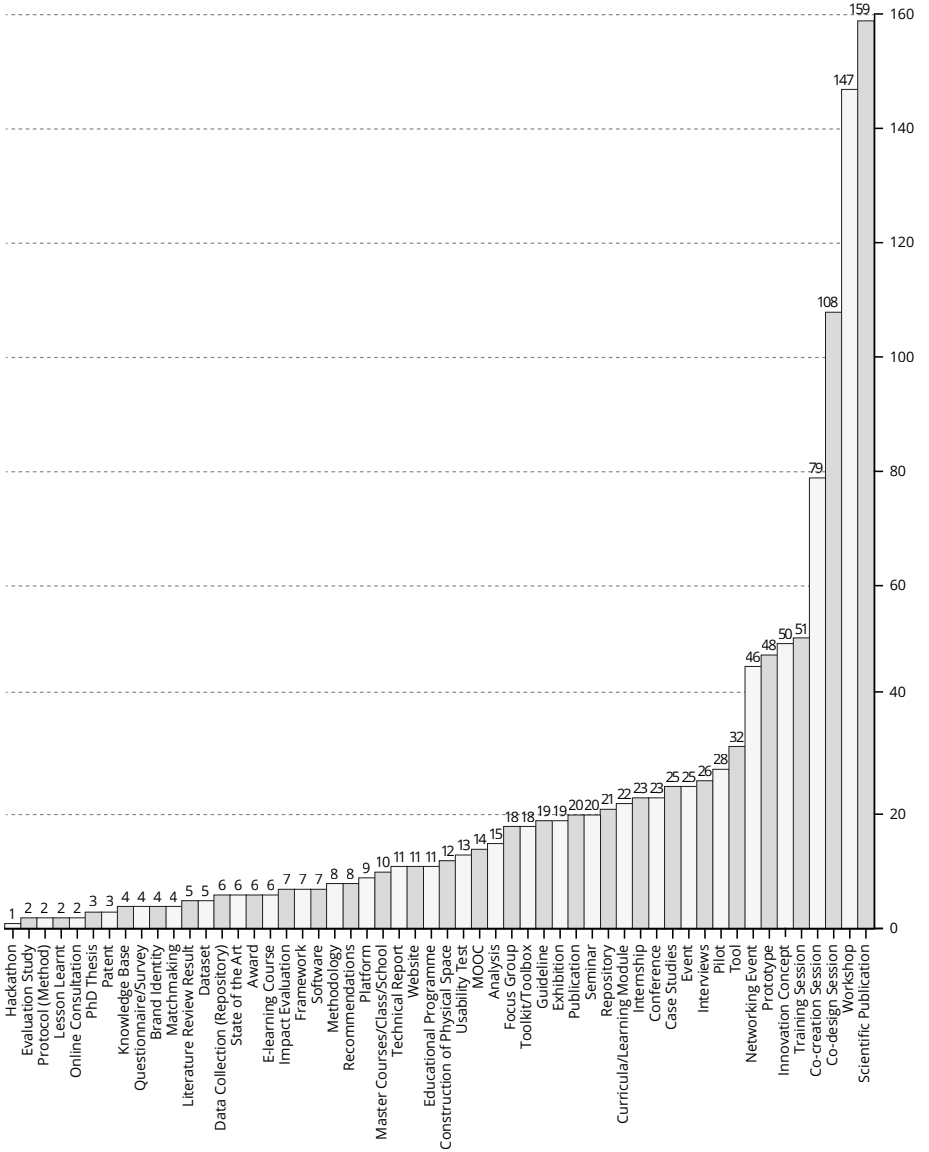


Fig. 4.4 – Typologies of outputs and their number.

of numerosity among the multiple projects and, the number of projects that generated the same outputs within the sample under analysis.

Figure 4.6 shows the cluster of the research outputs and, per each typology, its number. Looking at the elaborated data, we can argue that the research outputs with the highest numerosity are the "scientific publication" belonging to the "scientific output" category.

Having the "scientific publication" typology as the most prevalent is undoubtedly reassuring since research projects within an academy have a common goal: expanding and disseminating knowledge. However, at the same time (see figure 4.5), we can see how the scientific publications are not recurring in all thirty-two projects but only in twenty-eight of them.

Reasoning on the impact pathways, this data might mean that some projects did not generate outcomes and impacts directly related to the scientific dimension. Moreover, in the category "scientific output" we recognise a limited number of methodologies, recommendations, and datasets.

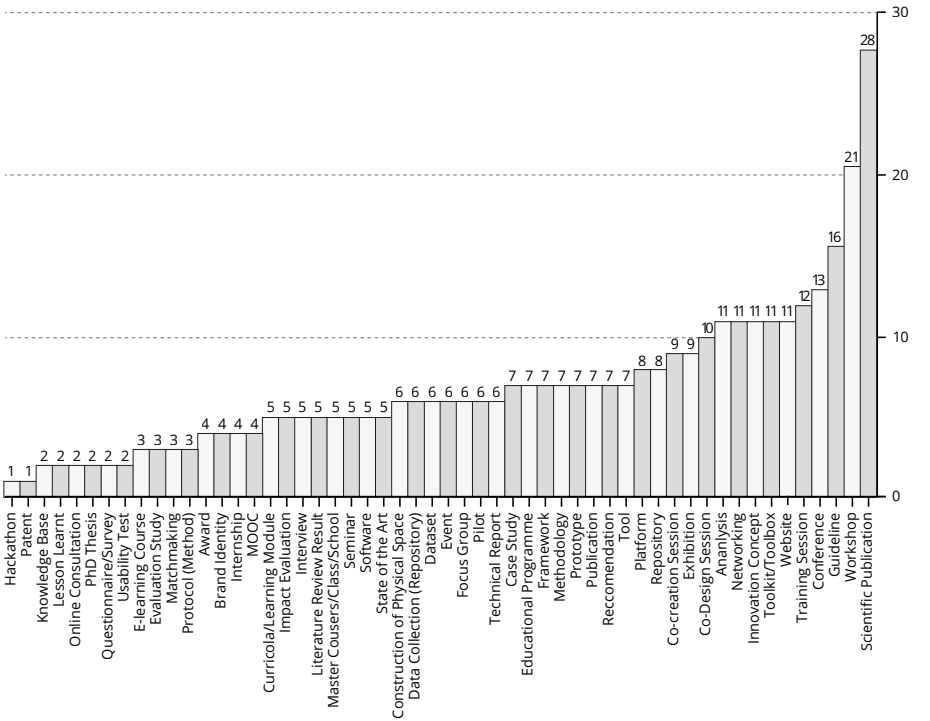


Fig. 4.5 – Typologies of outputs concerning the number of projects.

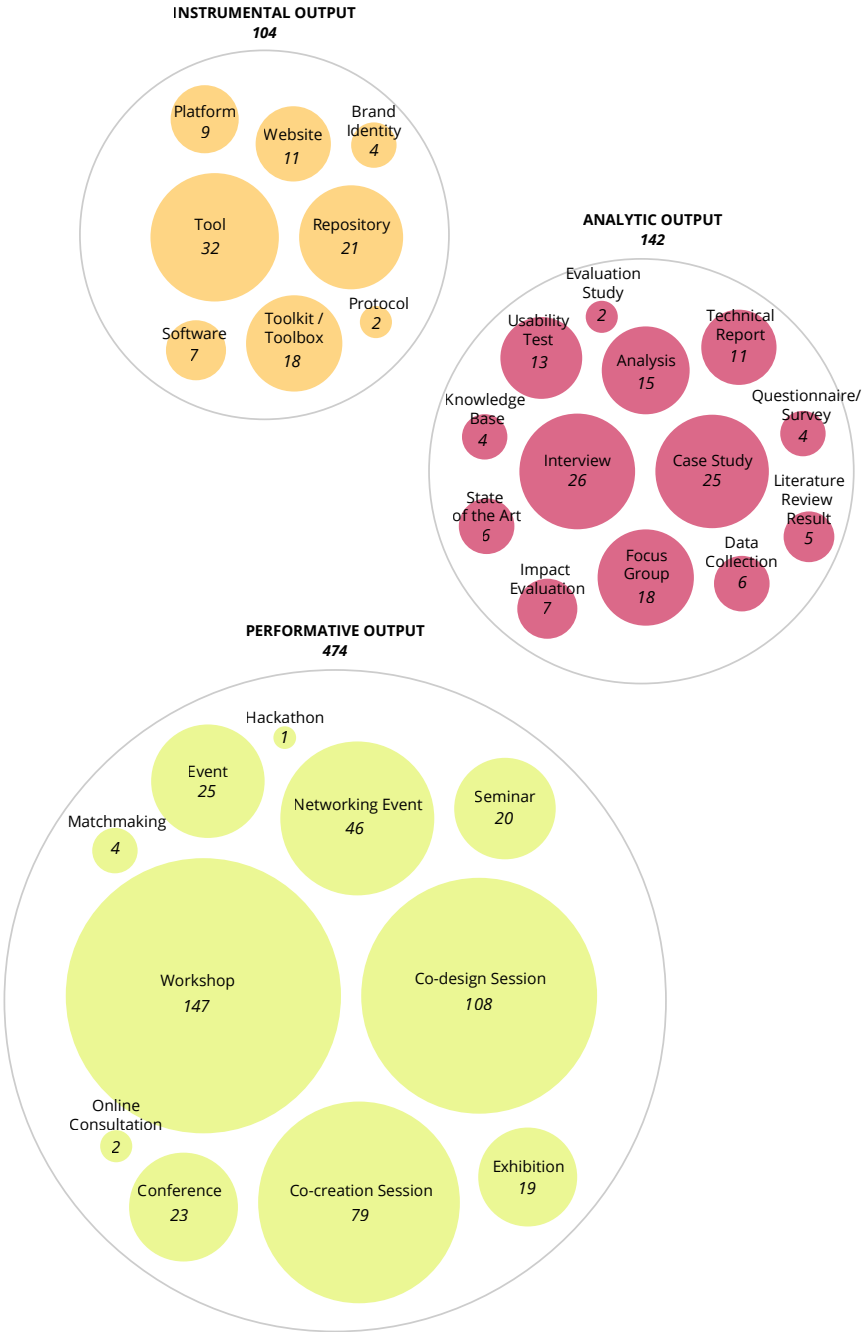
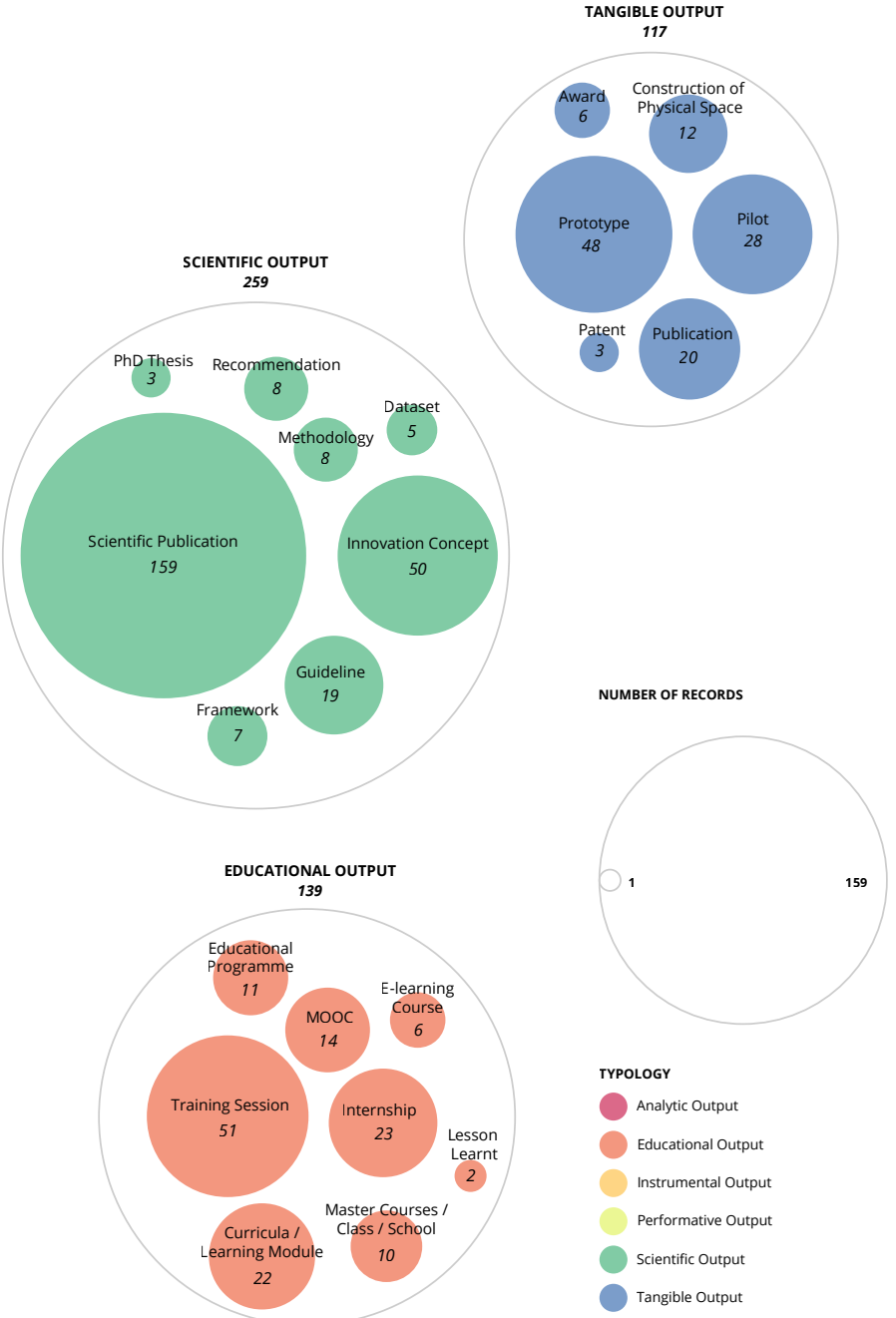


Fig. 4.6 – Typologies of outputs in relation to the number of projects.



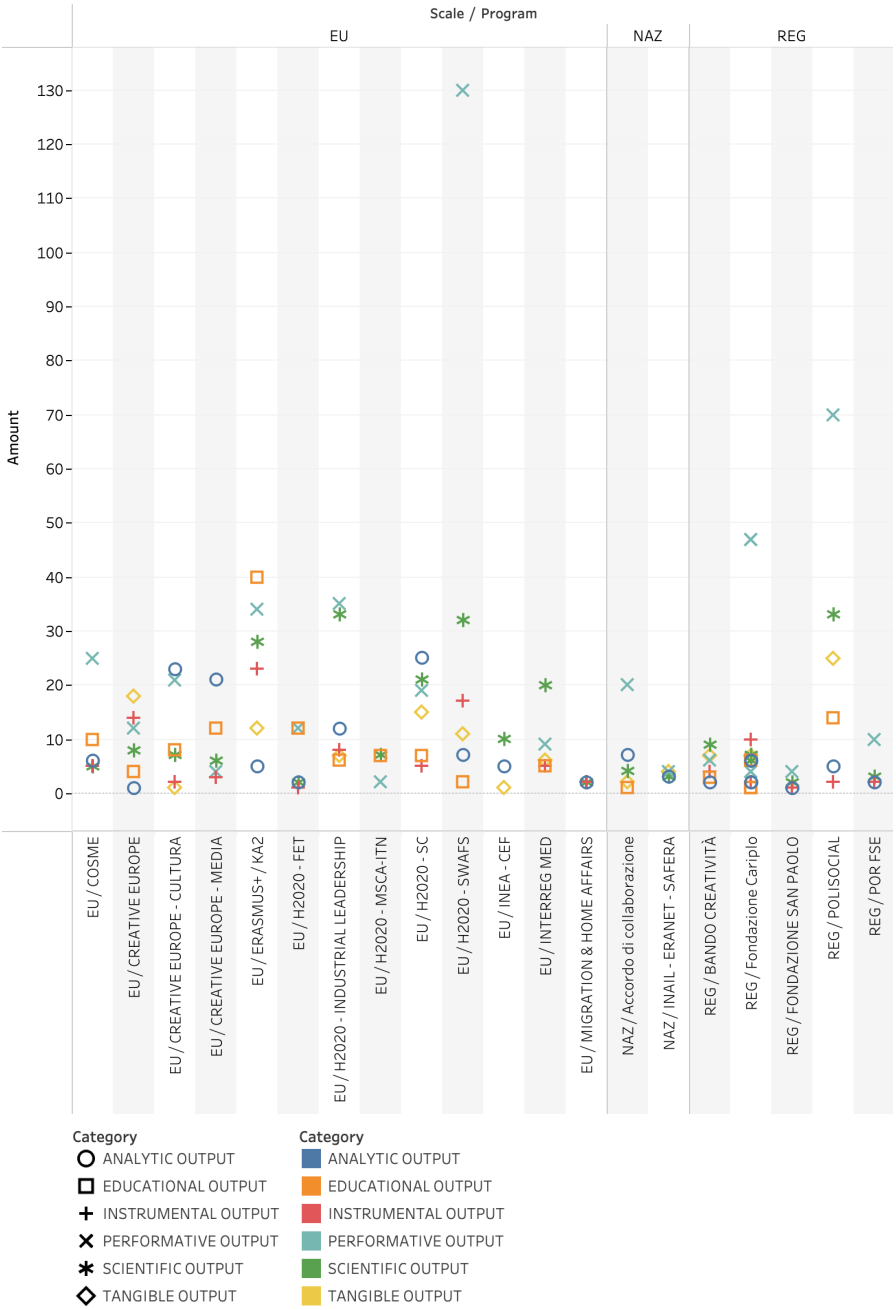


Fig. 4.7 – Cluster of outputs and research program.

It is evident that if the publications were excluded from the "scientific output" category, it would emerge how this category would no longer be listed in second place. This allows us to observe how – almost entirely – competitive research projects involving the Department produce a publication as scientific outputs.

Besides, the typologies of scientific publications, workshops, co-design, and co-creation sessions are very copious. This data might demonstrate a clear trajectory of the Design research toward the involvement of users, targeted groups, and communities directly and proactively. Indeed, the most relevant data extracted by the analysis is that competitive research projects involving the Department of Design mainly generate outputs belonging to the "performative output" category. Nevertheless, "workshops and co-design and "co-creation sessions" are widespread in twenty-one, ten and nine projects, respectively. This might also mean that typology of outputs is related to the Department's expertise and the nature of the funded projects.

We decided to move forward into the data analysis by comparing the cluster of outputs with the type of research program (figure 4.7). Investigating the relation between the typology of output and projects, we can see that "workshops", "co-creation sessions", and "co-design sessions" are very prevalent among projects that involve local and social innovation (both with regional and European scale funding). By comparing typologies of output and the type of project/program, we realised that the significant occurrence of "educational output" is closely related to the fact that within the sample under analysis, there are several Erasmus+, which involve the implementation of "educational program", "master course/class/school", "internship". In addition, other projects include activities such as "training sessions" with the engagement of companies and experts to promote the ongoing training of SMEs.

With the publication of Horizon 2020 till the new Horizon Europe, a great demand to generate something tangible is visible. Despite these requests, in our sample, we find few projects with tangible outputs; indeed, considering the most populous types in the cluster, we find 48 "prototypes" across seven projects and 28 pilots across six projects. This evidence might tell us that not all research projects involving design competencies reach tangible implementation but rather remain at an earlier level or, on the contrary, do not aim at producing physical artefacts.

Finally, deepening the data analysis, a significant finding is the high presence of "analytical outputs" (142) well balanced among themselves within the cluster. We don't consider this data an element to be discussed further since they no longer will find a place in European projects (see Horizon Europe Program).

4.3.1 Four exemplifying Case studies

The data analysis revealed how typologies of the outputs, their number, and the cluster they belong to might be connected and strictly tight to the nature of the research projects and their Work programme. In this regard, we will describe four exemplifying research projects chosen for their diversified nature in terms of programmes, calls, and typologies of outputs:

1. FIRE, Fighting Illicit firearms trafficking Routes and actors at European level – DG Home Affairs within the Prevention of and Fight against Crime (ISEC).
2. Cascina 9, Un progetto collaborativo per lo scambio di competenze, storie e produzioni creative fra attori del territorio – Fondazione Cariplo, Bandi Territoriali 2017.
3. C-Roads Italy CEF program 2014-2020 (Connecting Europe Facility).
4. DiDIY, Digital Do-It-Yourself – H2020 Industrial Leadership.

The choice to describe those projects was made to provide a more accurate, even if qualitative, understanding of the nature of research outputs and how they can be connected to outcomes and impacts. The four projects will be explored in detail by describing their scope, objectives and generated outputs.

The project "FIRE – Fighting Illicit firearms trafficking Routes and actors at European level" was funded under the Workprogramme *DG Home Affairs within the Prevention of and Fight against Crime (ISEC)*. The Workprogramme aims to support police cooperation, preventing and combating crime, and crisis management.

In this regard, FIRE set four main challenges: (i) tackle the urgent matter of identifying and mapping the information on the illicit trafficking of firearms (ITF) available at European level; (ii) analyse illicit trafficking of firearms routes, exchange markets and actors at the European level; (iii) conduct an innovative analysis of the web as an exchange platform, maximising the dissemination and interaction with EU stakeholders; (iv) address the emerging role of marketplaces in the dark web with regards to ITF.

Based on the purpose of the workporgramme and the set challenges, the project's main objectives were to: (i) Analyse the main dimensions of ITF in the EU: routes, markets, actors, dynamics, etc; (ii) Present and analyse the EU regulatory framework with a specific focus on the 2015 EC Proposal for amending the Firearms Directive, its loopholes, and the unintended criminal opportunities it could produce; (iii) Develop a set of recommendations to fight and prevent ITF at European level.

Regarding the scope and objective, FIRE generated as outputs, a *data collection*, an *analysis* of ITF routes, exchange markets and actors at European level, a set of *recommendations* on how to improve the fight against and the prevention of illicit trade and firearms flows, a *software scraper* to scrape the web (also the darknet), as well as to collect and cluster local newspaper articles from the 28 countries members of the EU, a *dataset* with all the occurrences mapped by the project and a *web platform* as a unique and EU-wide map of the situation at the time of the project.

During a two-year project, researchers of the department generated two analytic outputs, two scientific outputs and two instrumental ones. The development of such typologies of outputs allowed to reach multifaceted impacts likewise, socio-cultural, scientific, and technological ones showing a strong connection with the objective of both the Workprogramme and the project's objective (table 4.3).The outputs look pretty balanced in terms of efforts and coherency with the nature of the design discipline, specifically communication design, since the department's research group that participated at the Fire Project has expertise in communication and data visualization.

Tab. 4.3 – Connection FIRE project's output, outcome, and impact.

Output	Outcome	Impact
#Data collection (repository) #Analysis (Benchmarking/ Comparative analysis/etc)	• Analysis and representation of the main dimensions of ITF in the EU • Number of crimes committed Implement to search web and dark web • Knowledge for coping with illicit guns	Societal: Strengthening the uptake of research and innovation in society
#Software Scraper: Semi-automated process #Analysis (Benchmarking/Comparative analysis/etc)		Scientific/Technologic: Leveraging investment in research and innovation
#Recommendations: Knowledge derived from the analysis	• Improved awareness and evidence-based knowledge on firearms transfers • Data collected and visualized, became relevant information	Societal: Addressing EU policy priorities and global challenges through research and innovation
#Software Scraper #Datasets with all the occurrences mapped by the project #Web platform	• Unique access point to knowledge that before was distributed and unrelated • Support tool for law enforcement agencies	Societal: Strengthening the uptake of research and innovation in society

(continued)

Output	Outcome	Impact
#Web platform #Analysis (Benchmarking/ Comparative analysis/etc)	• Data turned into visualizations, favors understanding of the topic of illicit • Synergic cross-sector and multidisciplinary collaboration to fight a common and urging societal threat.	Socio-cultural: Strengthening the uptake of research and innovation in society

The project "Cascina 9 – Un progetto collaborativo per lo scambio di competenze, storie e produzioni creative fra attori del territorio" was funded under the Programme *Fondazione Cariplo – Bandi Territoriali 2017*. Fondazione Cariplo is an Italian foundation well known for being active in funding projects connected to social innovation.

The project challenges were to: (i) Create an open, inclusive, resilient space (creative hub) in Municipio 9, where cross-fertilization, exchanges of knowledge and among cultures are encouraged, in a perspective of socio-cultural inclusion and transformation; (ii) Build a place to experiment with favourable conditions for sharing skills and encourage creative activity among the multiple actors involved; (iii) Support the role of associations active in the area and the dialogue between communities of different cultures.

Following on Fondazione Cariplo mission and the challenges, Cascina 9 aimed at: building a space for social inclusion across every boundary, overcoming barriers such as nationality, language, social status, background and expertise; fostering capacity building & knowledge transfer, encouraging co-creation among persons with different backgrounds and promoting wide inclusion and empowerment and finally implement urban regeneration and economic boost for Nuovo Armenia (CCI), and local associations, building virtuous synergies in the neighbourhood.

As a result of 21 months of activities, the research group belonging to the department produced as outputs: 6 *workshops***,** 2 *exhibitions*, a *physical space*, 12 *co-creative sessions*, 15 *co-design sessions*, a *brand identity***,** a *guideline*, a *tool*, 6 *training session***,** a *scientific publication*, a *conference***,** 6 *events*, 1 *toolbox*, a *software* and an *analysis*.

The project analysis reveals that it mainly generated performative outputs (40) followed by educational outputs (6) with few instrumental ones.

This data confirms what we highlighted in the previous section: performative outputs (workshops. Co-design, and co-creative sessions) are prevalent among projects involving local and social innovation.

Table 4.4 shows Cascina 9's outputs, outcomes, and impacts. It appears that too many outputs have been produced to have a mainly social impact, relevant to the topic of the call but not well balanced in terms of numbers and typologies. Indeed, the relevant impacts have been produced by performative outputs, but it doesn't seem that researchers needed to develop 40 performative outputs to reach the expected impacts.

Tab. 4.4 – Connection Cascina 9 project's output, outcome, and impact.

Output	Outcome	Impact
#Co-creation sessions and #Co-design sessions: 12 Co-design and 3 Co-creation #Workshop: 6 Workshops #Exhibition: 1 Exhibition	• Sharing of know-how and practices with the ecosystem of local actors (third mission) • The Cascina space (Nuovo Armenia) as a creative hub	Societal: Strengthening the uptake of research and innovation in society
#Construction of physical space (lab & building) #Co-creation sessions: a total of 27 co-creation sessions #Brand identity #Communication strategy	• Accessible and inclusive space for all, at disposal for cultural and social events and activities of the neighbour and its actors, especially associations	Societal: Strengthening the uptake of research and innovation in society
	• A social innovation ecosystem that values different skills, expertise, and know-how, build on them in a systemic way	Techno-economic: Creating more and better jobs
	• A virtuous engine of human and social relations, inclusive towards minorities and vulnerable groups.	Societal: Strengthening the uptake of research and innovation in society
#Co-creation sessions #Co-design sessions: 15 working tables #Guidelines #Tool	• Nuovo Armenia's activities are currently planned and co-created with local stakeholders, engaging the community • Transfer of skills on digital strategies to cultural operators' partners	Societal: Strengthening the uptake of research and innovation in society
#Training sessions	• Transfer of skills and know-how to the migrants and refugee of Asnada	Societal: Strengthening the uptake of research and innovation in society

(continued)

Output	Outcome	Impact
#Exhibition	• Establishment of counter-narrative of migration against the hegemonic one	Societal: Strengthening the uptake of research and innovation in society
#Scientific publication: 1 open-access book chapter #Event: 1 Public presentation of the project	• Dissemination of findings	Scientific: Creating high-quality new knowledge
#Event: Nodi di Parole #Guidelines/Toolkit Format "Abitare le domande" #Software: a location-based game with distributed narration	• Involvement of students in the development of tools and activities that favour social engagement and mutual comprehension	Societal: Strengthening the uptake of research and innovation in society

"C-Roads Italy", funded by the programme *CEF program – Connecting Europe Facility 2014-2020* dealt with the topic of testing, implementing, assess the impact of cooperative intelligent transport systems.

It had three challenges: (i) cooperative intelligent transport systems (C-ITS) services allow effective data exchange through wireless communication technologies between components and actors of the transport system to improve road safety and efficiency of transport; (ii) C-ITS allows vehicles to communicate with other vehicles, with traffic signals and roadside infrastructure as well as with other road users; (iii) The challenge is identifying common specifications for C-ITS services to ensure cross-border interoperability and harmonisation in different operating environments, building the foundations for connected vehicles in the European Union.

The CEF Programme is an instrument to promote growth, jobs and competitiveness through targeted infrastructure investment at the European level. It aims to fund projects with a strong emphasis on implementation aspects and impacts.

By considering CEF Programme objectives and the project challenges, C-Roads Italy produced 10 *scientific outputs* encompassing diversified typologies such as *scientific publications*, *new concepts*, *recommendations***,** *guidelines***,** and *data sets***,** 4 *analytical outputs* and one *tangible one***.**

The typologies of the outputs (see table 4.5) seem to be designed on the clear purpose of generating scientific and techno-economic, and social impacts. The research group revealed a capability to set the proper typologies and numbers of outputs within specific clusters (i.e., diversified typologies of scientific outputs) and within the correct timeframe concerning the impact pathway.

Tab. 4.5 – Connection C-Roads Italy project's output, outcome, and impact.

Output	Outcome	Impact
#Literature review results #Evaluation study: impacts of the system on mobility & traffic #Scientific Publications: 1 book chapter, 2 peer-reviewed journals, 3 conference paper in international proceedings	• Scientific dissemination • Discussion on the topic of I-CTS impact and its evaluation	Scientific: Creating high-quality new knowledge
#Evaluation study: impacts of the system on mobility and traffic	• Dissemination of results with the industry of reference	Societal: Strengthening the uptake of research and innovation in society
#Pilot: Development of the Italian pilot of C-Roads State of the art Current status of the C-Roads deployments #Guidelines: Analysis of the results for transferability #Recommendations Results & lessons learnt shared across EU (C-Roads Platform)	• Uptake, diffusion, deployment, and use of project's results by direct target groups • Infrastructure upgrade and integration of V2I and V2V C-ITS service in the Autostrada del Brennero	Techno-economic: Generating innovation-based growth
#Impact evaluation Pilot	• Increased dialogue with carmakers and manufacturers • Participation as one of the 11 C-Roads pilots • Directions for harmonising the deployment of C-ITS in EU • Data-informed understanding and know-how for implementing traffic management policies	Societal: Addressing EU policy priorities and global challenges through research and innovation
#Interviews	• Relevant knowledge in terms of drivers' behaviour user acceptance transferred to the transportation industry	Societal: Strengthening the uptake of research and innovation in society

(continued)

Output	Outcome	Impact
#Datasets/Data collection (repository) #Recommendations	• Knowledge for harmonised specifications accounting the EU-C-ITS recommendations, linking all C-ITS deployments • Data-driven verification of C-ITS impact on mobility	Societal: Delivering benefits and impact through research and innovation missions
		Techno-economic: Leveraging investment in research and innovation

Finally, "*Digital Do-It-Yourself"* under the Workprogramme *"H2020-I-CT-31-2014-1 RIA – Industrial Leadership (Human-centric Digital Age)* was about Digital do it yourself-related technologies and social practices.

The project wanted to: (i) establish a conceptual framework that will enable the analysis, exploration and understanding of the impact of DiDIY technologies for 4 specific areas in a human-centric digital age; (ii) produce well-founded transferable information, models and guidelines to support both education and policymaking to make the best of DiDIY for society; (iii) provide a roadmap fostering a "DiDIY-based" "human-centric" European development.

After three years of the project, the research group of the department produced copious outputs, namely: *16 co-design sessions*, *16 workshops* (performative outputs), 6 *publications* and one *guideline* (scientific outputs) 4 *case studies* and 4 *technical reports* (analytical outputs) a *protocol* and a *toolkit* (instrumental outputs).

The outputs generated by the project DiDIY were coherent with the impacts expected by the Workprogramme whose objective is to explore the two-way interactions between technology and society.

Precisely, the majority of outputs were in the category of performative ones that proved to be relevant for the social impact, while on the other side, the scientific ones aimed at fostering the diffusion of knowledge related to the connection between digital technology and social practices like it is shown in table 4.6.

The project also demonstrated that the department's research groups are strong in three typologies of outputs, co-design sessions, workshops scientific publications.

The qualitative analysis made on four exemplified case studies showed that the outputs developed by the department are connected both to the skills of the research groups and to the challenges set by the Workprogramme.

Table 4.6 – Connection DiDIY project's output, outcome and impact.

Output	Outcome	Impact
#Guideline: instructions on how to use this toolkit, specific tools and provided cases, as well as on how to follow the whole process #Toolkits & #Tools: 19 tools divided into 8 activities #Case study result: 4 cases protocol(method) a DiDIY co-design process	• Deployment of co-design method and process by practitioners with diverse background in the Digital DIY scenario	Scientific: Fostering diffusion of knowledge and Open source Societal: Strengthening the uptake of research and innovation in society
#Scientific publication: 6 Scientific publications #Case study result: 4 case studies #Toolkits & #Tools	• Knowledge creation in the research areas relevant to applying DiDIY technologies in innovation and development	Scientific: Creating high-quality new knowledge
#Co-design activity #Workshop: 16 workshops conducted in Italy and Spain focused on the 4 selected area. #Technical report: 4 Project technical reports #Case study result: 4 case studies #Toolkits & #Tools	• Generation of understanding of the Digital DIY's impacts on diverse domains through co-design actions • Facilitation of community building among different actors relevant to DiDIY in the 4 areas	Societal: Strengthening the uptake of research and innovation in society

4.4 Discussion and future trajectories

The investigation revealed that the 32 projects mainly generated outputs belonging to co-design and co-creative sessions, educational workshops and, in general, to analytical outputs.

The presence of more analytical, performative, and educational outputs rather than scientific or tangible ones (one of the cores of design research) might be twofold: the typologies of European research projects investigated on the one hand and the recurrent skills of the Department of Design on the other.

This contribution aimed at answering the following research questions: which are the **main typologies of outputs** generated by the projects within the Department of Design? (ii) how the **nature of the outputs** is somehow

related to the nature of **design research** and to the **department's expertise**, and finally, (iii) what kind of outputs are directly attributable to the **outcomes and impacts**?

The analysis shows that there are types of outputs by which the Department expresses itself first and foremost; among them are co-design and co-creation sessions.

The presence of those copious typologies of outputs highlights that the research of the Department belongs to a research culture characterized by a participatory mindset (Sanders, 2008).

According to such an approach, as evident in the described sample of projects, design researchers use research-led strategies involving people to collect, analyse, and interpret data to develop specifications or principles to guide or foster relevant knowledge within society (societal impact). At the same time, there are other research outputs in which the Department of Design is "strong", namely "scientific publication". However, if we analyse the publications from a qualitative point of view, they are mainly narratives of the conducted research without giving ample space to scientific evidence, knowledge creation and theorising the design research (also confront chapter 3).

Concerning analytical outputs, the indications coming from the European Union community highlight how those types of research output will no longer be expected within the project pipeline; the analysis should be grounded in the evidence for structuring new proposals in response to competitive research calls. Therefore, it is worth remembering this element and trying to build broader lines of research that can create databases to inform and nurture future proposals and research.

New Horizon Europe calls require a new approach to constructing competitive research projects and their instructional phase.

Indeed, since it is no longer possible to found activities devoted to analytical outputs, researchers from the department should learn how to shape their proposals and/or contributions within a project so that the organization of analytical evidence results from constant and continuous systematic improvement.

An alarming factor emerges from the analysis: the spare presence of tangible outputs, likewise, prototypes, spaces, and pilots. This data seems bizarre since a design research activity should primarily have a tangible and experimental soul. Indeed, the design is an implicit activity of creating and making artefacts (Buchanan, 2001; Koskinen et al., 2011; Zimmerman et al., 2007).

For this reason, it would be essential to invest more energy in executing the research outputs typical of the experimental dimension, in which the Department still has no established experience. One of these could be a "hacka-

thon", which appears only once in the analysis but externally is considered a natural source of innovation.

Moreover, by speaking of expertise, even if the experimental dimension of Design research is implicit within our community, it is not yet so evident externally.

In any case, design research is not only targeted at refining practice. It should also address theoretical questions and issues to be effective (Collins et al., 2004).

In this regard, the experimental soul of our department is not well recognised yet because of the absence of relevant publications theorising such an approach. A future goal could be to build a line of scientific articles to model experimental research, taking the results, experience, and findings out of the funded research projects.

Building on this, a future trajectory could be modelling the most recurrent activity formats; this path might be helpful to bring out in a structured way what outputs are naturally synergistic to create a replicable structure.

Creating what could be defined as a "departmental formula" can foster the recognition of the department spirit in dealing with design issues within projects, favouring the construction of partnerships and the research proposal writing phase itself.

Leveraging the recognition and reputation of the research team can improve performance, both scientifically and in terms of social impact. As reputation and recognition increase, virtuous connections are generated, increasing involvement at strategic panels with decision-makers.

Moving forward, in the setting of possible future trajectories, we should engage in more self-criticism concerning the degree of innovation aimed by the research projects we conduct. The perception is that, in most cases, an affirmative approach is taken without exploring "frontier" topics. The lack of innovation from funded projects might be connected to the nature of the Workprogramme and the objective of the calls themself.

Reasoning instead on the numbers of the outputs, looking at the data, we highlighted that most of the time, the proportion between the number of outputs and related impacts is unbalanced (i.e., see Cascina 9 and DiDIY projects). In this regard, a warning is needed: all the effort brought to bear on a research project should be proportional to the budget recognized for the agreed-upon activities.

This target is not always easy to reach because the researcher's spirit gets the upper hand, and one tends to do everything possible to achieve the targeted outcomes and impacts. Structuring research proposals reasoning on the impact pathways can help frame what outputs are necessary and sufficient to

reach the relevant impacts for the project connected to the Workprogramme.

Following the impact pathway framework, a crucial factor to consider is the quality of the outputs; this is another element that should lead design researchers to reason on the typologies of outputs and their numbers.

Finally, while ideating and carrying out a project, it is relevant to override the mental barrier of the project deadline as the end of all activities.

Outputs are the only activities implemented within the project time frame; in the case of "outcomes" and "impacts", they come later, especially the impacts mainly visible after the end of the project.

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5. The projects' outcomes: the analysis of the results in the medium-term

Davide Spallazzo & Annalinda De Rosa
Department of Design, Politecnico di Milano

The chapter focuses on the outcomes of the design research, namely those results that can be defined as the achieved medium-term effects of an intervention's activities and outputs. It reports the results of the qualitative analysis conducted on 32 funded research projects, focusing on understanding the kind of outcomes of a project that is needed and able to contribute to achieving its objectives jointly. The study aimed at answering the following research questions: (i) what kind of outcomes have been produced in the projects? (ii) which outcomes are directly linked to the action performed by the Department of Design? (iii) are there commonalities among the diverse projects, or may we identify recurrent patterns? This analysis revealed how design research has a strategic role. Within interdisciplinary partnerships, the design discipline's contribution stands in the capability to bring and adapt its approaches, processes, and methods in the project to achieve objectives with scientific, social, and economic dimensions towards future transformations.

Despite the peculiarities of the diverse research projects, most share a common approach to the research and let emerge current evolutionary paths in the approaches and methods of the design research, widening its disciplinary boundaries, here discussed through the analysed research projects run at the Department of Design of Politecnico di Milano.

5.1 Framework

The desire to *scientise design* is one century old, as recalled by Nigel Cross in his renowned article for Design Issues (Cross, 2001) on the opposition between the design discipline and design science. It may be considered even a requirement when the design (science) must collaborate with others, as in the case of collaborative projects. The subjective speculation in art and

design, fiercely opposed by Theo van Doesburg already in the 1920' (Cross, 2001), must leave the floor to a recognizable and stable methodology (Koskinen et al., 2011) that must be applied to bring the expected results. Moreover, these results must be conceivable and, above all, measurable.

This tendency is even more evident in the Horizon Europe funding program that relies on *missions* (European Commission, Directorate-General for Research and Innovation & Mazzucato, 2018) that must be achieved with the contribution of every funded project, and necessarily, of every involved discipline. Suppose the missions' achievement represents the major impact of several projects (European Commission, Directorate-General for Research and Innovation et al., 2018). In that case, it is relevant to reflect on the smaller scale, analysing the results of every project and discipline.

Design makes no exception, and the present chapter is an attempt to analyse the outcomes achieved by the design research, namely those results that can be defined as the medium-term effects of an intervention's activities and outputs.

Outputs, outcomes, and impact are terms used to describe change at different levels. More in detail, INTRAC (2015) defines the outputs as the "products, goods and/or services which result from a development intervention", and they have an operational dimension. In fact, they represent the short-term results of a research project: they must therefore be devised to produce outcomes, namely

> The medium-term direct effects in the behaviour of target groups, under the control of the benefitting partner. The outcome is the likely or achieved short-term and medium-term effects of an intervention's outputs (European Commission, 2022).

The outcomes are close to the end of the results chain, following inputs and outputs and preceding the impacts, as they are informed by the outputs and, in turn, inform the impacts (long-term transformations).

It is clear, therefore, that outputs, outcomes, and impacts should never be independent elements, but are all needed components of a process that expands over time and, as said, by the scale of impact (short/medium/long-term). The European Research & Innovation agenda has clearly based its investment strategy on the so-called "Impact pathways" or "Pathway to impact", defined in the Horizon Europe application documents as *the logical steps towards the achievement of the expected impacts of the project over time, in particular beyond the duration of a project. A pathway begins with the projects' results, to their dissemination, exploitation, and communica-*

tion, contributing to the expected outcomes in the work programme topic, and ultimately to the wider scientific, economic, and societal impacts of the work programme destination. A pathway is, notably, time-sensitive and reflects the non-linear nature and the complexity of R&I actions, based both on quantitative and qualitative methodologies and tools. As professor Mariana Mazzucato states, this overall strategy recognises that innovation has a direction: "by harnessing the directionality of innovation, we also harness the power of research and innovation to achieve wider social and policy aims as well as economic goals" in an ambitious, collaborative, and systemic way (European Commission, Directorate-General for Research and Innovation & Mazzucato, 2018, p. 4).

The ability to devise, achieve and then, analyse the outcomes reached in any research activity is of specific – and often undervalued – importance. In fact, if on one hand there is the need for measurable results and creating tangible and quantifiable outputs makes this need partially achievable, on the other hand addressing complex challenges requires a deep understanding of intertwined social, economic, political and technological aspects. Certainly, a future transformation represents an inspirational vision for any research project; however, any complex transition needs to be first explainable, understandable, accepted and then visible and effective to any target group involved to make change happen, especially beyond the project itself. Outcomes, in fact, have a strategic dimension and an ongoing role in facilitating the achievement of impacts. It is, therefore, relevant to analyse the outcomes reached by the design research, alone or in collaboration with other disciplines.

The chapter focuses specifically on the outcomes of the design research to provide a comprehensive view of those achieved by the researchers of the Department of Design of Politecnico di Milano in a sample of 32 funded projects. Does it report the results of a qualitative study aimed at answering three main research questions: (RQ1) What outcomes have been produced in the projects? (RQ2) Which outcomes are directly linked to the action performed by the Department of Design? (RQ3) Are there commonalities among the diverse projects, or may we identify recurrent patterns?

The main aim is to understand the nature of the achieved outcomes with a phenomenological approach, studying for each funded research project, which effects have been achieved in the medium-term (RQ1). Beyond this significant goal, the ambition is to track which outcomes may be directly linked to the role of the researchers of the Department of Design or, eventually, to identify specific contributions from the Design field (RQ2).

Despite the study being limited in terms of the sample (32 projects) and referring to a single institution (Politecnico di Milano), the study attempts to infer some shreds of evidence of the role of Design in funded projects carried out by consortia. Recognising commonalities across the different projects and identifying patterns (RQ3) is the strategy chosen to attempt the generalisation of the results that may primarily benefit the Polimi Design community and, eventually, the Design community at large.

Looking back at the projects carried out by the Department and analysing them is a precious opportunity to gain new awareness of the identity of the Department itself, understand where the research is moving towards, and open new perspectives. Accordingly, a further aim of the study is to frame the achieved outcomes both within the Department of Design and in the larger context (national and international), contextualising the Design research at different scales.

5.1.1 Methodology

This study is part of a broader inquiry illustrated at the beginning of the book and analysed in detail throughout the chapters. Accordingly, it adopts the more general study methodology, consisting of the qualitative analysis of 32 funded research projects conducted by the Department of Design of Politecnico di Milano between 2014 and 2021.

In particular, the study described has analysed the projects' outcomes by triangulating data from official project documents (e.g., project reports, deliverables) and those collected through interviews with the principal investigators or their delegates. For each project, a list of outcomes has been created and further checked with the principal investigator or her/his delegate. The second action performed was to map the research projects' outcomes, aiming to contextualise them both within the Department and at the national/international level. The challenge here was to identify the criteria for grouping the outcomes, tagging them with categories relevant on the one side for the Department and, on the other, for the outer world.

In the first case, the choice was to stick to the keywords elaborated in 2015 on the delivery of the new Department website. They were proposed by each researcher with a bottom-up approach and then systematised. The resulting 113 keywords can be considered a self-portrait of the Department, made simultaneously as the projects under study were developed. They are organised into three broad categories: contents, approaches, and subject areas. Each category is, in turn, organised into subcategories containing key-

words, as later shown in the fig. 5.2. Each outcome has been analysed and tagged with one or more keywords taken from the list to identify commonalities and patterns. The PIs or their delegates then approved the selection of the keyword.

For the national/international level, the categories identified for the mapping are the 337 ERC keywords – and related descriptors – in their last available version dating back to 2020[1]. The choice of the ERC keywords is motivated by two factors: (i) The ERC sectors are recognized both at the national – Italian – and European level, being the analysed projects mainly at these two scales; (ii) They can be considered effective in covering all fields of science, engineering, and scholarship assigned to three research domains: Social Sciences and Humanities, Physical Sciences and Engineering, and Life Sciences. Furthermore, with the release of the new ERC keywords in 2020, the Department has been asked by the university research service to update the list of ERC keywords covered or partially covered by the research conducted.

Through a bottom-up approach, analogous to the selection of the Department keywords, every macro research group selected the ERC keywords more representative of the ongoing research. The result is another portrait of the research activity, dating back to 2020 and composed of 45 ERC keywords (out of 337).

Tab. 5.1 lists the selected ERC keywords. Moving from this selection, every project outcome has been associated with one or more ERC keywords.

[1] Panel structure for ERC calls 2021 and 2022: https://erc.europa.eu/sites/default/files/document/file/ERC_Panel_structure_2021_2022.pdf

Tab. 5.1 – List of the 45 ERC keywords (out of 337) selected by the Department of Design.

Domain	Discipline	Keywords
Social Sciences and Humanities	SH1 Individuals, Markets and Organisations *Economics, finance, management*	SH1_9 Industrial organisation; entrepreneurship; R&D and innovation SH1_10 Management; strategy; organisational behaviour SH1_11 Human resource management; operations management, marketing
	SH2 Institutions, Governance and Legal Systems *Political science, international relations, law*	SH2_1 Political systems, governance
	SH3 The Social World and Its Diversity *Sociology, social psychology, social anthropology, education sciences, communication studies*	SH3_1 Social structure, social mobility, social innovation SH3_2 Inequalities, discrimination, prejudice SH3_4 Social integration, exclusion, prosocial behaviour SH3_6 Social influence; power and group behaviour SH3_8 Social policies, welfare, work and employment SH3_11 Social aspects of teaching and learning, curriculum studies, education and educational policies SH3_12 Communication and information, networks, media SH3_13 Digital social research SH3_14 Social studies of science and technology
	SH5 Cultures and Cultural Production *Literary studies, cultural studies, study of the arts, philosophy*	SH5_4 Visual and performing arts, film, design and architecture SH5_5 Music and musicology; history of music SH5_6 History of art and architecture, arts-based research SH5_7 Museums, exhibitions, conservation and restoration SH5_8 Cultural studies, cultural identities and memories, cultural heritage SH5_10 Ethics and its applications; social philosophy SH5_11 History of philosophy
	SH6 The Study of the Human Past *Archaeology and history*	SH6_1 Historiography, theory and methods in history, including the analysis of digital data SH6_13 Gender history, cultural history, history of collective identities and memories, history of religions SH6_14 History of ideas, intellectual history, history of economic thought

(continued)

Domain	Discipline	Keywords
	SH7 Human Mobility, Environment, and Space *Human geography, demography, health, sustainability science, territorial planning, spatial analysis*	SH7_4 Social aspects of health, ageing and society SH7_5 Sustainability sciences, environment and resources SH7_6 Environmental and climate change, societal impact and policy SH7_7 Cities; urban, regional and rural studies SH7_8 Land use and planning SH7_9 Energy, transportation and mobility
Physical Sciences and Engineering	PE1 Mathematics *All areas of mathematics, pure and applied, plus mathematical foundations of computer science, mathematical physics and statistics*	PE1_17 Mathematical aspects of computer science PE1_21 Application of mathematics in sciences
	PE5 Synthetic Chemistry and Materials *New materials and new synthetic approaches, structure-properties relations, solid state chemistry, molecular architecture, organic chemistry*	PE5_6 New materials: oxides, alloys, composite, organic-inorganic hybrid, nanoparticles
	PE6 Computer Science and Informatics *Informatics and information systems, computer science, scientific computing, intelligent systems*	PE6_8 Computer graphics, computer vision, multimedia, computer games PE6_9 Human computer interaction and interface, visualisation PE6_10 Web and information systems, data management systems, information retrieval and digital libraries, data fusion
	PE7 Systems and Communication Engineering *Electrical, electronic, communication, optical and systems engineering*	PE7_8 Networks, e.g. communication networks and nodes, Internet of Things, sensor networks, networks of robots PE7_9 Man-machine interfaces PE7_11 Components and systems for applications (in e.g. medicine, biology, environment)
	PE8 Products and Processes Engineering *Product and process design, chemical, civil, environmental, mechanical, vehicle engineering, energy processes and relevant computational methods*	PE8_9 Production technology, process engineering PE8_10 Manufacturing engineering and industrial design PE8_11 Environmental engineering, e.g. sustainable design, waste and water treatment, recycling, regeneration or recovery of compounds, carbon capture & storage PE8_12 Naval/marine engineering PE8_13 Industrial bioengineering PE8_14 Automotive and rail engineering; multi-/inter-modal transport engineering

(continued)

Domain	Discipline	Keywords
Life Sciences	LS7 Prevention, Diagnosis and Treatment of Human Diseases *Medical technologies and tools for prevention, diagnosis and treatment of human diseases, therapeutic approaches and interventions, pharmacology, preventative medicine, epidemiology and public health, digital medicine*	LS7_11 Environmental health, occupational medicine LS7_12 Health care, including care for the ageing population

5.2 The outcomes of the design research

Describing the outcomes of 32 research projects (RQ1) is challenging since every project has its own aims and specificities. For the sake of brevity, we propose here a qualitative description of the outcomes of four projects as emblematic of the different nature of the research carried out between 2014 and 2021. The projects described in the following are three European-funded projects, *DeFINE – Developing a Fashion-Tech Innovation Network for Europe*[2]*, DDPM – Distributed Design Market Platform*[3] *and SISCODE – Society in Innovation and Science through CODEsign / Co-Design for society in innovation*[4]; the fourth one is *TAMBALI FII – Partiamo da qui*[5], a social engagement and responsibility project developed in Senegal.

The selected projects' challenges and aims are presented below to briefly understand their general domains and then, to focus the attention on the role played by the design researchers in the achievement of such goals within the transdisciplinary context through their outcomes.

[2] DeFINE – Developing a Fashion-Tech Innovation Network for Europe" (2018-2020). Funded by the COSME Work Programme 2017. Polimi Principal Investigator and Project Coordinator: Prof. Paola Bertola.

[3] "DDPM – Distributed Design Market Platform" (2017-2021). Funded by the Creative Europe Programme (Support to European Platforms). Polimi Principal Investigator Prof. Stefano Maffei (2018, 2019) and Prof. Massimo Bianchini (2020, 2021).

[4] "SISCODE – Society in Innovation and Science through CODEsign / Co-Design for society in innovation" (2018-2021). Funded by the Horizon 2020 Programme (Integrating Society in Science and Innovation). Polimi Principal Investigator and Project Coordinator: Prof. Alessandro Deserti.

[5] "Tambali Fii, Ripartiamo da qui" [Let's start over here. E.d.] (2016-2018). Funded by the Polisocial Award, The social engagement and responsibility programme of Politecnico di Milano. Polimi Principal Investigator and Project Coordinator: Prof. Andrea Ratti.

DeFINE project aimed at developing European networks of Fashion-Tech business and financiers to support the growth and scaling-up of innovative start-ups and SMEs. Whereas the field of Fashion-Tech is still largely dominated by multinational firms (i.e., Yoox-Net a Porter, Google, and Apple), most of the European fashion industry is made up of start-ups and SMEs, which are struggling in adopting new technologies, market approaches and business models suited to foster their growth and their competitiveness in a global marketplace. To cope with these issues, the project's main aims were to: i) develop a European network of Fashion-Tech business to support organisations through mapping and networking events and a European Fashion-Tech Financier Network to support the growth and scaling-up of innovative start-ups/SMEs; ii) deliver a mentoring process to prototype products/services, processes, or market approaches for scale-up. Focusing the attention on the role that design played in the development of the project and in achieving the objectives, DeFINE is positioned in the design and entrepreneurship research area, where design-led research and approach to innovation could support vision and problem-framing/solving skills within managerial environments towards innovative entrepreneurial opportunities. More specifically, the design contribution here is not meant to support the development of ideas or innovation paths for specific ventures, but to play a core role in the change management of the whole system. To do so, the tangible actions delivered are the organisations of info days and bootcamps, training sessions towards a mentoring process to prototype either products/services, processes or market approaches, and community members platforms, to encourage transnational collaboration between incubators and accelerators, start-ups and SMEs, and financiers.

DDMP project has been developed under the Platform funding stream of the Creative Europe programme, supporting the development of connections between cultural and creative sectors with the related market environment through networking platforms, able to promote the role of Europe in the cultural sector and its connection with the development and coordination of global networks and supply chains. DDMP operated in the intersection of two global trends: the Maker Movement and the digitisation of the design discipline, focusing on the platform ecosystem for the Fab Lab network. Beyond the promotion and improvement of the connection between makers and designers with the European market, DDMP aimed at fostering the development and recognition of the emerging European Maker and Design culture by supporting makers, their mobility and circulation of their work, providing them with international opportunities, highlighting the most outstanding talent, and stimulating the creation of financially sustainable business

activities. The actions run to achieve these aims consists of both online and offline activities such as events, resources, workshops, fairs, and bootcamps that promote and advocate for emerging creative talent in Europe and their business productivity and sustainability through the resources put in place by the Fab Labs (project development, business models' definition, projects' labelling, promotion). Within the consortium, made up of fab labs and makers organisations, the Fab Lab of the Department of Design was the only partner with an academic profile: it promoted the creation of a common framework in each institution for the development, analysis, comparison and promotion of the projects through co-creation activities, workshops, interview results, pilot experiences; it also conducted a series of "design through prototyping" paths through training sessions, in order to design a repository guiding digital fabrication technologies as well as guidelines for documentation and repeatability of open source projects.

SISCODE project operated in the Responsible Research and Innovation (R&I) and Co-creation fields, experimenting with co-creation as a way to make R&I more responsible, integrating civic society in science and technology policy making. Public engagement and participatory approaches have gained momentum to address different scale societal issues, with the scope of mitigating the gap between the scientific community and society, making research more accessible, inclusive, relevant to practice, and responsive to real problems. Within these issues, the SISCODE focus and impact are twofold: experimenting with co-creation ecosystems under different societal, cultural, organisational, institutional, and regulatory conditions as (1) innovation communities where to grasp effective dynamics, and (2) playgrounds for policy makers where to gain knowledge on how co-creation and design methodologies can cross-fertilise RRI/STI practices and policies. In particular, the design researchers' role focused on ecosystems of co-creation, bridging the small-scale experimentations analysed and conducted within the project to potentially universally applicable co-creation. The importance of contextual factors and circumstances that need to be considered led to the development of a flexible model to understand and map the functioning and development of co-creation ecosystems through comparative analysis, co-creation and co-design sessions, towards the definition of assessment framework, operational tools (toolbox for co-creation and recommendations) and impact evaluation studies. A particular focus was taken on approaches to overcome the variety of barriers and challenges identified.

As the last project to be briefly presented, TAMBALI FII was in line with the European approach towards the migration issue, acting to combat the root causes of migratory flows. It aimed to generate a virtuous system that

fosters a process of social growth and economic independence for countries like Senegal, which is strongly conditioned by foreign economic interests and emigration phenomena. The project intended to develop nautical skills and promote research in the field of additive manufacturing technologies and Do It Yourself materials, to strengthen the local fish supply chain and promote entrepreneurial opportunities. TAMBALI FII supported the creation of a pole of technological and social innovation to transfer consolidated training models through courses and co-design workshops with students and local partner companies, enhancing the skills of local researchers, artisans, and entrepreneurs, and at the same time providing the tools to support the Senegalese fish market characterised by constantly growing local and international demand.

To better clarify the pathway to impact (European Commission, 2022), outcomes of the four analysed projects are grouped according to the project outputs that enabled the achievements of these results in the medium-term.

With the establishment of European networks through the creation of platforms and datasets, the constitution of a website mapping the network, and the building of online community members repositories, the DeFINE project achieved the enlargement of the Fashion-Tech network, increasing the interaction among incubators, accelerators, and other business support organisations able to then promote dialogue towards the growth and scaling-up of innovations. The development of capacity-building initiatives facilitated the realisations of those innovations, supporting the incubation of business ideas to get follow-up requests from financiers. On the other side, the organisations of info days and webinars, the building up of a mentoring program, and the creation of a toolkit were functional to stimulate knowledge sharing to further support the transition of business ideas to market, reviewing the business models. Finally, the creation of an impact assessment methodology and framework as well as an in-depth analysis of lessons learned were helpful to generate guidelines and recommendations for the creation of development policies and entrepreneurial support dedicated to the Fashion-Tech sector.

The framework defined and tested in the DDMP research brought out the enhancement of the role of design as discipline into the field of open and distributed production, demonstrating the effectiveness and replicability of i) "design through prototyping" scientific and project results to a broad and diverse audience to support the importance of prototyping, as well as ii) of a learning-by-doing process in real-life to advance digital fabrication knowledge and open design possibilities.

In SISCODE research project, the development of analytic outputs such as knowledge base construction, comparative analysis and assessment framework, built evidence-based knowledge on the effectiveness of co-cre-

ation and the adoption of design methodologies and tools for a better integration of society in science technology innovation policies, experimenting cross-sector co-creation methods as well as systematising RRI processes and tools. The development of co-creation/co-design sessions and events demonstrated the value of involvement of society in developing RRI solutions to explore responsible and impactful co-creation in innovation ecosystems and to strengthen and spread awareness on the culture of co-design.

TAMBALI FII achieved relevant outputs that contributed to the fulfilment of several outcomes. In particular, the creation of a framework for a training model, the setting up of training workshops, and the definition of guidelines for the replication of methods and practices contributed to the development of skills and knowledge. They were transferred to and taken by local actors and communities around the fishing sector on innovative manufacturing technologies and composite materials to promote an entrepreneurial mindset. The organisation of conferences, exhibitions, and co-design workshops, together with the development of prototypes and the starting of new projects, favoured the diffusion of wider acknowledgment and awareness of applying new technologies and materials as means to foster economic and social engagement growth.

5.2.1 Recognising the design research contribution (RQ2): looking for commonalities (RQ3)

What does it emerge in terms of medium-term effects of the above-mentioned activities and outputs delivered to address the specific challenges and to achieve the identified goals?

This analysis revealed how design research has a strategic role. Despite the peculiarities of the diverse research projects, most share a common approach to the research that appears human-centred, focused on actual needs, and keen on the implications of the actions conducted throughout the project, able to strategically face the relational, educational, and political transformations within the target groups. Research, by addressing complex transformations, needs to develop new knowledge creation paths to stimulate knowledge creation and sharing as well as its benefits towards educational, entrepreneurial, political and/or social opportunities and synergies. The analysed projects demonstrate the capability of design research to conduct practical and analytical explorations able to generate impactful new knowledge for system change, going beyond the sole – however fundamental – production of high-quality publications within the scientific community, therefore

favouring cross-fertilization. By committing to upskilling processes, design research has a role in strengthening human capital in research and innovation, favouring capability building and enhancing the impact of a design mindset through a high-quality intervention able to bring the whole system forward into a more desired state (Dorst, 2018).

The objective of creating networks of stakeholders is another common feature. The design research attitude demonstrates the capability to constitute a system, intensify cooperation between research bodies and other stakeholders, and create a system of transferred competencies in areas in which design is beginning to play a strategically important role. Multi-actor ecosystems become goals and means at the same time to reinforce collaboration and synergies between research and industry, government, and society. In this sense, design research at the Department of Design is progressively exploring the capability of adaptation and the evolution of its approaches and methods, making this an object of design.

Besides the evolution in the approaches and methods, the research portrays a continuous widening of disciplinary boundaries. Beyond the traditional fields of application – that appear somehow underrepresented in the analysed sample – the design discipline is progressively entering new domains. The distinctive feature of the design discipline to design innovations through its product (in the broadest sense, cf. Margolin in Buchanan & Margolin, 1995) is in fact applied to other fields by transferring evidence-based strategies for growth, scaling-up and replicability, always adapted to contexts. These innovations are not only product-based, ergo siloed into only technological or industrial advancements, but spread into policy solutions, social innovations, and life quality improvement.

5.3 Mapping the outcome inside and outside the Department

The previous section described the outcomes of a sample of four projects, as representative of the 32 analysed, highlighting the design contribution in achieving those results and commonalities between the projects.

As already stated in the introduction, a further aim of the study was to map the outcomes achieved both within the Department of Design and outside it, to understand if the funded design research is in-line with Department identity and how it covers – or contributes to cover – the fields of knowledge. A mapping of outcomes according to different criteria may indeed provide an aggregate view, meaningful for conducting a critical analysis.

The methodology section introduced the strategy adopted for the mapping, based upon the Department keywords (inside) and the ERC keywords (outside). In the following, we show and discuss the results of the mapping.

5.3.1 Mapping within the Department

The 113 keywords defined by the Department in 2015 have been used as tags to mark the outcomes of the 32 research projects analysed.

As briefly introduced in the methodology sections, the keywords are organised into three typologies: contents, approaches, and subject areas.

Each category is, in turn, divided into other subcategories, as shown in tab. 5.2. In particular, the typology of the contents is organised into 9 subcategories: Arts & Humanities, Design & Management, Health and Safety, Knowledge management, Production models, Representation systems, Responsible development, Social Innovation, and Urban landscape. The Approaches are divided into Design approach, Design process and methods, and Design research. Finally, the Subject areas are organised into 5 subcategories: Communication, Interior, Service, Fashion, and Product. Each sub-category is then populated by the keywords.

Tab. 5.2 – The 113 keywords gathered grassroot from the community of the Department of Design in 2015 to describe its research.

Typology	Topic	Department Keywords
Contents	Arts & Humanities	Aesthetics Cultural and Creative Industries Cultural Heritage Design for Cultural Heritage Design History Museum Studies Semantics and Semiotics Visual Arts
	Design & Management	Change Management Competitive Advantage Design Policy Product Performance Service Assessment
	Health & Safety	Design for Older People Design for Subjective Well-Being Risk Evaluation Safety and Prevention Smart Systems Wearable Technologies
	Knowledge Management	Communication Process Data Visualisation Digital Archives Digital Platforms Information Design
	Production Models	(New) Craftsmanship Digital Manufacturing Distributed and Open Microproduction Local Craft Made In Italy Materials Networks
	Representation Systems	Augmented Reality Computer Aided Design Drawing(S) Parametric Design Reverse Modelling Virtual Models & Virtual Reality
	Responsible Development	Environmental Design Life Cycle Design Sustainable Energy Sustainable Lifestyle

(continued)

Typology	Topic	Department Keywords
	Social Innovation	Collaborative Services Corporate Social Responsibility Deintermediation Games for Change Gender Issues Welfare
	Urban Landscape	Mobility Smart City Spatial Design Temporary Living Traffic Management Urban Spaces
Approaches	Design Approach	Co-Design Creativity Cross-Cultural Research Design Driven Innovation Design for All Design Thinking Emotional Design Experience Design Metadesign Strategic Design User Centred Design
	Design Process and Methods	Case Studies Decision Making Envisioning Ethnography Interdisciplinarity Mapping Product Development Prototyping Scenarios Storytelling Transmedia Practices
	Design Research	(Design) Education Design Theory Epistemological Research Phenomenological Research Reflective Practice

(continued)

Typology	Topic	Department Keywords
Subject Areas	Communication	Basic Design Brand Communication Communication Design Game Design Graphic Design Interaction Design Media Studies Movie Design Packaging Design Synesthesia
	Interior	Exhibition Design Hospitality Design Interior Design Lighting Design Private and Public Spaces Retail Design Urban Design Yacht Design
	Service	Product Service System Service Design Transportation Design
	Fashion	Fashion Design Jewellery Design Knit Design Textile Design Texture Design
	Product	Car Design Colour Design Ergonomics Furniture Design Lighting Product Design Product Design Usability

The first analysis was conducted on the keywords associated with the project outcomes to highlight areas of density. Tab. 5.3 shows the results graphically. The areas coloured in dark grey highlight those keywords that were associated with several outcomes, while more desaturated versions of grey indicate a lower incidence of the keyword. Non-underlined keywords were not tagged to any outcome.

Tab. 5.3 – Frequency of association of Department keywords to the outcomes of the 32 projects analysed.

Typology	Topic	Department Keywords
Contents	Arts & Humanities	Aesthetics Cultural and Creative Industries Cultural Heritage Design for Cultural Heritage Design History Museum Studies Semantics and Semiotics Visual Arts
	Design & Management	Change Management Competitive Advantage Design Policy Product Performance Service Assessment
	Health & Safety	Design for Older People Design for Subjective Well-Being Risk Evaluation Safety and Prevention Smart Systems Wearable Technologies
	Knowledge Management	Communication Process Data Visualisation Digital Archives Digital Platforms Information Design
	Production Models	(New) Craftsmanship Digital Manufacturing Distributed and Open Microproduction Local Craft Made In Italy Materials Networks
	Representation Systems	Augmented Reality Computer Aided Design Drawing(S) Parametric Design Reverse Modelling Virtual Models & Virtual Reality
	Responsible Development	Environmental Design Life Cycle Design Sustainable Energy Sustainable Lifestyle

(continued)

LEGEND

37-53% of the analysed projects
33-20% of the analysed projects
16-10% of the analysed projects
3-6% of the analysed projects
0% not used

Typology	Topic	Department Keywords
	Social Innovation	Collaborative Services Corporate Social Responsibility Deintermediation Games for Change Gender Issues Welfare
	Urban Landscape	Mobility Smart City Spatial Design Temporary Living Traffic Management Urban Spaces
Approaches	Design Approach	Co-Design Creativity Cross-Cultural Research Design Driven Innovation Design for All Design Thinking Emotional Design Experience Design Metadesign Strategic Design User Centred Design
	Design Process and Methods	Case Studies Decision Making Envisioning Ethnography Interdisciplinarity Mapping Product Development Prototyping Scenarios Storytelling Transmedia Practices
	Design Research	(Design) Education Design Theory Epistemological Research Phenomenological Research Reflective Practice

(continued)

Typology	Topic	Department Keywords
Subject Areas	Communication	Basic Design Brand Communication Communication Design Game Design Graphic Design Interaction Design Media Studies Movie Design Packaging Design Synesthesia
	Interior	Exhibition Design Hospitality Design Interior Design Lighting Design Private and Public Spaces Retail Design Urban Design Yacht Design
	Service	Product Service System Service Design Transportation Design
	Fashion	Fashion Design Jewellery Design Knit Design Textile Design Texture Design
	Product	Car Design Colour Design Ergonomics Furniture Design Lighting Product Design Product Design Usability

The first consideration is that almost all the keywords were associated at least once with an outcome. This result opens up two considerations. The Department keywords (which are coeval with the projects) well represent the nature of the research projects running at that time (2015) and after (till 2021). Furthermore, the sampling of the 32 projects that were analysed in depth seems to well represent the nature of the funded research. In general, we may state that the two images of the Department, keywords and funded research, are partially aligned, resulting in a mostly coherent unique image. Looking more in-depth, it is evident that the typology Approaches counts most of the keywords in darker red, primarily related to design approaches and methods. In particular, co-design, design-driven innovation, user-centred design, and interdisciplinarity are the most cited keywords. This result

is largely predictable, as all projects were conducted in a fairly defined disciplinary area, sharing approaches and methods. Regarding the contents, it is evident that the keywords are more widespread and less polarised. This result entails a good coverage of the contents by the funded research with an exception: the area of the representation systems (e.g., augmented reality, parametric design, virtual reality) suffers from a lack of coverage of funded research in the considered timespan. The subject areas see a fair distribution of the keywords testifying to a good representation of the design subdisciplines in the funded research.

The second study on the keyword was more precise, in quantitative terms, counting every occurrence of the keywords in the outcomes. The results are graphically mapped in fig. 5.1.

The more detailed study confirms the previous results: larger dots, implying higher occurrences, are concentrated in the Approaches typology, while Subject areas and Contents see less polarised results, with smaller and more distributed dots. Looking more in detail at the subject areas, it emerges that fashion design has the larger dot, highlighting a very positive strand of funded projects in the field (e.g., DeFINE), followed by game design, product service system, and product design.

The Contents typology is the one showing more polarised results, with both big and small dots. This result is useful to understand which specific topics are sustained by funding within the same coherent group of topics. Taking the subcategory Arts & Humanities as an example, we may highlight how the Cultural & Creative Industries (CCIs) keyword is the most cited. On the contrary, more disciplinary topics such as Design History are much less represented. This result is not surprising, given the focus of Horizon 2020 on the CCIs, confirmed in the Horizon Europe Programme.

We may recognise the same behaviour in all the subcategories of the Contents. Bigger dots represent trending topics (e.g., production networks, design for subjective well-being, sustainable lifestyle, collaborative services, digital platforms). Smaller dots may indicate either a growing topic (e.g., gender issue) or a less represented one (e.g., environmental design). Instead, we can highlight thematic areas poorly covered by funded projects, such as the area of representation, which is characterised by small numbers of points and limited size. This condition may highlight the poor ability of the Department to get funding for trending topics such as virtual and augmented reality.

In summarising we may underline the most evident elements emerging from this mapping. The first is that the Department covers a great variety of topics in its funded research, as demonstrated by the rich use of keywords in

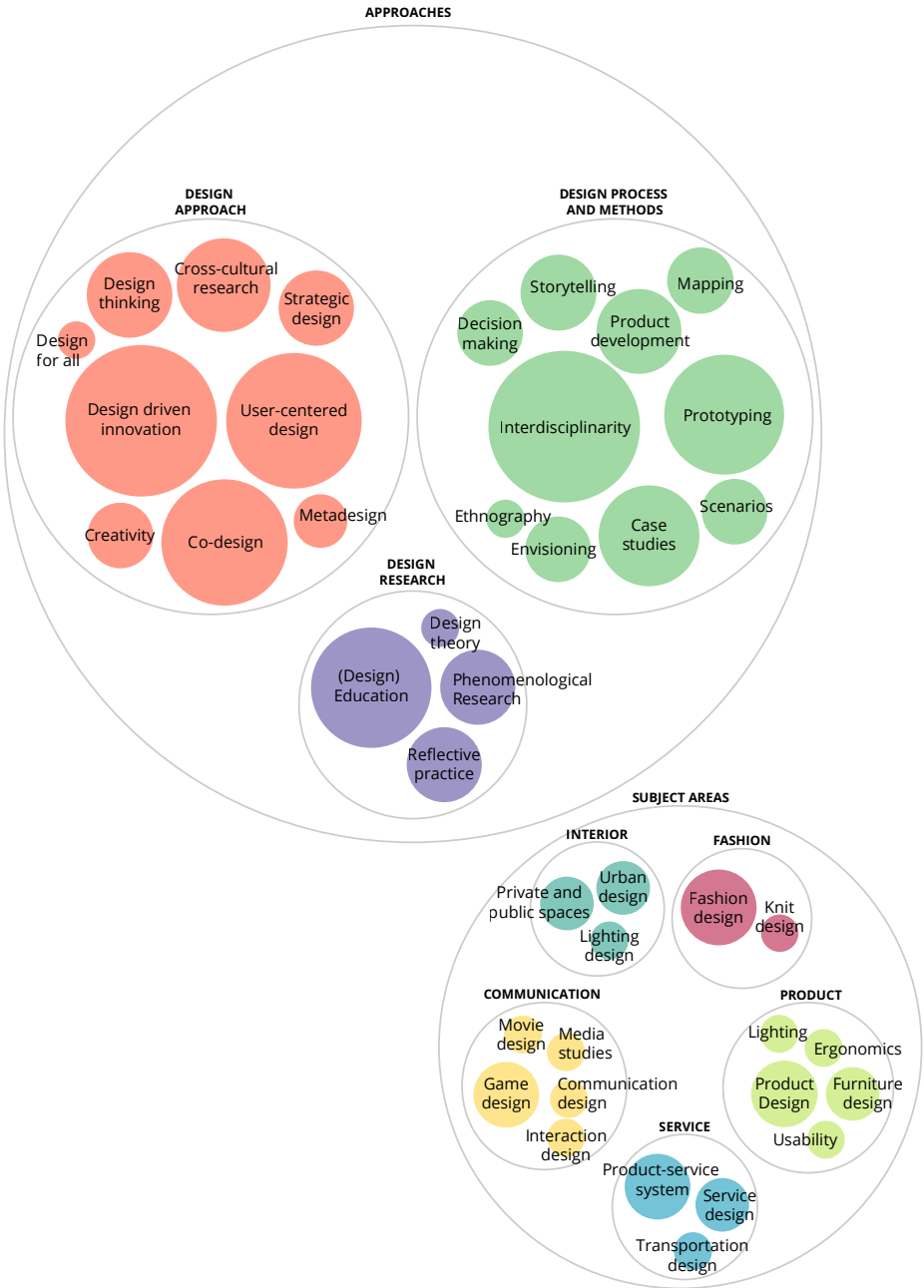
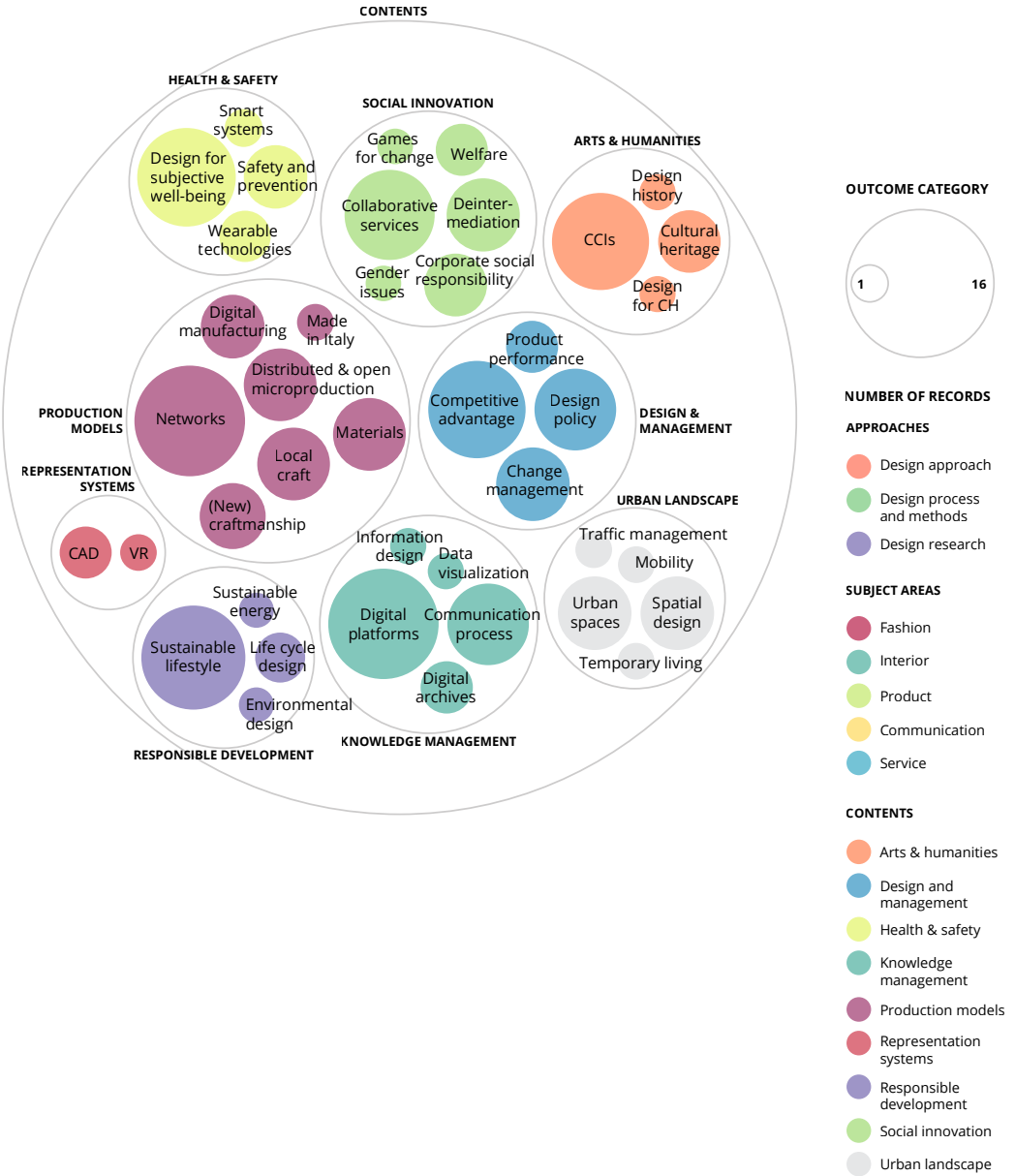


Fig. 5.1 – Occurrence of the Department keywords in the outcomes.



the outcomes. Common traits may be identified in the methodologies and in the approaches, that are the most shared keywords. Finally, we may pinpoint more popular topics (category Contents) that see higher occurrences in the outcomes.

5.3.2 Mapping in the national/European context

The second mapping action was performed by looking outside the Department and precisely at the national and European contexts. More precisely, the mapping has been conducted against the 45 ERC keywords selected by the Department in 2020. As stated in the methodology section, one or more ERC keywords have been assigned to every outcome. The selection has been then discussed with the projects' PIs for approval.

The ERC keywords are essentially related to fields of inquiry and allowed to group the outcomes following a thematic approach efficiently. The considerations emerging from this part of the study are therefore primarily thematic and may highlight the Department-funded research's positioning.

The analytical inquiry has been conducted by counting the time every ERC keyword has been associated with the project outcomes. Fig. 5.2 aggregates the analysis results, grouping them according to the three main ERC fields.

At first glance, it is evident that most of the outcomes, and thus projects, settle in the Social Science and Humanities field, which counts a wider variety of selected keywords and more numerous occurrences. 19 keywords come from SH fields, 10 from PE and just 1 from LS. So, it is evident that not all the 45 ERC keywords selected by the Department to represent its identity have been mapped to the outcomes. Just 30, so two thirds of the total, have been associated. This result is not surprising. As we have repeated several times in the text, the sample of projects selected does not necessarily represent all the research conducted in the Department.

Delving deeper into the analysis, we can quantify the number of times an outcome was associated with an ERC keyword. Fig. 5.3 visualises the results by providing a ranking of the most tagged keywords with the number of occurrences. SH3_11 – Social aspects of teaching and learning, curriculum studies, education and educational policies is by far, the most tagged keyword (17). This result is in line with the high number of research projects dealing with higher and vocational education. It is followed by SH3_8 – Social policies, welfare, work and employment and SH1_9 – Industrial organ-

isation; entrepreneurship; R&D and innovation both counting 12 occurrences. The first is related to social innovation projects, while the second returns a good presence of projects related to the field of Design & Management. PE8_10 – Manufacturing engineering and industrial design is considered the ERC keyword par excellence of the Design discipline. It represents the main panel for evaluating projects stemming from that field in Italy. In the study, it only ranks fourth with 9 occurrences. Concurring with the general tendency to prefer ERC keywords from the SH field, this result is an important indicator to be carefully considered.

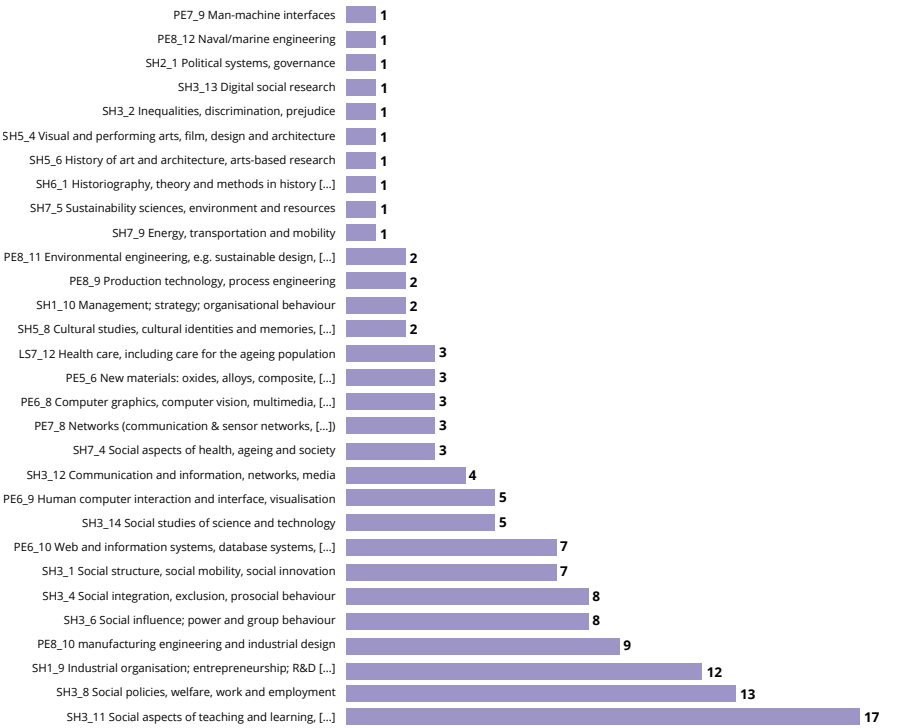


Fig. 5.3 – Quantified occurrence of the ERC keywords in the outcomes.

On the one hand, the result may be justified by the top-down approach of the funded research, which hardly funds projects strictly coherent with the traditional Industrial Design field. As seen in the previous section, it is more frequent that Design contributes to the projects with transversal approaches and methodologies adapting to the topics of the calls.

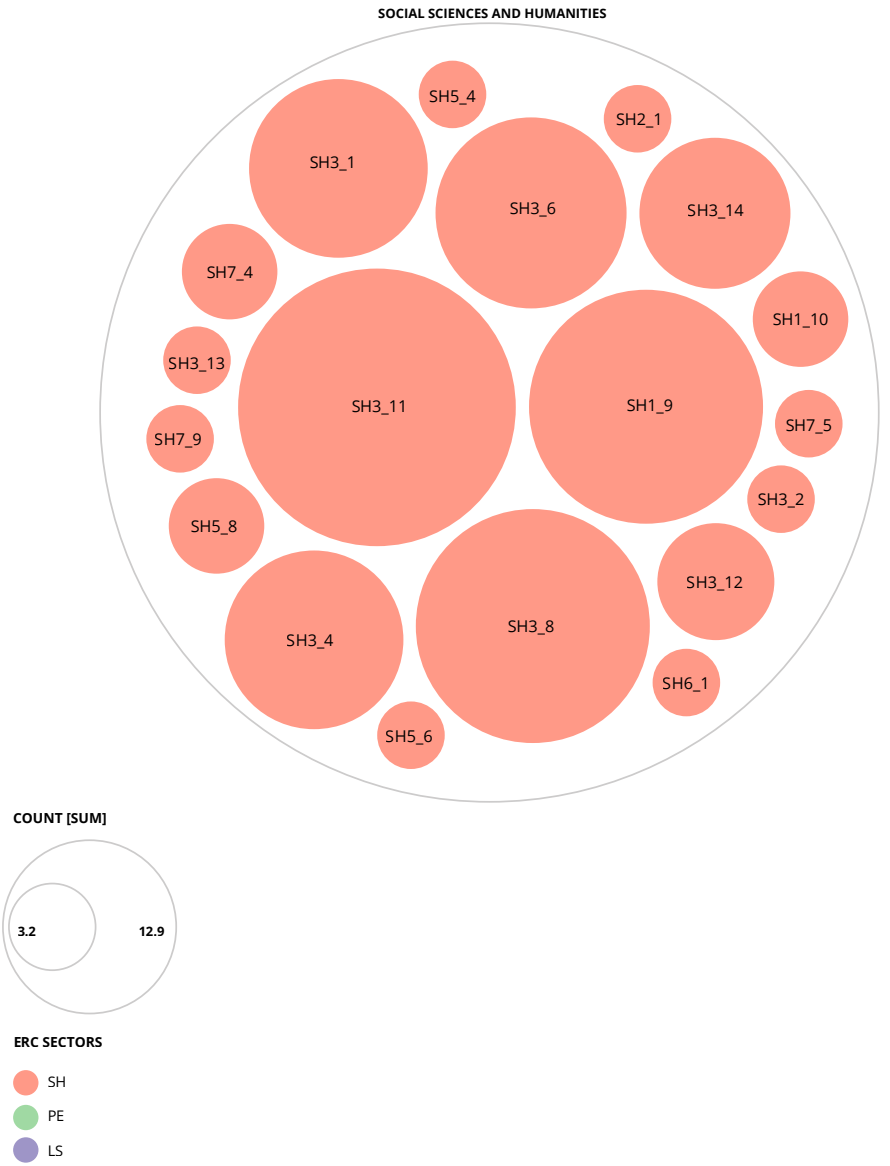
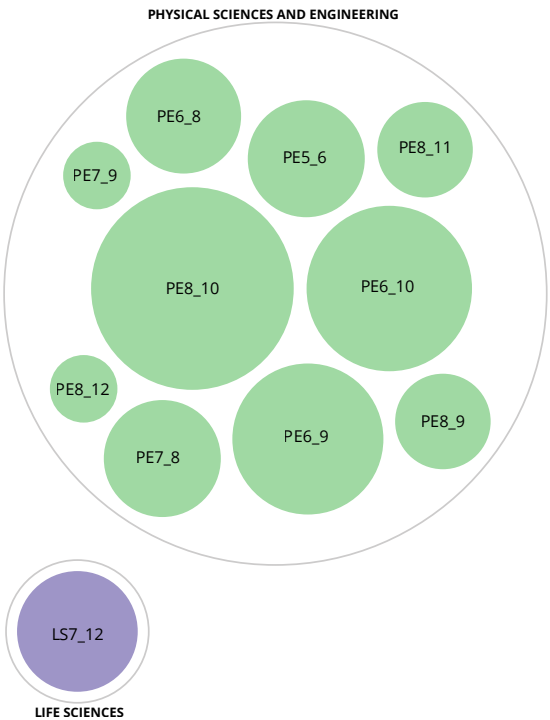


Fig. 5.2 – Occurrence of the ERC keywords in the outcomes, grouped according to the three main ERC fields.



SH1_9 Industrial organisation; entrepreneurship; R&D and innovation
SH1_10 Management; strategy; organisational behaviour
SH2_1 Political systems, governance
SH3_1 Social structure, social mobility, social innovation
SH3_2 Inequalities, discrimination, prejudice
SH3_4 Social integration, exclusion, prosocial behaviour
SH3_6 Social influence; power and group behaviour
SH3_8 Social policies, welfare, work and employment
SH3_11 Social aspects of teaching and learning, curriculum studies, education and educational policies
SH3_12 Communication and information, networks, media
SH3_13 Digital social research
SH3_14 Social studies of science and technology
SH5_4 Visual and performing arts, film, design and architecture
SH5_6 History of art and architecture, arts-based research
SH5_8 Cultural studies, cultural identities and memories, cultural heritage
SH6_1 Historiography, theory and methods in history, including the analysis of digital data
SH7_4 Social aspects of health, ageing and society
SH7_5 Sustainability sciences, environment and resources
SH7_9 Energy, transportation and mobility

PE5_6 New materials: oxides, alloys, composite, organic-inorganic hybrid, nanoparticles
PE6_8 Computer graphics, computer vision, multimedia, computer games
PE6_9 Human computer interaction and interface, visualisation
PE6_10 Web and information systems, database systems, information retrieval and digital libraries, data fusion
PE7_8 Networks (communication networks, sensor networks, networks of robots...)
PE7_9 Man-machine interfaces
PE8_9 Production technology, process engineering
PE8_10 manufacturing engineering and industrial design
PE8_11 Environmental engineering, e.g. sustainable design, waste and water treatment, recycling, regeneration or recovery of compounds, carbon capture & storage
PE8_12 Naval/marine engineering

LS7_12 Health care, including care for the ageing population

On the other hand, the result may portray an increasingly pronounced tendency to widen the disciplinary boundaries of the Design discipline that is progressively entering new domains. Looking at the ranking in fig. 5.3, the impression is that, for what concerns funded research at Polimi, the traditional fields of application have already left the floor to less consolidated ones.

5.4 Discussion

This opening to new areas and disciplines entails on the one hand the enrichment in terms of outcomes that the design contribution may achieve. On the other hand, it requires a progressive acquisition of new vocabularies to enter constructive dialogues with new stakeholders. Within interdisciplinary partnerships, the design discipline's contribution stands in the capability to bring and adapt its approaches, processes, and methods in the project to achieve objectives with scientific, social, and economic dimensions towards future transformations. Through traditional design approaches and methodologies (i.e., phenomenological, constructivist, participatory, design thinking), and designerly methods and tools (i.e., co-design, workshops, toolsets, prototypes, seminars), design research acts towards the stimulation of knowledge sharing, and the diffusion of the wider acknowledgement and awareness of complex issues. In fact, the very notion of "research through design" (Frayling, 1993; Redström, 2017; Stappers & Giaccardi, 2017) – or "constructive design research", as defined by Koskinen et al. (2011) to underline how design research outputs are key means in constructing knowledge – amplifies the nature of the design object and expands its sphere of influence in terms of enabling possibilities for actions (Margolin in Buchanan & Margolin, 1995, pp. 121–141).

Design research has brought into cross-sector and transdisciplinary collaborations its traditional capability to address complexity, with a relevant focus on the social (social innovation and sustainability, policy innovations) and entrepreneurial dimensions, where the educational one assumes a transversal role in transferring the design mindset (reflexive, contextual, iterative, hands-on skills, and process-oriented visions). A distinctive design trait also emerges here, with a tacit contribution that is gradually building its foundations related to research that must be necessarily explicit and measurable in methodology, analytical perspective, and result (Poggenpohl, 2015).

Therefore, by expanding the design object to what was previously unthinkable for design, new avenues open for design research as drivers to bring already established design approaches and processes to other areas. Of

course, this implies that objects that were previously unknown or unfamiliar to the design discipline require preparation because it means entering areas not traditionally covered and building the foundations for distinctive and scientific methodologies and tools.

Consequently, an extensive reflection on semantics issues still requires to be fully explored to sustain the dialogue with other disciplinary areas. Considering the cyclical evolution of complexity that knowledge faces, we know that disciplines (human, social, technical ones) need to reframe the way they approach it and how they relate to each other in a collaborative way: hybrid literacies are required as well as further reflections around the implications of transdisciplinarity, specifically in scientific research. Regardless of the domain, a specific transdisciplinary approach must be envisaged to break the boundaries and expand the approaches. For the design discipline, this also requires going beyond "the concept that makes design the glue that can hold different disciplines together and uses design thinking as the methodology" (Kelley & VanPatter, 2005, p. 3) to better understand internal and external tensions towards continuous transformation. To reflect on the continuous change of the positioning of design in relation to education and research, an evolutionary path on the same design transdisciplinary skills, knowledge and attitudes needs to be nurtured to adapt to the space of transdisciplinary research and innovation.

5.5 Conclusions

The presented analysis on the effects achieved in the medium-term and on the evidence of the role of Design in a sample of funded projects brought us to a wider reflection on the current drivers of change of design research, especially within interdisciplinary partnerships. Research projects developed within funding programmes like the ones considered in this study requires the clear explication of impact pathways, and therefore of achievable outcomes: this requires an operational approach and the setting of the direction for innovative change (European Commission, Directorate-General for Research and Innovation & Mazzucato, 2018). The study points out that the research projects run by the researchers of the Department of Design of Politecnico di Milano is strongly heading towards the social science and humanities field and is devoting its capabilities to strategic transformations at managerial, organisational and systemic levels in various fields. A transformation of internal skills, moving beyond the object of design and questioning its traditional and acknowledged focus. The top-down approach of the funded

research may have influenced this shift; our opinion is that, more than this, the inspirational goals of European and national funded research are opening to stimulating challenges to achieve effective change and to transformative objectives for the design discipline.

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6. The projects' impacts and trajectories: the relationship between research topics and impact pathways

Marzia Mortati & Xue Pei
Department of Design, Politecnico di Milano

The chapter explores the impacts achieved by the research projects conducted at the Department of Design between 2014 and 2019. Adopting the framework used in the Horizon Europe programme (HEu), the analysis answers the following research questions: (i) What impacts have been generated by the funded projects according to the 3 main categories (scientific, societal, technological/economic) identified in HEu? (ii) Which are the research topics that have mainly contributed to achieving the impact categories? (iii) How have the funded projects contributed to reaching the 9 Key Impact Pathways (KIPs) proposed in HEu?

Findings reveal that all 32 research projects contribute to creating both scientific and societal impact. However, 21 research projects have also generated technological/economic impact. The Department of Design has performed best in achieving the following 4 KIPs: strengthening the uptake of research and innovation in society; fostering the diffusion of knowledge and Open Science; creating high-quality new knowledge; and strengthening human capital in research and innovation. Research topics related to "design methodologies" have contributed significantly to generating all 3 types of impact. Other clusters – "distributed production", "health", "innovation studies", "education" and "ICT"- have played important roles in achieving scientific and societal impact. The other most relevant clusters in reaching technological/economic impacts are "health" and "education".

The final discussion addresses how these impacts relate to the identity of the local scientific community in terms of research and innovation activities, reflecting on the strengths and weaknesses of the research performed at the Department of Design in terms of impact.

6.1 Evaluating the impact of research

6.1.1 Research impact and evaluation models

The interest in the evaluation of the impact of research actions has grown rapidly in the last decade with the goal of seeking the evidence of the values of investments made by governments and funders (Edler et al., 2012; Oancea, 2019). In the growing body of literature referred to the field, research impacts go beyond the academic realm; increasingly, non-academic impacts are recognised to be crucial to demonstrate how research might benefit a wide range of targets and the society. However, research impacts, especially those non-academic ones, are often indirect, non-linear and long-term, making their measurement highly complex.

Attempting at providing a brief non-exhaustive overview of the topic, providing a description of the notion of impact is relevant. The Oxford English Dictionary defines impact as a 'marked effect or influence'. In the realm of research, impact has been discussed and defined in a number of studies. Many of these have also produced guidelines to assist in description and measurement. ESF (European Science Foundation, 2009) has defined impact as the consequences of an action that affects people's lives in areas that matter to them. REF (UK's Research Excellence Framework, 2014) defines impact as 'an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia'. This second definition is relevant in the context of this analysis as it points out the multi-faceted attributes of an impact and provides an initial list of the different perspectives to be examined. UKRI (UK Research Innovation) in its report on *Pathways to Impact* (2018) depicts impact as the influence of research or its effect on an individual, a community, the development of a policy, or the creation of a new product or service, thus adding to the previous definition an understanding of the different targets and beneficiaries of impact. Based on a review of diverse studies, Reed et al. (2021) define research impacts as the demonstrable and/or perceptible benefits to individuals, groups, organisations and society that are causally linked (necessarily or sufficiently) to research. This brief overview provides a foundation to describing impact in the context of this study: **an effect created by actions alongside a process (or pathway); this effect can be perceived from a variety of angles and received by diverse targets**.

To capture and evaluate the complexity of impacts, Bruno and Kadunc (2019) have recognised a set of methodological challenges specifically tied to research and innovation (R&I) activities:

- The time lag issue, linked to the wide range of interconnected activities that typically occur during research making the generation of impact possible only in the very long-term (sometimes even twenty or thirty years after);
- Uncertainty and risk, linked to the unpredictability of innovation work (Irvine & Martin, 1989) and the high-risk nature of the most innovative activities that often leads to a process of trial and error in which value is produced also by research activity that apparently fail;
- The attribution/contribution problem, linked to the inexhaustible nature of knowledge that develops and spreads over time often creating unexpected results (i.e., spillover effects).

These multi-faceted characteristics have intensified discussions on how to identify and account for research impact, giving rise to several proposals of frameworks, methodologies, processes of analysis, and methods for evidence (data) collection. Guthrie et al. (2013) have studied 14 such frameworks and observed that existing proposals focus on two main objectives: (1) accountability and better allocation of resources, for which quantitative approaches are best suited because allowing comparability; (2) learning, for which qualitative methods are more fitting, because more flexible even if they do not produce comparable results. Graham et al. (2018) found that the majority of R&I monitoring and evaluation frameworks aim at the first objective. At the same time, they present several shortcomings, for instance the widespread idea that scientific excellence can only be measured through bibliometric data (i.e., scientific publications and citations). This conception has evolved because of the events that have characterised the European socio-economic environment in the last fifteen years. For instance, the austerity in public spending that has dominated since after 2008 has highlighted the relevance of monitoring data on jobs and company turnover (Ravet et al., 2019), thus leading to the introduction of related metrics. Further, shifting socio-political conditions and priorities (i.e., the acceptance of the Sustainable Development Goals as a worldwide target to improve the condition of humanity) have led to the understanding that R&I should tackle the needs of society in general, beyond scientific excellence. However, the societal impact is highly complex to measure and in many frameworks is confused with the dissemination of R&I outputs (i.e., outreach on social media and policy documents) (Bruno & Kundac, 2019). Scholars (Alla et al., 2017; Reed, 2018) have thus argued that there is no single and best method or

process for evaluating impact of research; the challenge is to select the most appropriate methods in an overall evaluation design suited to a certain type of action and context.

When inspecting diverse proposed evaluation frameworks (Alvarez et al., 2010; Douthwaite et al., 2003; Research England, 2019), significance and reach appear as the two most commonly used criteria. These consider both the intensity of the effect on, and the number, extent and diversity of the beneficiaries. Furthermore, frameworks most often include the evaluation of the intermediate effects that occur over time at different time scales, beyond the impacts reached at the end of an action. Reed et al. (2021) emphasise evaluation as the process of collecting and interpreting data to assess the significance, reach and attribution of impacts deriving from research, whether positive or negative. Further, they identify five types of evaluation designs mainly distinguishing methods: i) experimental and statistical methods; ii) systems analysis methods; iii) textual, oral and arts-based methods; iv) indicator-based approaches; v) evidence synthesis approaches. These five methods can be categorised according to the extent to i) which they provide summative evidence versus formative feedback, and ii) the extent to which they provide evidence of research as a sufficient or necessary cause of impact. Crossing methods and extents, the authors propose a matrix to guide the design and use of the appropriate evaluation model according to the aims and contexts.

One element that is especially hard to evaluate in R&I activities is the chain of causality that might bring from an action to several different (and desired) effects. Approaches like programme-theory (Chen, 1990; Weiss, 1987; Donaldson, 2007) offer interesting insights in this respect. As Bruno & Kundac (2019, p. 66) observe "the central thesis of the programme-theory evaluation is that the impact of the programme is expected to occur based on a logical set of events and interactions between the participants to the programme, the results of the projects funded and the wider environment". This approach became a standard in the European Commission since 2017 (European Commission, 2017). Prior to this, the first global attempt to capture the socio-economic impact of research for all disciplines has been proposed by the Australian Research Quality Framework developed by Duryea et al. (2007). This framework provided a relevant basis for the development of the British system for assessing the quality of research in higher education institutions (Penfield et al., 2014). In the British case, the programme-theory approach was adopted introducing the notion of impact pathways. These typically include sketching a set of steps that, linked to one another along a process, can indicate how a certain output transforms into a wider aggregate impact. Pathways to impact have been adopted in the British system mainly

collecting evidence through a case study approach, and using a division between academic and non-academic impact, referring non-academic to societal and economic impacts.

These experiences have been central to elaborate the framework for impact evaluation proposed in the Ninth European Framework Programme – Horizon Europe (HEu). Presented in 2018, HEu moves beyond mere monitoring of programme implementation and aims at incentivising the generation of impact applying specific conditions to the research funding, and at diffusing a culture of evaluation of research that goes beyond academic excellence (European Commission, 2018). Instilling this culture of evaluation is crucial to demonstrate the European added value of R&I investments and reinforce accountability, transparency, and learning.

Building on the previous experiences, HEu adopts the notion of Key Impact Pathways and identifies three broad and non-exclusive impact categories which reflect the non-linear and long-term nature of R&I investments:

- **Scientific impact**: supporting the creation and diffusion of high-quality new knowledge, related to skills, technologies and solutions to global challenges.
- **Societal impact**: strengthening the impact of R&I in implementing EU policy priorities, and in supporting the uptake of innovative solutions in industry and society to address global challenges.
- **Technological and Economic impact**: fostering all forms of innovation, including break-through innovation, and strengthening market deployment of innovative solutions.

Each impact category is further detailed in Key Impact Pathways, 3 for each category identified (further details on this are provided in the following paragraph). Based on this, the HEu impact assessment framework expects research actions to generate:

- New and excellent scientific knowledge, attracting the world's best research resources and promoting world class scientific impact;
- Significant social impact, communicating, disseminating and exploiting the scientific results, by translating them into new products, services and processes to be offered to political concerns, citizens and the society in general;
- Positive growth on the economy, creating new job opportunities (including high skilled positions), attracting investments on R&I activities, and overall increasing the European GDP.

At present, this framework is considered the most advanced for the evaluation of research impact and is thus adopted as the main reference for the analysis reported in this chapter.

6.1.2 Key Impact Pathways and related Indicators

The literature review briefly reported in the previous paragraph has clarified that research impact evaluation is a process aimed at capturing both the final and intermediate effects (significance and reach) of research actions. Combined with this, the non-linear and long-term nature of the relationship between research activities and impacts (Bornmann, 2012; Reed et al., 2021) makes it challenging to depict the causal links that might attribute an impact to a single research project or output. For instance, effects deriving from research are often mediated by several factors (that might boost or limit the impact), including incentives, local/cultural specificities, laws and norms, ethical considerations, and so on. To account for these multi-faceted and dynamic relationships, the notion of pathways to impact has been first introduced in the British system for research quality assessment (UKRI, 2018) and further adopted in the HEu framework.**The pathways to impact can be described as the knowledge exchange or the engagement activities that facilitate impacts** (UKRI, 2018). They are typically used in indicator-based approaches to impact evaluation, hinged on identifying variables (indicators) that indicate the achievement of impacts. Indicators can be organised and evaluated in categories of logical structures (e.g., logic models and Theory of Change), consequently using any method to collect the evidence needed for each indicator. Indicator-based approaches aim at tracing causal chains from research to impact, based on an anticipated theory or desired change. HEu adopts a logic model (and prompts research actions to do the same) working forward from impact goals to identify the steps that would be necessary to move along the chain of planned research activities, research outputs, intermediate outcomes, short-term impacts, and ultimate benefits (fig. 6.1). This enables the design of the pathway to impact reflecting the impact delivery process. Further, it enables the design of an evaluation process that measures indicators to infer whether the research is making progress towards the desired impacts.

In HEu, pathways to impact are further detailed in Key Impact Pathways (KIPs) to provide measures to monitor the progress of research actions towards the programme's objectives. For each KIP, proxy indicators are identified to track progress and distinguish between the short (directly generated by research outputs), medium (produced during the research period) and longer terms (reached beyond the research duration) (fig. 6.1). Overall, 9 KIPs and 27 proxy indicators are proposed covering the 3 main impact categories (scientific impact, societal impact and technological/economic impact). Each pathway consists of a storyline (the main message that communicates the

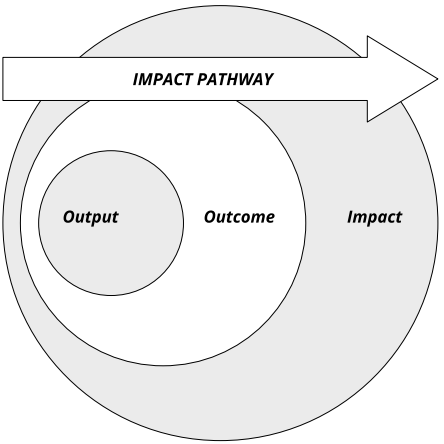


Fig. 6.1 – The impact pathway sheet.

progress towards impact), a time-sensitive indicator (distinguishing between short, medium, and long terms) and data needs (the information needed and the possible methodologies for data collection). The specifics of the KIPs and related indicators are illustrated in the following.

Scientific impact is expected to be achieved through creating high-quality new knowledge and enabling its diffusion, strengthening human capital, and promoting Open Science. The specific KIPs in this domain include:

1. **Creating high-quality new knowledge**. The traditional way to evaluate university research activities is mainly based on measuring academic quality and impact through the process of peer review (Grant 2006). This is further measured by citation-based metrics, such as H-index, I-index and citation counts. These academic metrics aim to measure the dissemination of the new knowledge created across the scientific community (Ravenscroft et al., 2017).
2. **Strengthening human capital in R&I**. The payback framework (Buxton & Hanney, 1996) included "the use of research in the research system" (e.g., acquisition of formal qualifications by members of the research team, career advancement, and use of project findings for methodology in subsequent research). REF (2014) mentioned the consideration of the interdisciplinary and diversity of researchers involved in the projects.
3. **Fostering diffusion of knowledge and Open Science**. A number of attempts are exploring ways to present the socio-economic impact of

publications and scientific knowledge by examining the online footprints, such as on social media (e.g., Altmetric uses a publication's online footprint – Twitter mentions, Facebook posts and shares etc.- to score its impact), and elaborating the Impact Story (a combined view of academics' citations and social media footprint). The idea is to provide a wider understanding of the academic impact beyond the simple citation count.

Tab. 6.1 – The detailed short, medium, and long-term indicators for the three KIPs linked to scientific impact.

Towards scientific impact	Short-term	Medium-term	Longer-term
KIP 1. Creating high-quality new knowledge	Publications - Number of peer-reviewed scientific publications resulting from the Programme	Citations - Field-Weighted Citation Index of peer-reviewed Publications resulting from the Programme	World-class science -Number and share of peer-reviewed publications resulting from the projects funded by the Programme that are core contribution to scientific fields
KIP 2. Strengthening human capital in R&I	Skills - Number of researchers involved in upskilling (training, mentoring/ coaching, mobility and access to R&I infrastructures) activities in projects funded by the Programme	Careers - Number and share of upskilled researchers involved in the Programme with increased individual impact in their R&I field	Working conditions – Number and share of upskilled researchers involved in the Programme with improved working conditions, including researchers' salaries
KIP 3. Fostering diffusion of knowledge and Open Science	Shared knowledge - Share of research outputs (open data/ publication/software etc.) resulting from the Programme shared through open knowledge infrastructures	Knowledge diffusion - Share of open access research outputs resulting from the Programme actively used/cited	New collaborations -Share of Programme beneficiaries which have developed new transdisciplinary/trans-sectoral collaborations with users of their open access research outputs resulting from the Programme

Source: Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU

Societal impact is referred to the benefits that research brings to the wider society and is expected to be achieved by addressing EU policy priorities through R&I, delivering impact through R&I missions and strengthening the uptake of R&I within society. This includes the following KIPs:

4. **Addressing EU policy priorities through R&I**. In the Research Impact Framework developed by Kuruvilla et al. (2006), "policy" is one of the impact categories used to depict the relationship between research findings and policy issues. This builds on the notion that research findings might support policy proposals, guide policymaking, and suggest changes to policy practices. The policy category is also included in the payback framework (Buxton & Hanney, 1996).
5. **Delivering benefits and impact through R&I missions**. The payback framework (Buxton & Hanney, 1996) identifies one impact category related to the behaviour change observed or expected through the application of research findings at a geographical, organisational and population levels.
6. **Strengthening the uptake of innovation in society**. The SIAMPI measurement model has a central theme related to capturing 'productive interactions' between researchers and stakeholders by analysing the networks that evolve during research programmes (Spaapen & Drooge, 2011).

Economic impact is the category of impact assessment that has probably received most attention by scholars and practitioners. Economic models used to assess impacts of research vary from cost benefit analysis to return on investment and employ a variety of methods for defining the economic benefits of research (Milat et al., 2015). For example, the payback model (Buxton & Hanney, 1996) lists service/economic benefits as one of the impact categories, looking at factors like improved service delivery, cost savings, improved health, or increased equity. Buxton et al. (2008) have stated that economic measurements should consider a wide range of benefits, like indirect cost savings for production and innovations stimulated by research.

In HEu, economic impact also includes the benefits of adopting/deploying new technologies and is expected to be achieved by influencing the creation and growth of companies, especially SMEs, generating new job opportunities (both directly and indirectly), and increasing investments in R&I activities. This includes the following KIPs:

7. **Generating innovation-based growth**. One of the commonly recognised economic impact indicators is the economic growth in terms of market performance, enhancement of the skills base, and improve-

Tab. 6.2 – The detailed short, medium, and long-term indicators for the three KIPs linked to societal impact.

Towards societal impact	Short-term	Medium-term	Longer-term
KIP 4. Addressing Union policy priorities and global challenges through R&I	Result - Number and share of results aimed at addressing identified Union policy priorities and global challenges (including SDGs) (multidimensional: for each identified priority) Including: Number and share of climate-relevant results aimed at delivering on the Union's commitment under the Paris Agreement	Solutions - Number and share of innovations and research outcomes addressing identified Union policy priorities and global challenges (including SDGs) (multidimensional: for each identified priority) Including: Number and share of climate-relevant innovations and research outcomes delivering on Union's commitment under the Paris Agreement	Benefits - Aggregated estimated effects from use/ exploitation of results funded by the Programme on tackling identified Union policy priorities and global challenges (including SDGs), including contribution to the policy and law-making cycle (such as norms and standards) (multidimensional: for each identified priority) Including: Aggregated estimated effects from use/ exploitation of climate-relevant results funded by the Programme on delivering on the Union's commitment under the Paris Agreement including contribution to the policy and law-making cycle (such as norms and standards)
KIP 5. Delivering benefits and impact through R&I missions	R&I mission results - Results in specific R&I missions (multidimensional: for each identified mission)	R&I mission outcomes – Outcomes in specific R&I missions (multidimensional: for each identified mission)	R&I mission targets met – Targets achieved in specific R&I missions (multidimensional: for each identified mission)
KIP 6. Strengthening the uptake of R&I in society	Co-creation - Number and share of projects funded by the Programme where Union citizens and end-users contribute to the co-creation of R&I content	Engagement - Number and share of participating legal entities which have citizen and end-users engagement mechanisms in place after the end of projects funded by the Programme	Societal R&I uptake - Uptake and outreach of co-created scientific results and innovative solutions generated under the Programme

Source: Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU

ment of productivity (e.g., revenues and turnovers increased by means of the results of research).

8. **Creating more and better jobs**. Another important factor of economic impact evaluation is the improvement in employment rates by means of job creation and creation of new entities, like start-ups and spin-offs.
9. **Leveraging investments in R&I**. The measurement of socio-economic impact was introduced in research impact assessment frameworks to assess and justify the significant investment in research (Grant 2006) in the medicine and healthcare sectors, which has revealed the importance to demonstrate research impact on further investments

Tab. 6.3 – The detailed short, medium, and long-term indicators for the three KIPs linked to economic impact.

Towards societal impact	Short-term	Medium-term	Longer-term
KIP 7. Generating innovation-based growth	Innovative results - Number of innovative products, processes or methods resulting from the Programme (by type of innovation) & Intellectual Property Rights (IPR) applications	Innovations - Number of innovations resulting from the projects funded by the Programme (by type of innovation) including from awarded IPRs	Economic growth – Creation, growth & market shares of companies having developed innovations in the Programme
KIP 8. Creating more and better jobs	Supported employment - Number of full time equivalent (FTE) jobs created, and jobs maintained in participating legal entities for the project funded by the Programme (by type of job)	Sustained employment – Increase of FTE jobs in participating legal entities following the project funded by the Programme (by type of job)	Total employment - Number of direct & indirect jobs created or maintained due to diffusion of results from the Programme (by type of job)
KIP 9. Leveraging investments in R&I	Co-investment - Amount of public & private investment mobilised with the initial investment from the Programme	Scaling-up - Amount of public & private investment mobilised to exploit or scale-up results from the Programme (including foreign direct investments)	Contribution to ' 3 % target' – Union progress towards 3 % GDP target due to the Programme

Source: Council Decision (EU) 2021/764 of 10 May 2021 establishing the Specific Programme implementing Horizon Europe – the Framework Programme for Research and Innovation, and repealing Decision 2013/743/EU

The indicator system adopted in HEu may appear simple and linear. However, indicators should be understood as the identification of the key dimensions where impact is desired and information needed, without overlooking interdependencies and connections. Bringing in also qualitative data and storytelling, the framework allows to produce a much richer picture of the impact produced in research, and how this generates value for the society and the economy, as well as scientific advancements.

The 3 impact categories, the 9 KIPs and the 27 indicators have provided both the theoretical framework and a practical guide to analyse the impact of the funded research projects developed at the Department of Design of Politecnico di Milano between 2014 and 2019.

6.2 Research design and methodology

6.2.1 Research objectives and questions

The analysis presented in this chapter aims at answering three main research questions.

a. What **impacts** have been generated by the funded projects of the Department according to the 3 main categories (scientific, societal, technological/economic) identified in HEu?

The aim of this question is to depict an overview of the impacts generated by the funded research projects in the last seven years, according to the framework adopted in the analysis. This first question adopts the categorisation of the three main impact categories (scientific, societal, and technological/economic) and crosses it with the main impacts identified by each project coordinator during the development of case studies (for details refer to chapter 3).

b. Which are the **research topics** that have mainly contributed to achieving the three impact categories identified in HEu *(scientific, societal, and technological/economic)*

This question is an in-depth investigation of the relationship between impacts and research topics. The aim is to understand which research topics (described in chapter 3) are working on producing which types of impact. More specific questions include: Which are the research topics that have created scientific impact, societal impact, and technological/economic impact? Which are the topics that have generated all the three types of impact? The results indicate the strengths and areas of improvement, but from the aggregated perspective of research topics rather than from the granular understanding offered by individual projects.

c. How have the funded projects contributed to reaching the 9 KIPs proposed in HEu? What KIPs are covered by which research topics? Instead, what KIPs might help us identify areas to strengthen competences and capabilities

The third research question aims to depict strengths and areas for improvement in the Department, according to the 9 different pathways to impact. The analysis reveals in which pathway the Department has achieved quantitatively more significant results, that is the pathways covered by a higher number of R&I projects. The investigation on the relationship between pathways and research topics allows to understand how different topics contribute to the 9 KIPs, depicting the overall profile of the Department in terms of research impact. At the same time, it suggests areas where less effort has been dedicated, as part of the activities developed by the Department in the same actions.

6.2.2 Research methodology and process

To answer the research questions stated above, data collection and analysis have been designed following the HEu impact assessment framework and the research topics described in chapter 2.

Firstly, the impacts identified by project principal investigators (PIs) for the sample analysed (32 research projects investigated through the project analysis described in chapter 2) have been referred more explicitly to the HEu impact categories and clustered accordingly. This activity has produced a general overview of the impact generated (reported in tab. 6.4 below) by crossing the impacts identified by PIs both with the three impact categories and the 9 KIPs. Through the projects, the link has also been made with the research topics (thematic clusters and keywords described in chapter 3) to understand their diverse degree of contribution to reaching specific impacts (pathways and impact categories). More specifically, the analysis has followed three main steps:

a. **matching** projects to a specific impact category and a specific impact pathway. Starting from the results of the semi-structured interviews conducted, the researchers involved have firstly listed the created impacts identified by the PI of each of the 32 projects. Afterwards, research projects' impact has been associated with impact categories and impact pathways of the HEu framework, creating the list reported in Annex I.
b. **crossing** projects, research topics and impact pathways to generate an overview on what and how many research topics could be connected

to which impact (pathway and impact category). The specific investigation on the 9 KIPs allowed us to focus on the research topics that have contributed to creating the pathways, uncovering further points of strength and areas where the Department might need to build more competence.

c. **visualising** the results. To better communicate the results of the analysis, the researchers used the open access visualisation platform RAW to create maps and make sense of the data collected. These maps and the analysis performed are presented in more detail in the remainder of the chapter.

Annex I presents the result of these two steps showing how the analysis of the samples led us to connect research topics (clusters and keywords) and impacts. This list was then split into 3 lists (each associated with one impact category) and other 9 lists (each associated with one KIP) to aid visualisation.

Table 6.4 summarises the overview of the relationship between projects, impact categories, and research topics (clusters and keywords). The details about the clusters and keywords that have contributed to each of the impact categories are illustrated in the following paragraph 6.3.

Tab. 6.4 – Relationship between impact categories, projects, and research topics (number of clusters and keywords).

Impact category	Number of projects that have reached the impact	Number of clusters linked to the projects	Number of keywords linked to the projects
Scientific impact	32	22	159
Societal impact	32	22	159
Technological/ economic impact	21	21	121

Table 6.5 shows an overview of the relationship between projects, KIPs, and research topics (thematic clusters and keywords).

Tab. 6.5 – Relationship between impact pathways, projects, and research topics (number of clusters and keywords).

Impact category	Number of projects that have reached the impact	Number of clusters linked to the projects	Number of keywords linked to the projects
#1 Creating high-quality new knowledge	27	22	135
#2 Strengthening human capital in R&I	25	22	124
#3 Fostering diffusion of knowledge and Open Science	28	21	139
#4 Addressing EU policy priorities through R&I	15	19	74
#5 Delivering benefits and impact through R&I missions	8	17	40
#6 Strengthening the uptake of innovation in society	31	22	154
#7 Generating innovation-based growth	17	19	85
#8 Creating more and better jobs	6	13	30
#9 Leveraging investments in R&I	4	9	23

6.3 The relationship between research topics, impact categories and KIPs

6.3.1 The impacts of the funded research projects

Our analysis shows that the 32 research projects analysed have resulted in a wide range of impacts, covering all three clusters adopted in HEu. In particular, we have identified: 136 types of scientific impact, 123 types of societal impact and 31 types of technological/economic impact (as shown in fig. 6.2 in an aggregate manner). These types derive from the case studies developed and have been directly indicated by each PI (all the details of created impact could be found in Annex I). The numbers reported do not correspond univocally to the projects analysed, but rather consider impacts individually accounting for the possibility of each project to generate more than one type of impact, as well as more impacts under the same category. As the figure

emphasises, the Department of Design has shown a significant influence in generating both scientific and societal impact, meaning that the funded research projects have contributed to creating new knowledge, diffusing the knowledge, delivering and transferring the research and innovation results in the society. However, at the same time, it shows significantly lower numbers in the area of technological/economic impact, meaning that the Department has focused less on translating the research and innovation results into economic growth, creation of new jobs and increase of investment in research.

When we focus this analysis on the 9 KIPs, the difference in focus and achievements is even clearer, as shown in the fig. 6.3. Here, the pathway with the highest number of entries is "strengthening the uptake of research and innovation in society", which is highly relevant to design research practices focused on co-creation and societal participation (i.e., users and stakeholders engagement, co-design, civic participation) to understand and solve different types of problems. The Department of Design shows good results also in "fostering diffusion of knowledge and open science". This shows consolidated practices linked to making knowledge and results produced in research projects available to the society (i.e., using open access publication strategies). The other two pathways under scientific impact, "creating high-quality new knowledge" and "strengthening human capital in R&I", also demonstrate significant results, speaking to one of the pillars of universities, that is, the creation of new knowledge and the education of a class of knowledge workers that is highly prepared for the future. On the contrary, the results obtained in other pathways show areas where more effort is needed. In particular, the analysis has shown limited results in "creating more and better jobs" and "leveraging investment in research and innovation" under the category of technological/economic impact. This might also be due to the fact that the Department focuses on these areas through other activities, that involve direct collaboration with industrial partners and do not use public funding. However, the consistent difference between the three areas shows one important area of reflection for future growth and enhancement of organisational capabilities.

6.3.2 The relationship between research topics, impact categories and KIPs

All 32 projects analysed have consistently created both scientific and societal impact. Consequently, when looking at these two impact categories, all the 22 clusters (21 thematic clusters plus one "specific from project") and the 159 keywords identified in the analysis reported in chapter 3 are repre-

sented (fig. 6.4). Among all the clusters of topics, "design methodologies" presents the highest number of results with 25 keywords reported to indicate the creation of scientific and societal impact. Following that, the clusters "distributed production" and "health" have also performed well, and both have 11 keywords present. The clusters "education" – 10 keywords, "ICT" – 10 keywords, "innovation studies" – 10 keywords have also made a significant contribution to achieving scientific and societal impact. The following ones are "CCI", "entrepreneurship", "ethics" with 7 keywords.

Among the 32 funded projects analysed, 21 have created technological/economic impact. In these 21 projects, 21 clusters are present with 121 keywords, meaning that some topics didn't manage to transfer the research actions into technological/economic impact. The cluster "communication" and the keywords belonging to it are not present in generating technological/economic impact (fig. 6.5). Even though all other clusters can be seen on the map, some keywords disappear when compared to scientific and societal impacts. Among all, the most important cluster still is "design methodologies", but it only covers 14 keywords (11 keywords disappeared). The number of keywords in the cluster "distributed production" has reduced to 9 (2 keywords are missing). Instead, in the cluster "health", all the 11 keywords are present and linked to achieving technological/economic impact. The same thing for cluster "education", in which 10 keywords are present. The number of keywords in the cluster "ICT" has reduced to 8, and the cluster "innovation studies" has only 7 keywords. Clusters like "entrepreneurship", and "capacity building" have remained the same. Instead, clusters like "material", "social innovation", "ethics", and "documentation" have shown a clear decrease, around half of the keywords belonging to them do no longer appear for the creation of technological/economic impact.

6.3.3 Relationship between research topics and KIPs

6.3.3.1 Scientific impact

KIP #1 Creating high-quality new knowledge (fig. 6.6)

27 funded projects have achieved the first KIP in the scientific impact. These projects represent 22 clusters and 135 keywords. The most prominent cluster is "design methodologies" with 22 keywords. The cluster that scored second is "innovation studies", in which all the 10 keywords are present. Other important clusters in this area (each with 8 keywords) are "ICT" "capacity building", and "education". Keywords in the clusters "ethics" (7 key-

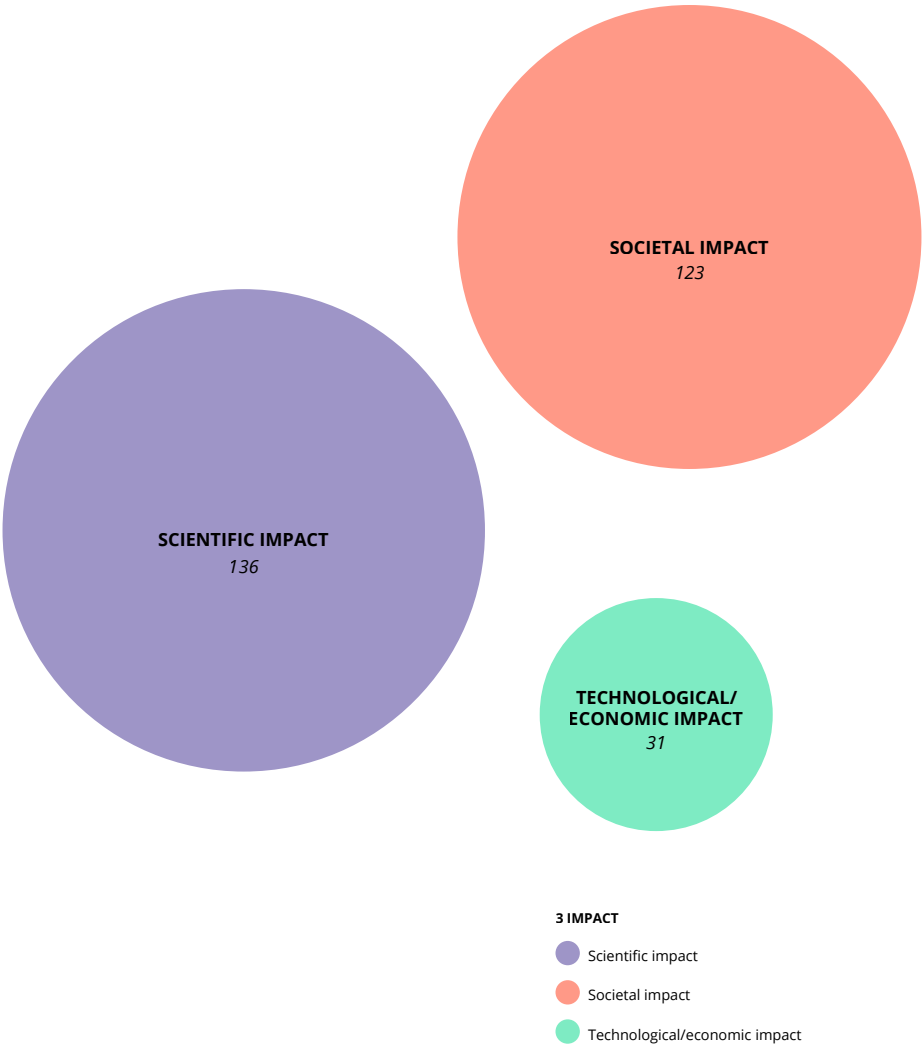


Fig. 6.2 – The relative relevance of the three impact categories according to the impacts generated by the funded research projects of the Department of Design in the past seven years.

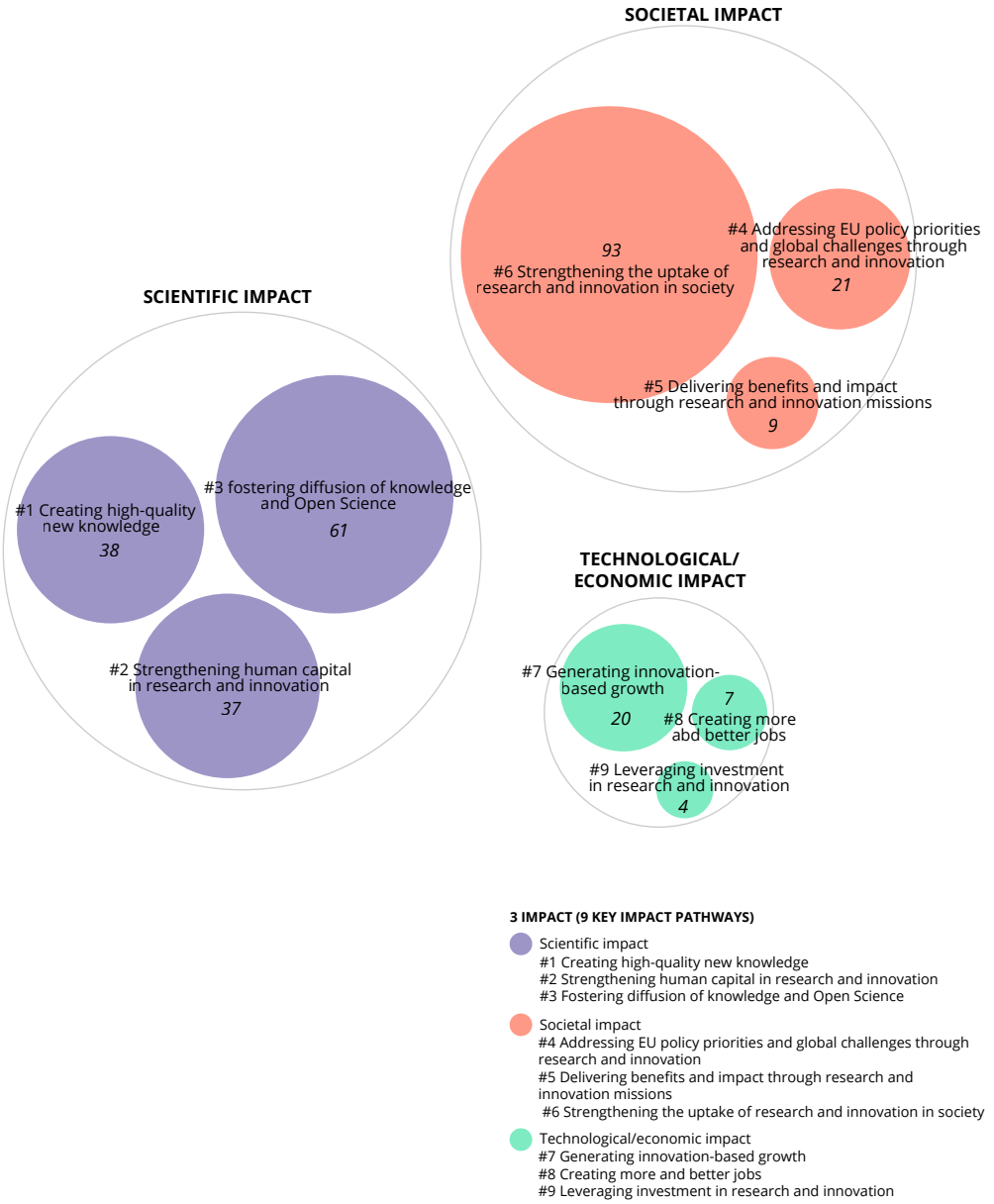


Fig. 6.3 – The distribution of the research projects analysed along the 9 KIPs in the past seven years.

words), "social innovation" (6 keywords), and "public sector" (6 keywords) are also fully present here. Instead, two other clusters that have played an important role in creating scientific impact – "distributed production" and "health" – have slightly reduced to 9 keywords and 8 keywords respectively.

KIP #2 Strengthening human capital in R&I (fig. 6.7)

25 funded projects have achieved the second pathway in the scientific impact. These cover 22 clusters and 124 keywords. The cluster "design methodologies" is still the most significant one but reduces the number of keywords to 17 (compared to 25 in total). Clusters "distributed production" and "health" have well performed with 11 keywords in achieving impact in this KIP. The cluster "education" is present with 9 keywords (only one keyword is missing), and the cluster "ICT" contributed with 8 keywords. The cluster "innovation studies" has only half of its keywords present – 5 keywords. Instead, the cluster "sustainability" is fully present with all its 5 keywords to contribute to strengthening the impact on human capital.

KIP #3 Fostering diffusion of knowledge and Open Science (fig. 6.8)

28 funded projects have achieved the third pathway in the scientific impact. The research topics cover 21 clusters and 139 keywords. Once again, "design methodologies" is the most representative one with 22 keywords. This is followed by two clusters "distributed production" and "health" both with 11 keywords. Three other clusters include 9 keywords: "ICT", "education", and "innovation studies". In the clusters "CCI" "capacity building", and "ethics", 7 keywords are present, and the cluster "sustainability" is fully present again with 5 keywords. Instead, in the cluster "entrepreneurship", the keywords number reduces to 6.

6.3.3.2 Societal impact

KIP #4 Addressing EU policy priorities through R&I (fig. 6.9)

15 funded projects have created societal impact in its first pathway, covering 19 clusters and 74 keywords. Though the most influential cluster in this area is still "design methodologies", it only includes 9 keywords (compared to 25 in total), observing a decrease that might be due to the limits of research activities in the field of methodologies in addressing policy priorities. The second most important cluster in this pathway is "innovation studies", which contributes with 7 keywords. The cluster "public sector" has played an active role with 6 keywords. Clusters "CCI" and "Ethics" have both 5 keywords. The number of keywords in cluster "health" reduces here to 3, and the same happens in the cluster "ICT", which includes only 4 keywords in addressing EU

policy priority. Clusters "distributed production", "advanced manufacturing", and "material" are not represented when looking at achieving this pathway.

KIP #5 Delivering benefits and impact through R&I missions (fig. 6.10)

8 funded projects have created the second pathway in the societal impact, covering 17 clusters and 40 keywords. The analysis shows that very few projects managed to achieve this pathway, as clusters and keywords represented are quite limited. The cluster "design methodologies" has only 6 keywords, and the cluster "health" has 5. Three clusters "ICT", "innovation studies", and "transportation" are represented via 4 keywords. The five mentioned are the main research topics that have successfully generated impact through R&I actions.

KIP #6 Strengthening the uptake of innovation in society (fig. 6.11)

31 funded projects have created the third pathway in the societal impact, covering 22 clusters and 154 keywords. This pathway appears to be the most represented in the work conducted by the Department, as shown by the analysis: all the clusters are present and have the highest number and diversity of keywords. 24 keywords represent the cluster "design methodologies"; the clusters "distributed production" and "health" have 11 keywords; both the cluster "education" and the cluster "innovation studies" have 10 keywords. All are important clusters in this pathway. The "ICT" and "capacity building" clusters also perform well with 9 keywords. Clusters that have 7 keywords are "entrepreneurship" and "Ethics"; while with 6 keywords there are "CCI", "public sector", and "social innovation".

6.3.3.3 Technological/economic impact

KIP #7 Generating innovation-based growth (fig. 6.12)

17 funded projects have created the first pathway in the technological/economic impact, covering 19 clusters and 85 keywords. The analysis shows that this is one of the areas requiring strengthening in the Department, as the technological and economic impact dimensions of the funded research projects are significantly less represented if compared to the other two main areas of impact. Under this category, a good performance can be observed for this first pathway. "Health" is the most significant cluster with 11 keywords. This is followed by "distributed production" with 8 keywords, "ICT" and "capacity building" with 7 keywords and "design methodologies" that reduces to 6 keywords. Clusters "public space", "communication" and "documentation" do not have any keyword in this pathway.

KIP #8 Creating more and better jobs (fig. 6.13)

6 funded projects have created the second pathway in the technological/economic impact, covering 13 clusters and 30 keywords. A continuous decrease can be observed in both the number of clusters represented and keywords linked. With a very limited number of projects present, the relatively important clusters are "design methodologies", "education", "CCI", "sustainability" and "health".

KIP #9 Leveraging investments in R&I (fig. 6.14)

4 funded projects have created the third pathway in the technological/economic impact, covering 9 clusters and 23 keywords. The most influential cluster is "distributed production" which contributes with 7 keywords. Following, the cluster "transportation" has performed well in leveraging investment in R&I with 4 keywords present. Other clusters that are sufficiently represented here include: "ethics", "design methodologies", "health", "ICT", "public sector", and "documentation".

Finally, the relation between the 9 KIPs and the research topics is summarised in tab. 6.6, which provides an overview of how clusters link to KIPs. In the table, one can notice that the cluster "design methodologies" is playing an active role in most of the KIPs, especially those linked to scientific and societal impact. This means that the Department of Design has successfully transferred design approaches, methods, and tools (e.g., co-design, participatory design, and design-led research) into recognizable scientific and societal impacts through diverse research activities and in different areas. Following this, the cluster "health" has performed relatively well in generating all three categories of impact. The cluster "capacity building" is also an active contributor to all three types of impact apart from the #9 pathway under the technological/economic impact. Similarly, the cluster "distributed production" has contributed to all three impacts, only being absent in the #4 and #5 pathways under the societal category. Though the cluster "sustainability" is not including many keywords, it also plays a significant role in generating impact in all the 9 pathways. The same can be observed in clusters "fashion" and "transport". As opposite, several clusters are represented quite differently across the 9 pathways. The cluster "innovation studies" has actively contributed to 6 KIPs, however, it has a relatively limited contribution in the #8 and #9 under the technological/economic impact category. The same happened to the clusters "ICT", "ethics", "social innovation", "public sector", "service", and "public spaces". Clusters "materials" and "advanced manufacturing" have almost disappeared in #4 and #5 KIPs (societal impact category), as well as in #8 and #9 (technological/economic impact category).

6.4 Strengths and weaknesses emerged in the analysis

The analysis described in this chapter has allowed to identify the strengths and weaknesses in the achievement of impact for each of the research topics covered at the Department. The previous paragraphs have already offered summative comments on the most represented topics for each KIP identified in HEu. Notably, the presence of the cluster "design methodologies" is central across all pathways and impact categories, showing a clear specialisation of the Department in this area of research with more than one group working on this topic, and with a clear international reputation for the community. This result is in line with the analysis conducted initially on research topics, showing even more predominantly the significance of this cluster. However, the focus on this theoretical specialisation might also weaken the impacts that the research might have. Developing mainly methodologies and processes might lead to roles in multi-disciplinary collaborations that operate at the *meta* level of research, remaining further from the practical applications typically developed in collaborative projects (e.g., pilots and demonstrators).

Looking at the results of the analysis, it is also easy to notice how the core keywords of the design discipline do not emerge from our sample. It is thus difficult to say whether these keywords contribute to the impact produced by the research conducted at the Department. Areas like product design or interior design, and keywords like prototyping and storytelling do not appear prominently in the research sample. Building further on the discussion started in connection to the research topics where these areas emerged as distant from the topics currently covered by researchers at the Department, the analysis on impacts strengthens this finding highlighting how the core of the discipline for our researchers is shifting away from the basics of design. On the one hand, this might mean that the discipline can now count on a consolidated and recognised basis of knowledge that pushes it to explore new applications and topics. On the other, this is in opposition with the lack of recognition of design research in multi-disciplinary contexts and in the funded research, as shown for example by the absence of an ERC area dedicated to the design discipline (area 08a in the Italian categorisation of disciplinary scientific sectors).

New areas of application seem to become predominant instead. Areas like "health", "distributed production", "entrepreneurship", "public sector", "sustainability" seem to be core matters meeting the concerns of both funding institutions and researchers at the Department, where a relevant number of impact pathways can be found. Interestingly however, even when working in these domains, the researchers at the Department seem to be somewhat far from actions that lead to technological and economic impacts. This bares

Tab. 6.6 – The detailed short, medium, and long-term indicators for the three KIPs linked to societal impact.

Clusters	Scientific impact			Societal impact			Technological/ economic impact		
	KIP #1	KIP #2	KIP #3	KIP #4	KIP #5	KIP #6	KIP #7	KIP #8	KIP #9
Advanced manufacturing	2	2	1	0	0	2	2	0	0
Capacity building	8	5	7	3	2	9	7	3	0
CCI	5	5	7	5	1	6	5	3	0
Communication	3	1	2	3	2	3	0	0	0
Design methodologies	22	17	22	9	6	24	6	5	2
Distributed production	9	11	11	0	0	11	8	1	7
Documentation	1	2	3	3	0	1	0	0	1
Education	8	9	9	4	1	10	5	4	0
Entrepreneurship	6	5	6	4	0	7	6	2	0
Ethics	7	4	7	5	2	7	2	0	3
Fashion	4	5	5	3	2	5	3	2	0
Health	8	11	11	3	5	11	11	3	2
ICT	8	8	9	4	4	9	7	1	2
Innovation studies	10	5	9	7	4	10	6	1	0
Material	5	5	4	0	0	5	2	0	0
Public sector	6	5	5	6	1	6	1	0	1
Public spaces	3	2	3	2	1	3	0	0	0
Services	4	2	4	2	2	4	2	0	0
Social innovation	6	5	4	3	1	6	1	1	0
Sustainability	2	5	5	2	1	5	1	3	0
Transportation	4	4	0	4	4	4	4	0	4
Specific topics from project	4	6	5	2	1	6	6	1	1

important threats, as the funded research that only stays relevant in the theory risks remaining detached from the practice and lacks potential of real and effective take-up and diffusion.

Connected to this, it is important to comment on the high discrepancy of results between the three impact categories. The scientific impact is the cluster that receives most attention from researchers. This is in line with the type of mission and institution that a university represents, with the production and diffusion of high-quality new knowledge at the core of its mission. Under this heading, all three pathways to impact are well represented. This also shows a good reputation of the Department among other researchers operating in the same discipline, as the academic diffusion of knowledge derived from the design research is mainly published and diffused through sectoral channels (e.g., design research journals and international conferences).

The area of societal impact plays as important a role. However, here we find the prevalence of one pathway linked to strengthening the uptake of R&I in society. As opposite, other areas linked to delivering benefits and addressing global challenges through R&I receive considerably less attention. This might represent a weakness, as it might indicate less attention towards developing research in frontier and emerging topics or in working in the more complex domains linked to the current global challenges (i.e., the Sustainable Development Goals, the digital transition, the climate and energy crises). At the same time, it might also indicate a lack of recognition of the design research operating in these domains by funding institutions and researchers in adjacent fields, thus requiring further efforts coming from the design discipline to reinforce and disseminate its relevance.

Finally, the area of technological and economic impact emerged as the weakest. This result indicates one of the main areas of concern and raises many questions. In this third area, the generation of innovation-based growth is the most tackled by funded projects; while consistently under-represented are the two other areas linked to creating more jobs and leveraging investment in R&I. The weakness in generating technological/economic impact raises concerns linked to the untapped potential of the Department to participate more consistently in technological research. This is in opposition to its strong relationship to engineering disciplines and with industries (from 2018 to 2021 the Department has established 400 research agreements with 263 enterprises and institutions). Building on this, many areas of future improvement might emerge in response to the need to reinforce the collaboration of the Department with researchers in technological disciplines. This might help strengthen the impact of the research conducted at the Department, while also leading to exploring more consistently future and emerging research topics.

6.4.1 Open questions

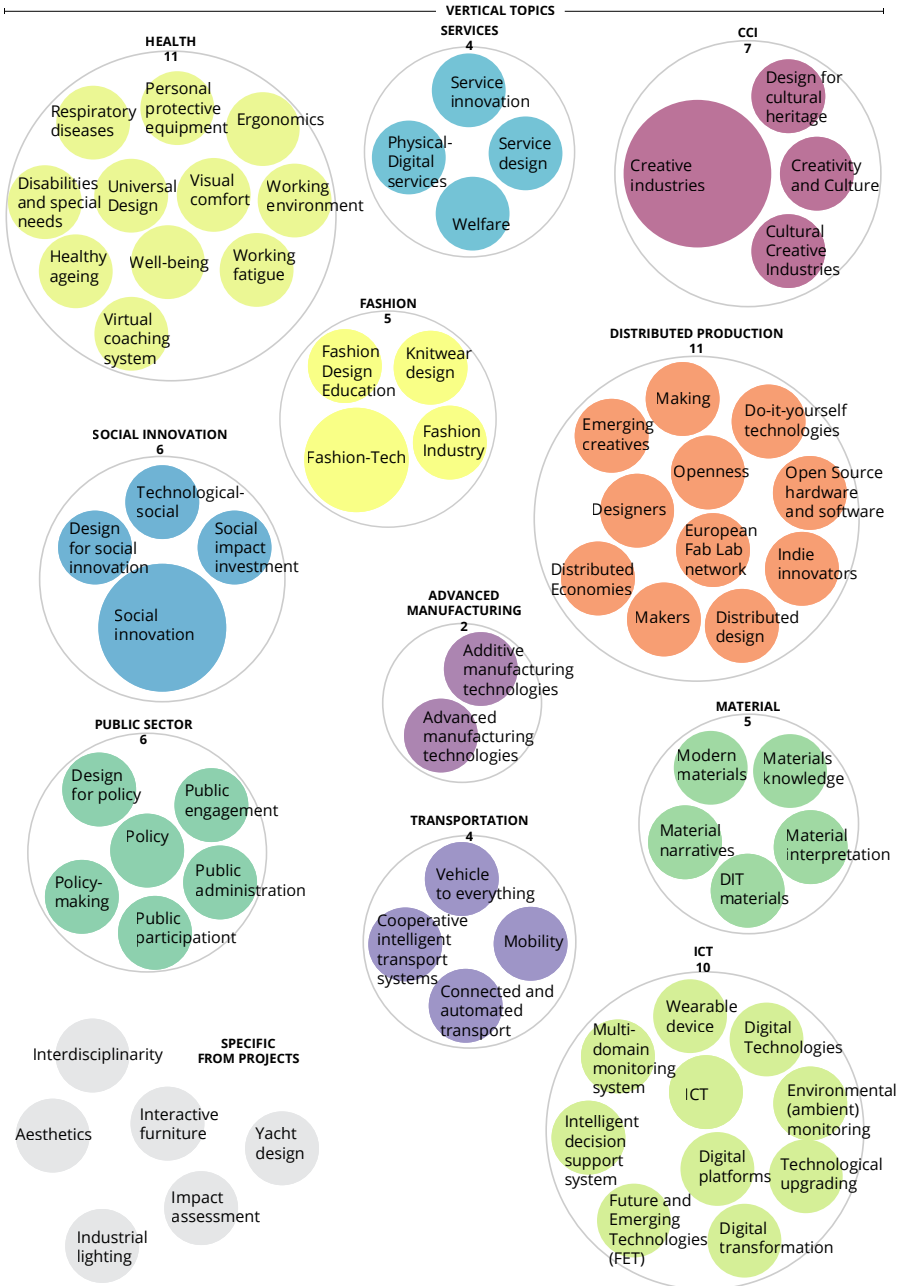
Building on the picture described, open questions emerge that might lead to future areas of work to strengthen the impact of the design research conducted at the Department. These are linked to three main areas of reflection:

- *theorical positioning and stronger relationship with technological disciplines*: to reinforce its role in funded research projects, the Department might need to clarify its peculiarities focusing on the added value of the approach that design brings to R&I. This might help find new collaborations and create new and stronger links with technological disciplines, where the participatory and iterative approach of design might represent an added value to tackle the complexity of current global challenges;
- *future and emerging research topics*: to strengthen the technological/economic impact, researchers at the Department might need to reinforce their attitude to exploring future and emerging research challenges. These might again be linked to reinforcing collaboration with technologists, but it might also cover disciplines dealing with transformation and transition management. The recent attitude of design to look into organisational and systemic change and its consolidated process to tackle ill-defined issues might be further reinforced to open/explore new frontiers of the discipline.
- *internal impact and link between research and education*: in the analysis conducted, the internal impact of the research also seems weak, that is the impact that the results of the funded research has inside the institution itself. There seems to be no pathway or practice to transfer the results of the research internally to the institution and build on existing or past work. This is evident also in the lack of a clear link between the research conducted and the teaching delivered, that often leads educational programmes to remain more static when compared to the evolution of the discipline. A stronger reflection is needed in this area to consolidate good practices aimed at transferring research results between researchers and towards educational programmes. In the long run, this might help strengthen a sense of community at the Department, but also to reinforce impact on society and economy as the new generations trained might represent an important multiplier of collaborations for the university.

6.4.2 Limits of the analysis

The analysis presented in this chapter has adopted an interpretative approach. As such, it suffers of all the typical limits associated with this type of qualitative work. One important limit is linked to the application of an impact assessment framework developed for research activities conducted from 2021 onwards (year in which HEu has started) to a sample of projects run from 2014 to 2020. This means that the framework incorporates considerations and initiatives (i.e., the European Missions) that were not present when the projects in the sample were conducted. This discrepancy might have biased some of the results presented.

Limited understanding of the projects in the sample by the researchers that have performed the analysis might also have biased the results. Moreover, the sample itself might have skewed results, as only funded projects have been considered, leaving outside other forms of research projects like for example those conducted in direct collaboration with industry. Funded research projects are typically steered (in terms of topics and actions) by the funding authority, that dictates top-down both research strategies and main objectives. Although this element might have steered topics and pathways in a certain direction, the analysis focused on the specific activities conducted by the Department in the projects. This has contributed to mitigating this limit, allowing researchers to make considerations on how the Department has been recognised in these international and multi-disciplinary collaborations and thus its identity in terms of research impact.



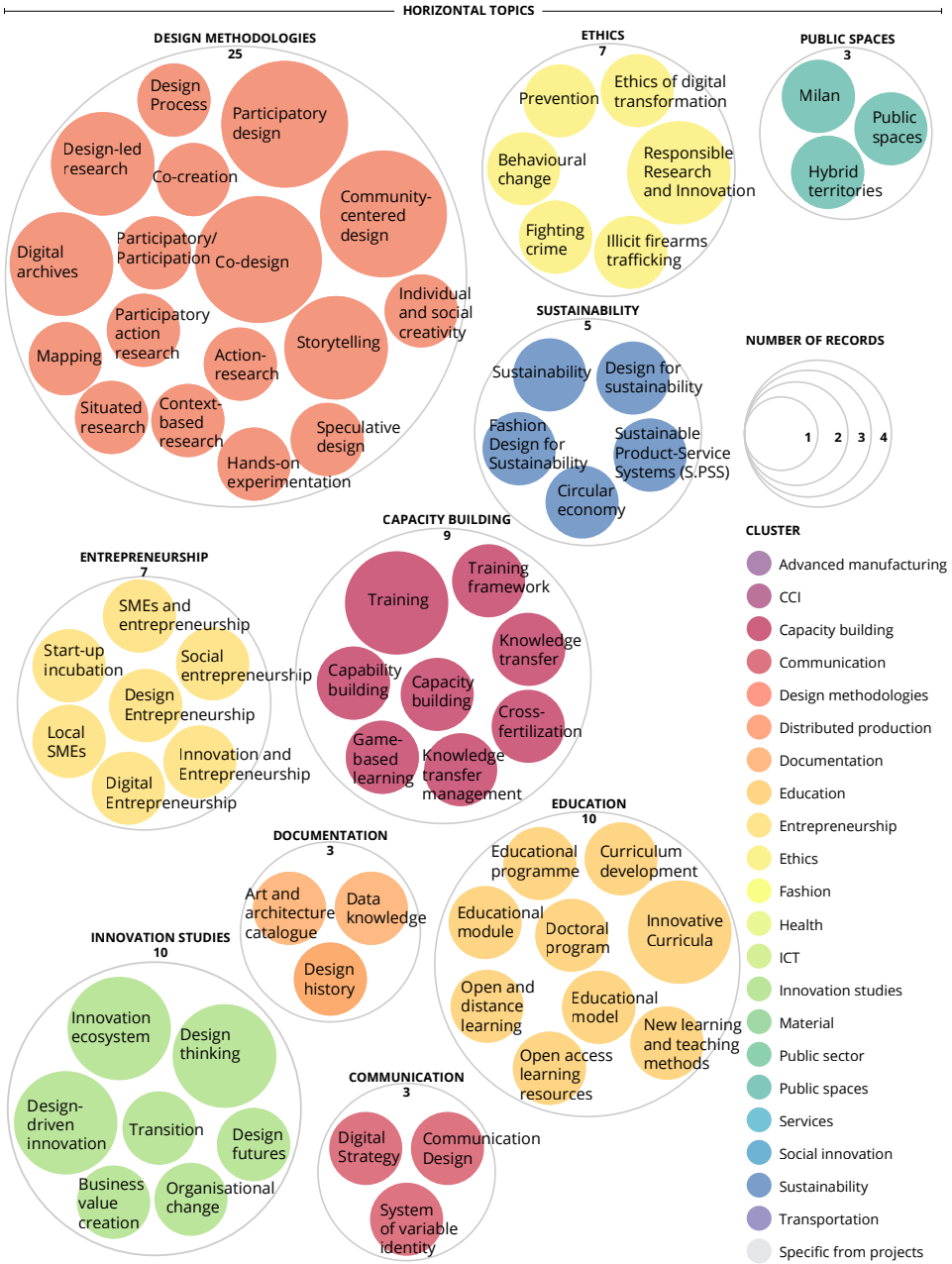
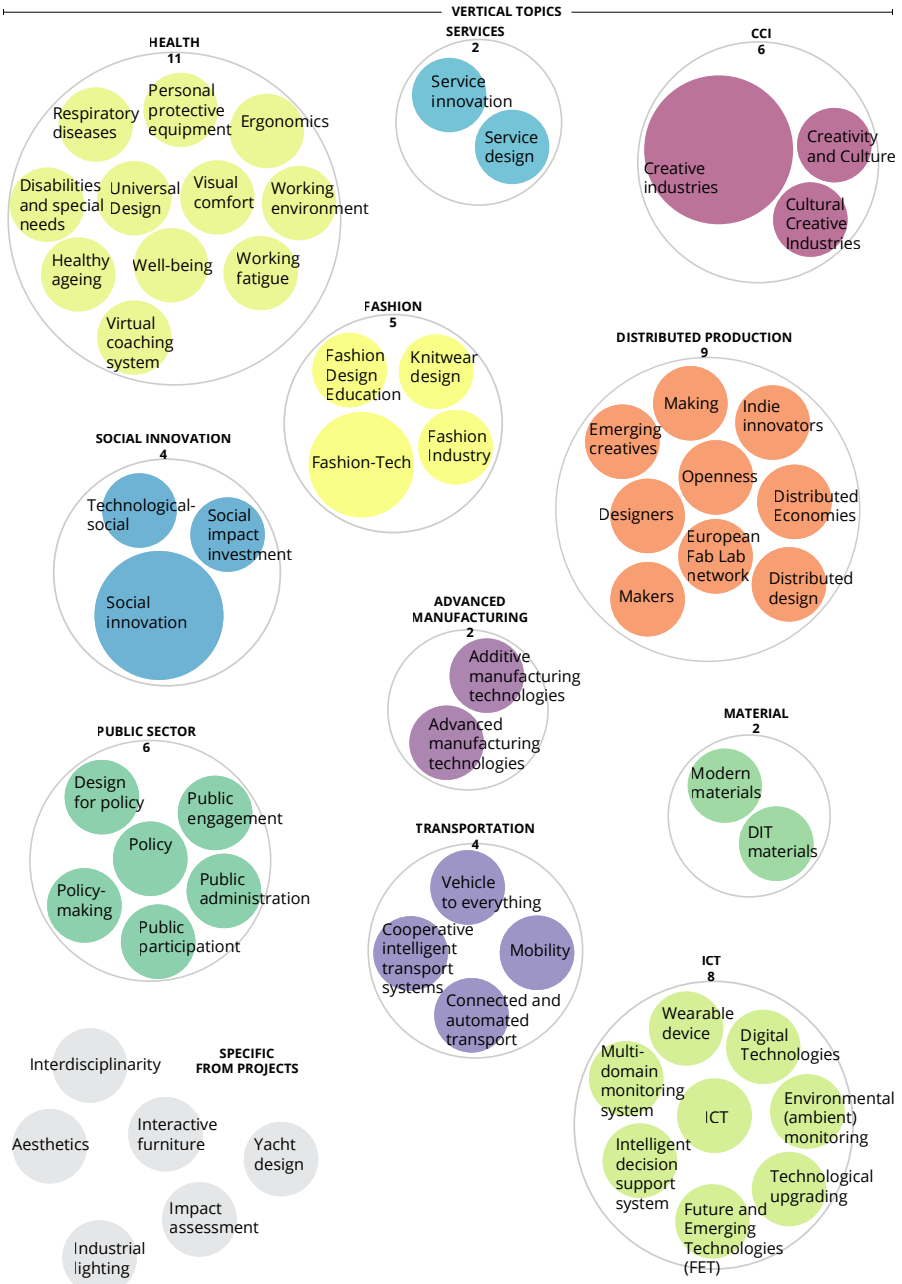


Fig. 6.4 – The distribution and relevance of the 22 clusters of research topics and the 159 related keywords indicating which research topic has contributed to reaching scientific and societal impacts.



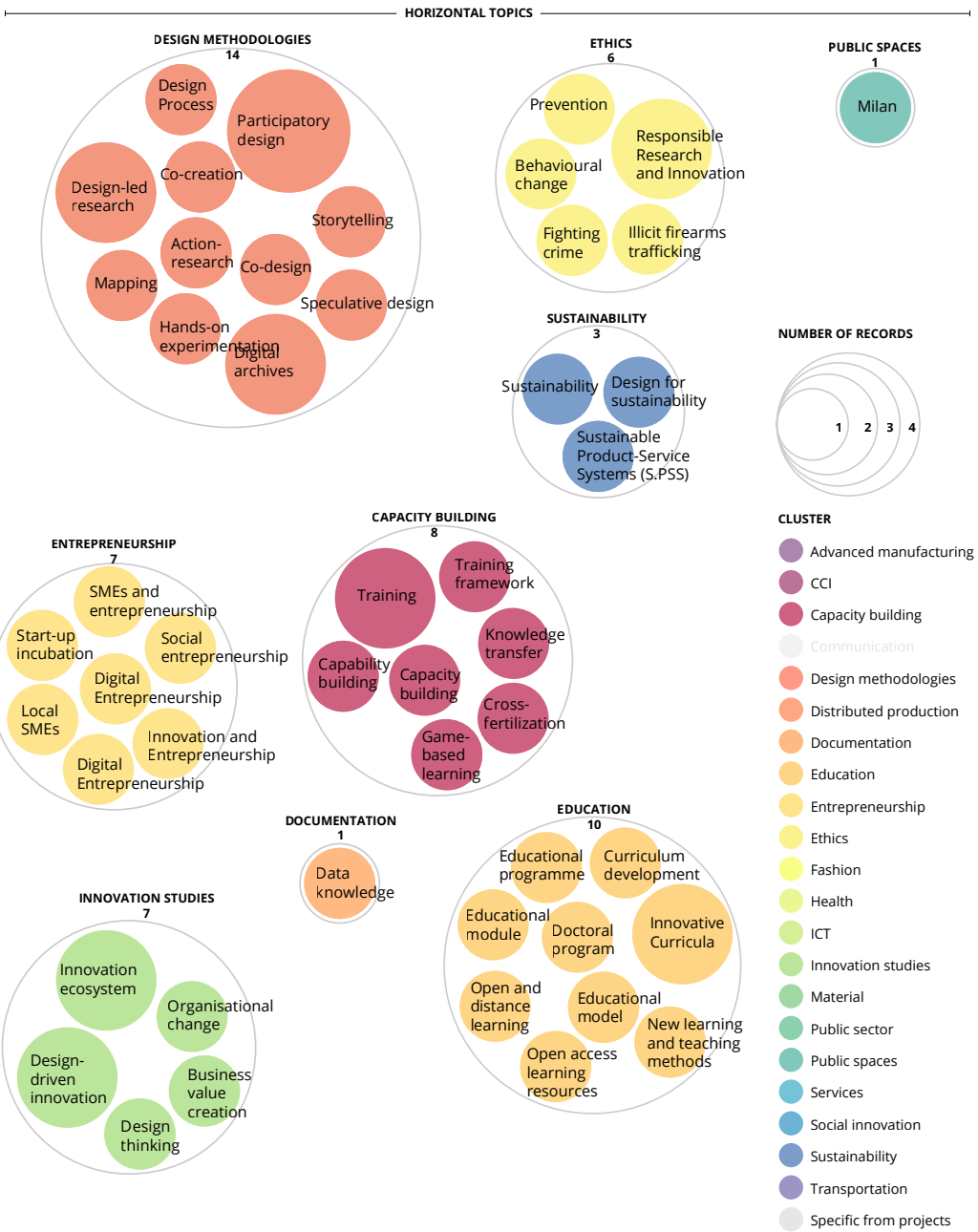
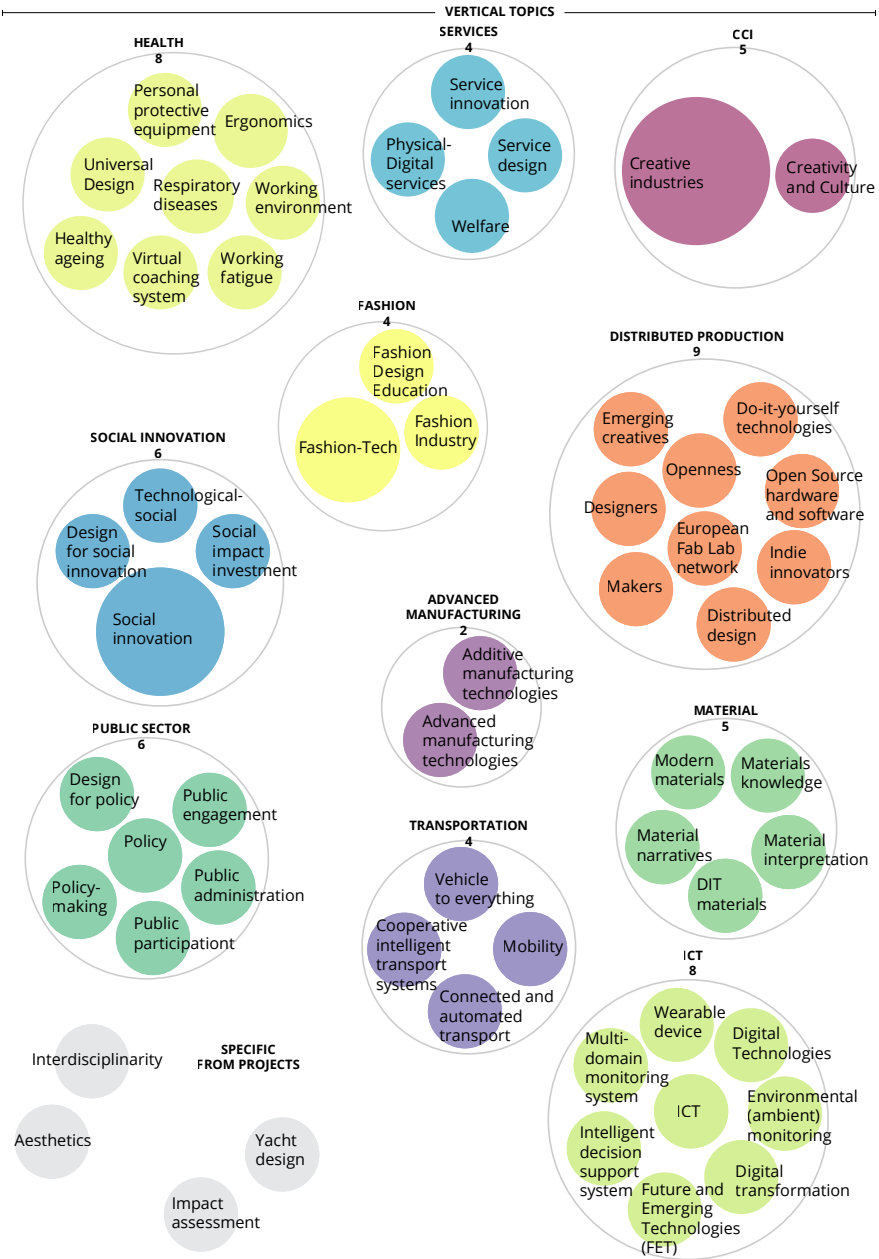


Fig. 6.5 – The distribution and relevance of the 21 clusters of research topics and the 121 keywords indicating which research topic has contributed to reaching technological/economic impact.



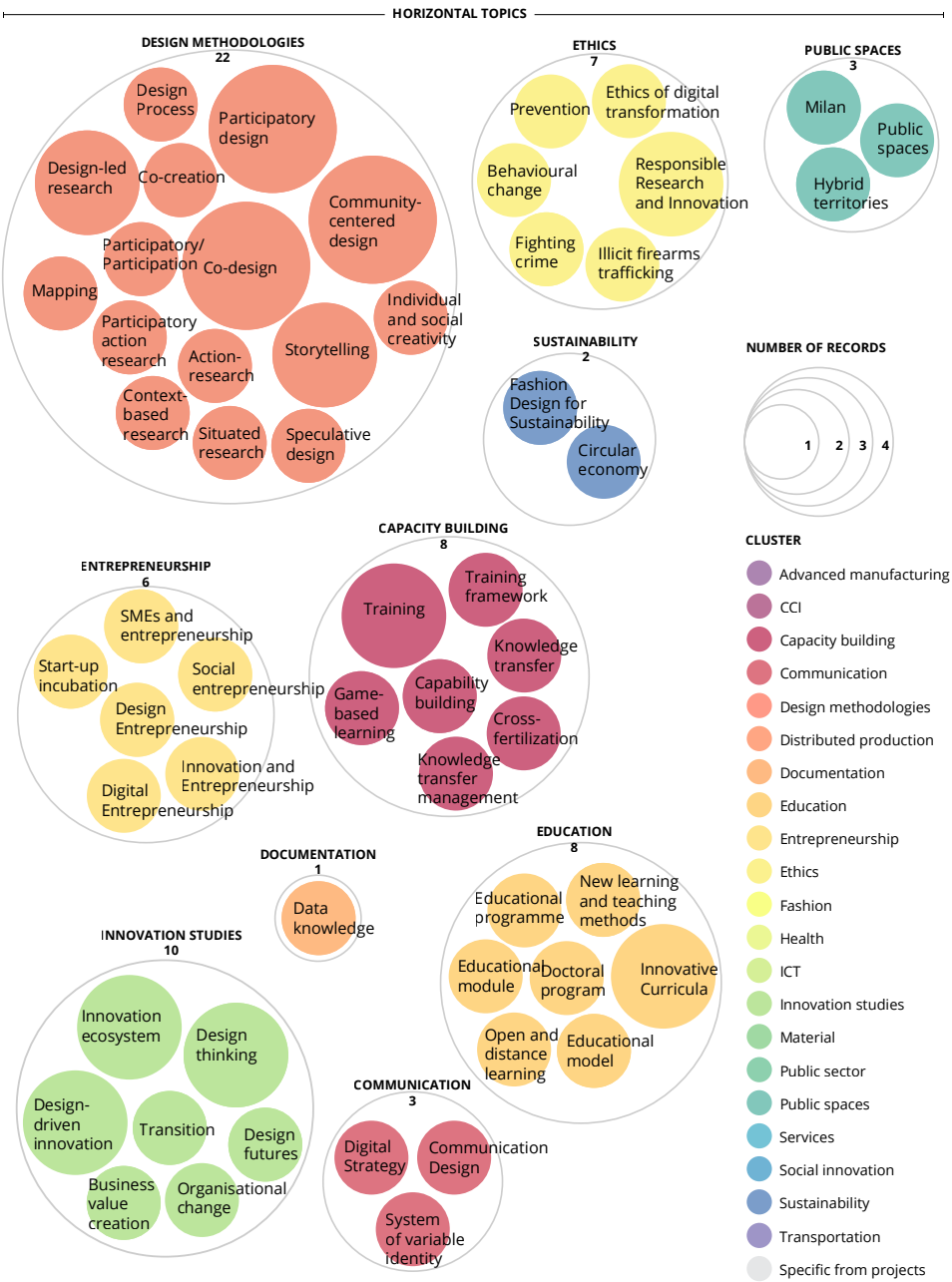
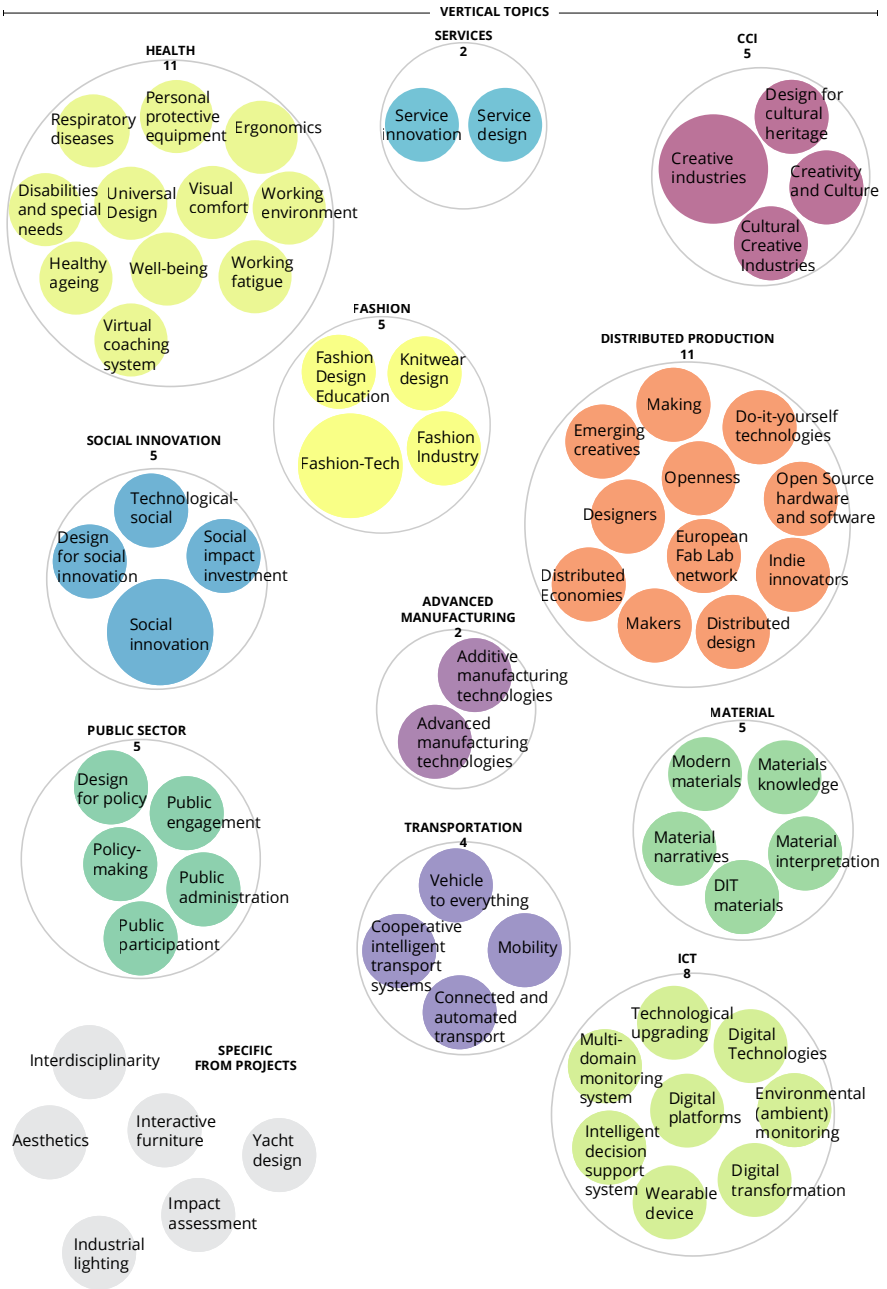


Fig. 6.6 – The distribution of the 22 clusters and the 135 keywords of the funded projects that have contributed to KIP#1 "creating high-quality new knowledge".



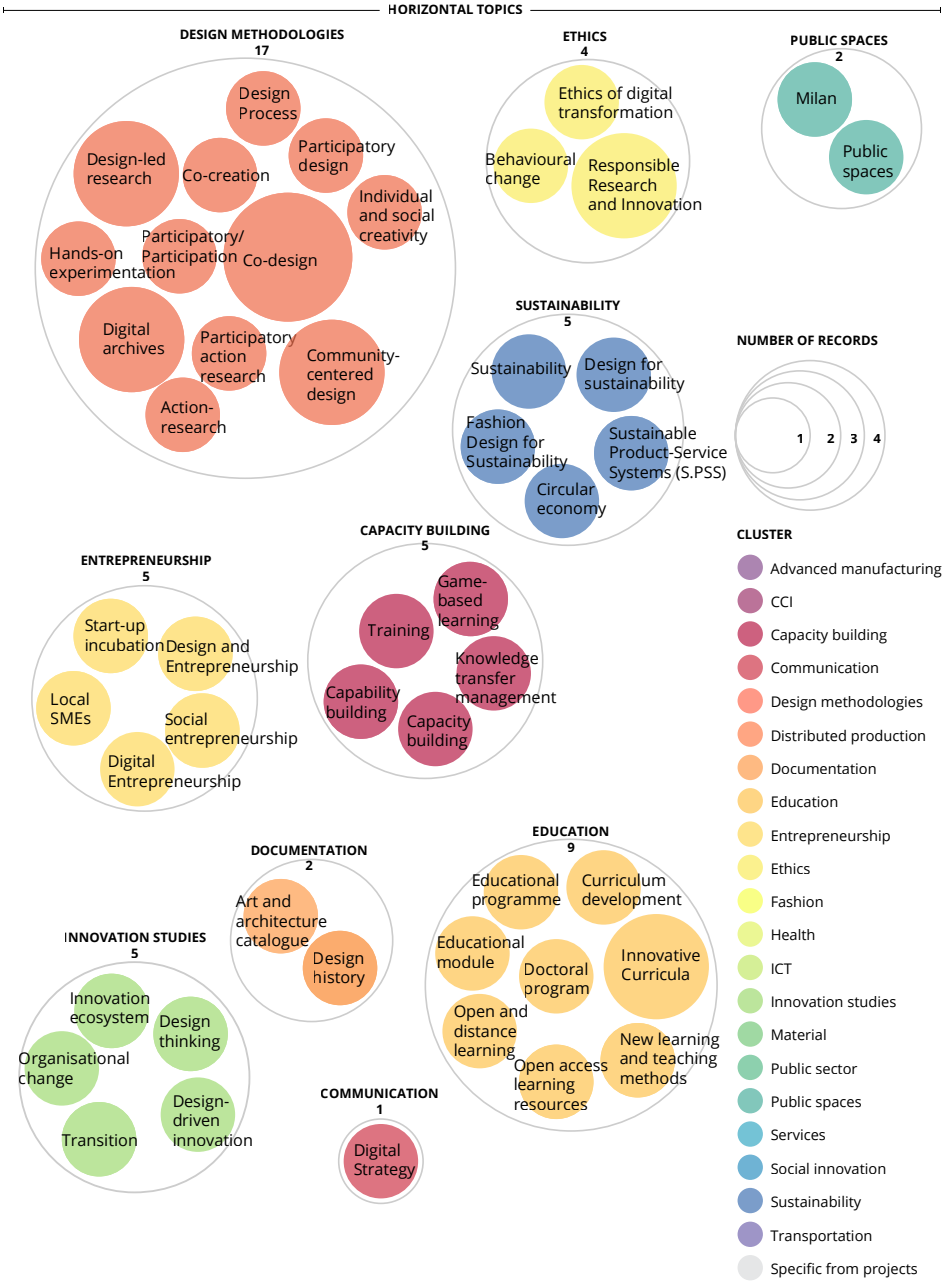
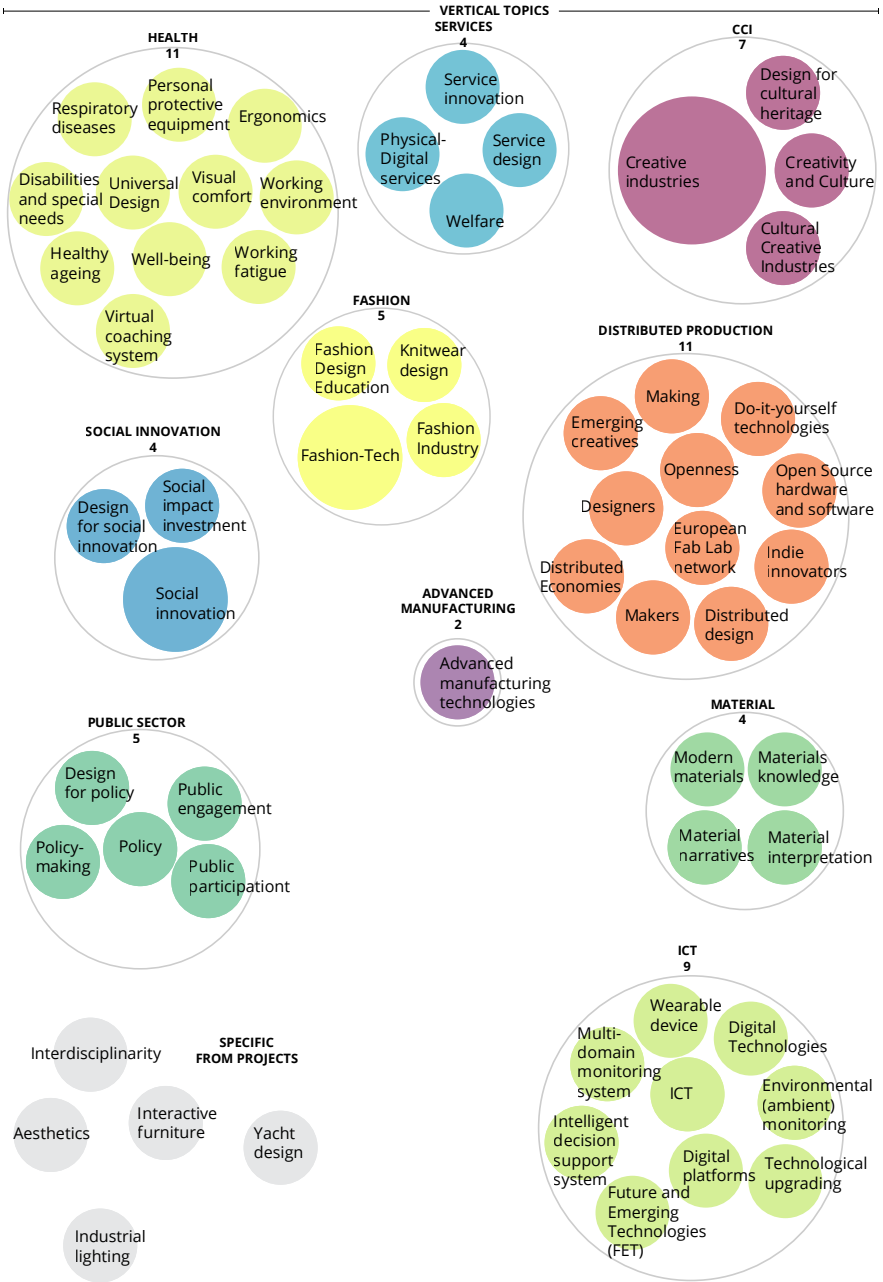


Fig. 6.7 – The distribution of the 22 clusters and the 124 keywords of the funded projects that have contributed to KIP#2 "Strengthening human capital in R&I".



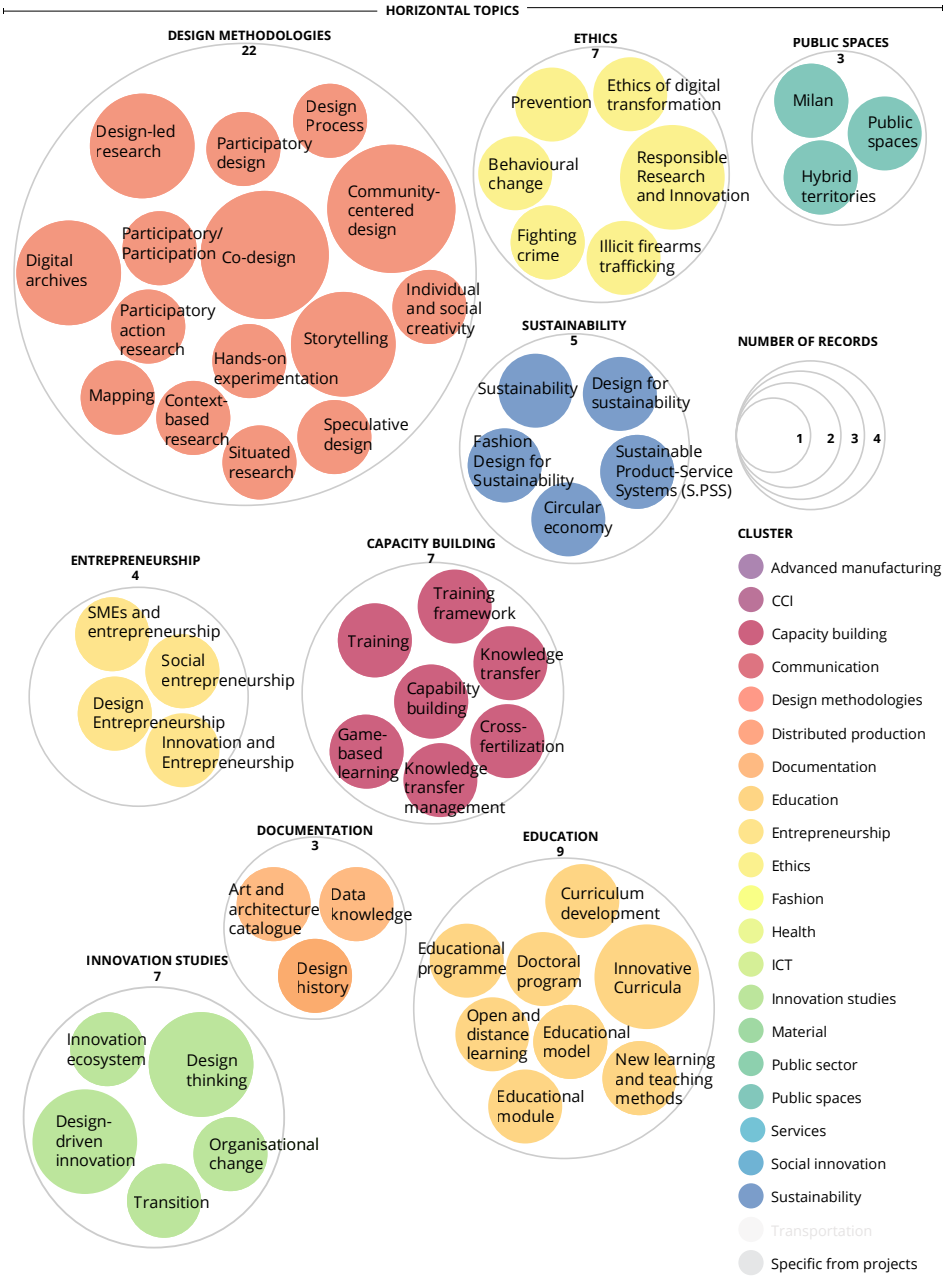
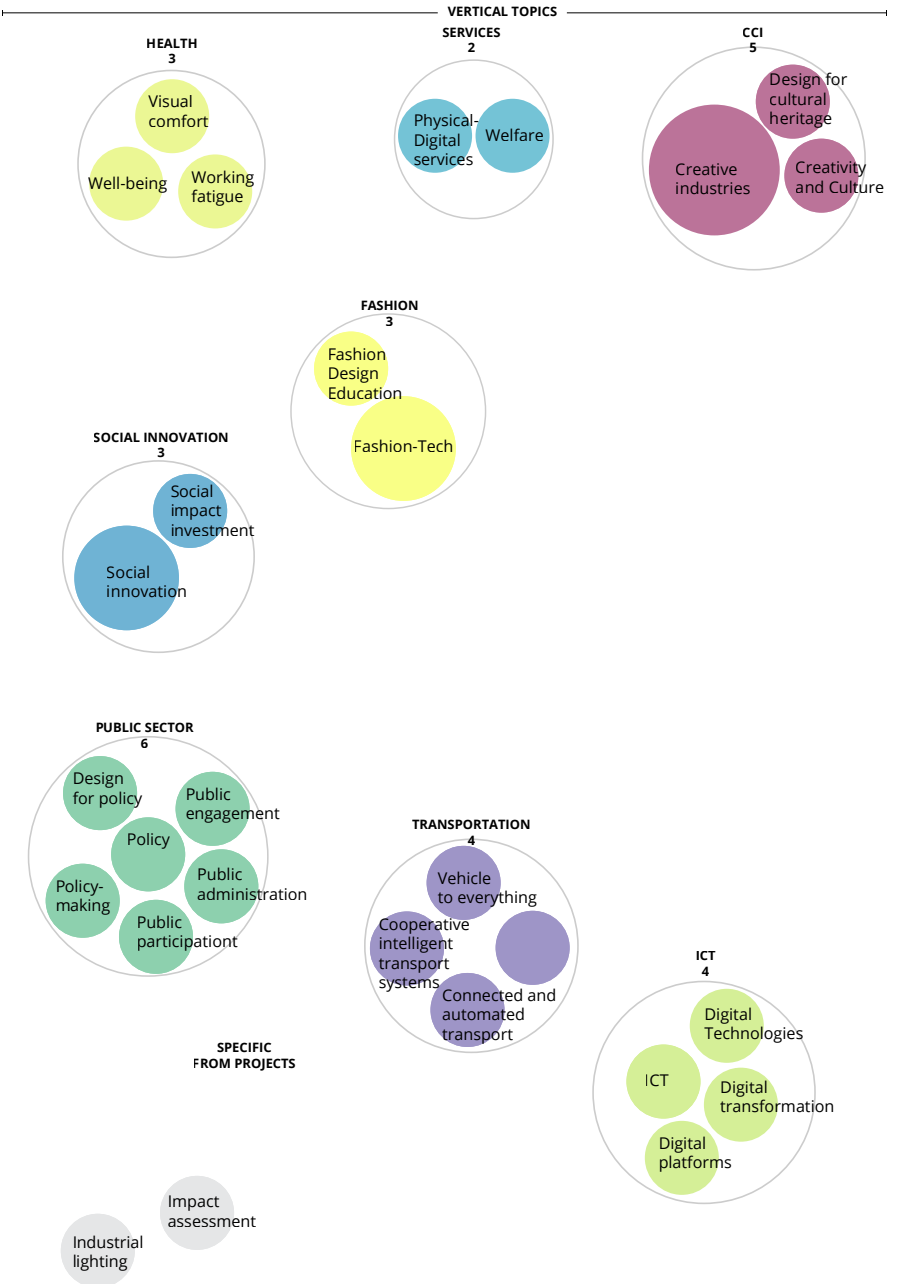


Fig. 6.8 – The distribution of the 21 clusters and the 139 keywords of the funded projects that have contributed to KIP#3 "Fostering diffusion of knowledge and Open Science".



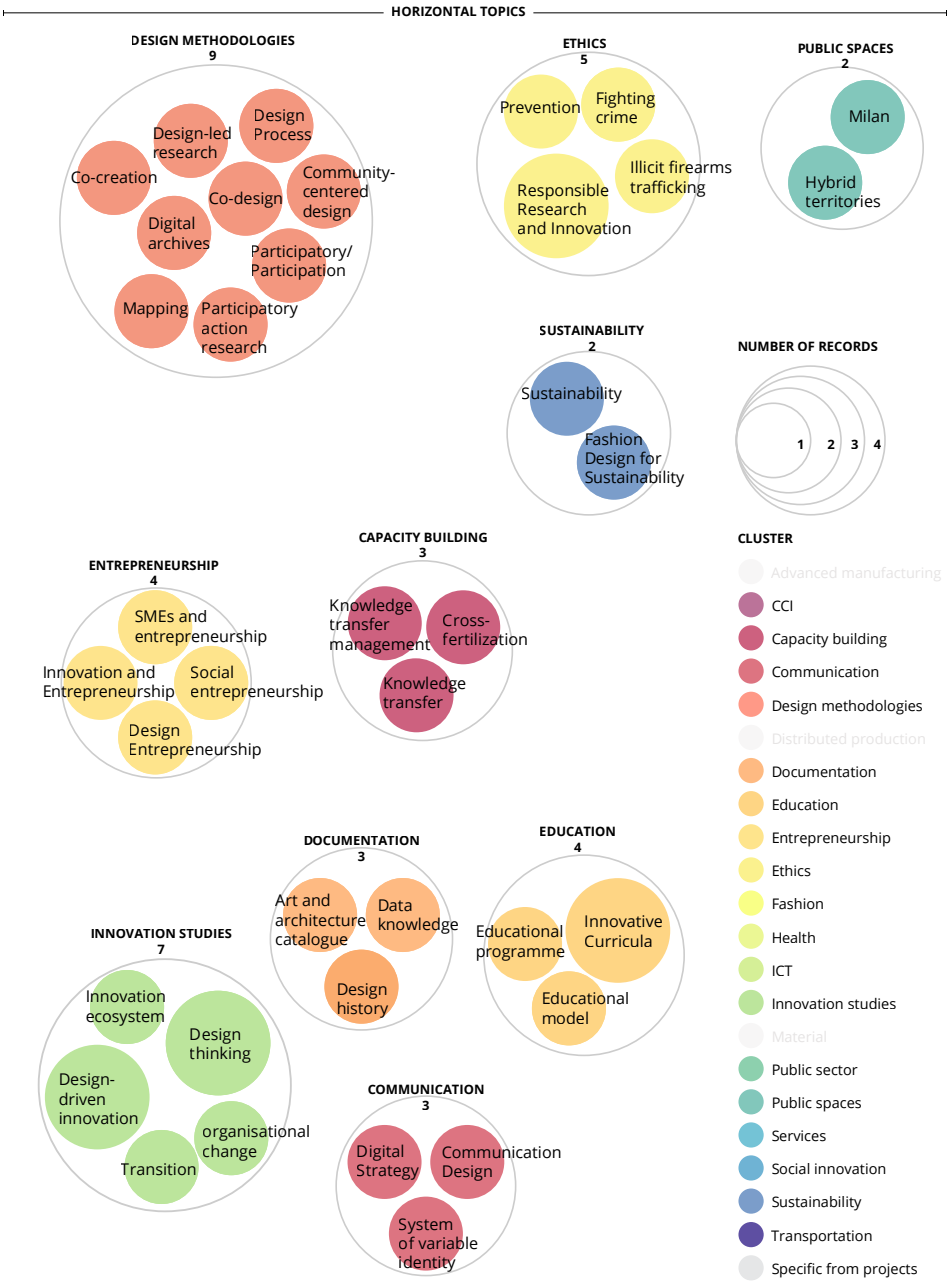
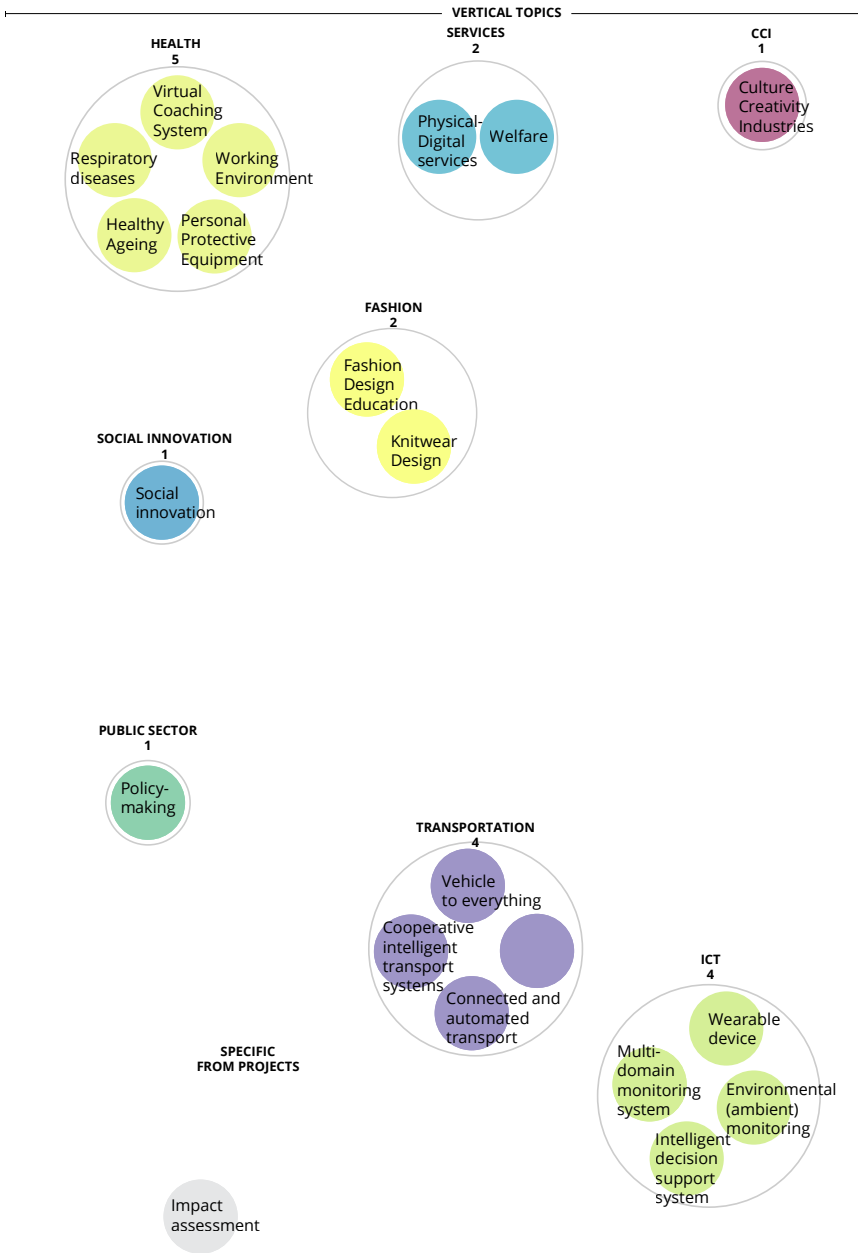


Fig. 6.9 – The distribution of the 19 clusters and the 74 keywords of the funded projects that have contributed to KIP#4 "Addressing EU policy priorities through R&I".



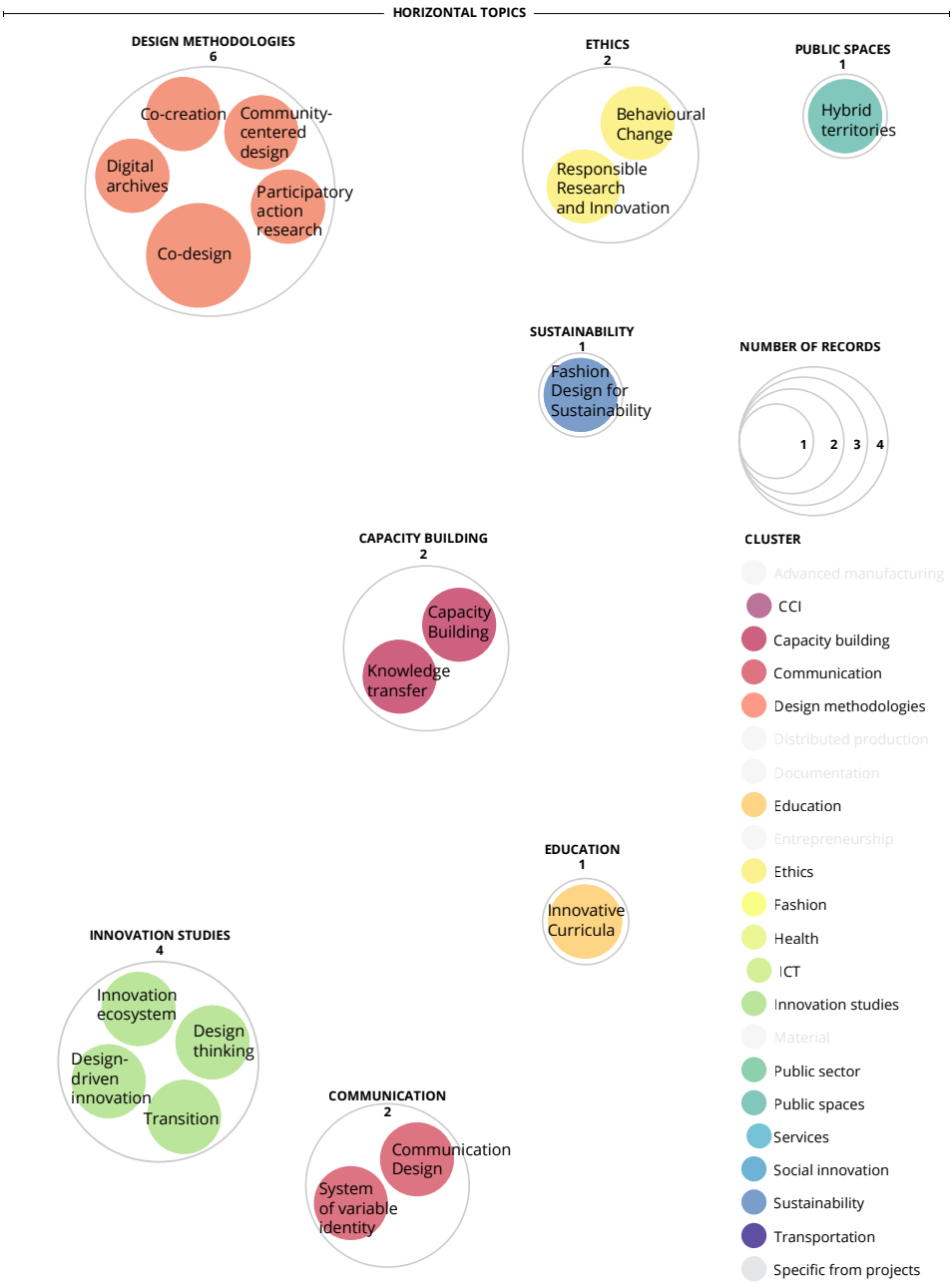
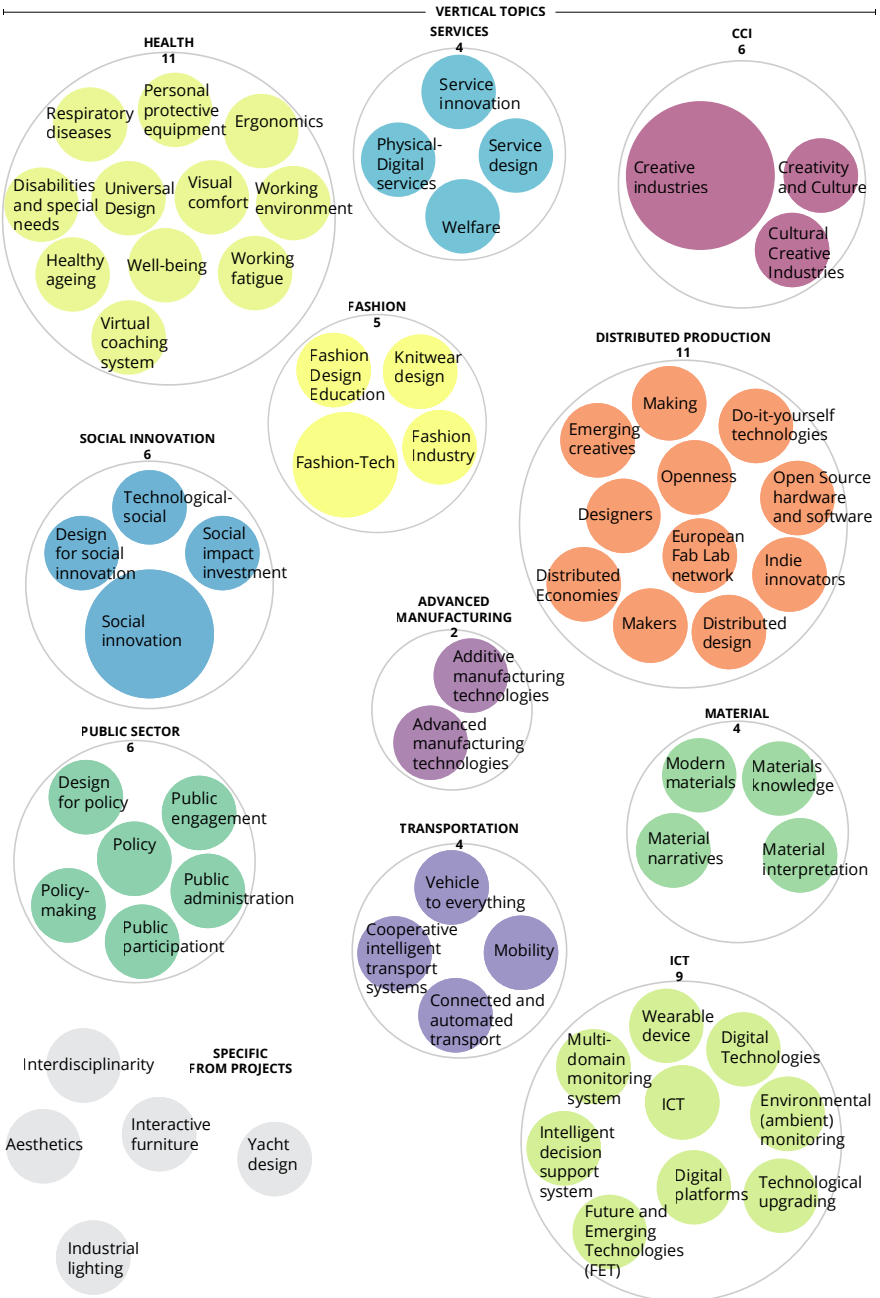


Fig. 6.10 – The distribution of the 17 clusters and the 40 keywords of the funded projects that have contributed to KIP#5 "Delivering benefits and impact through R&I missions".



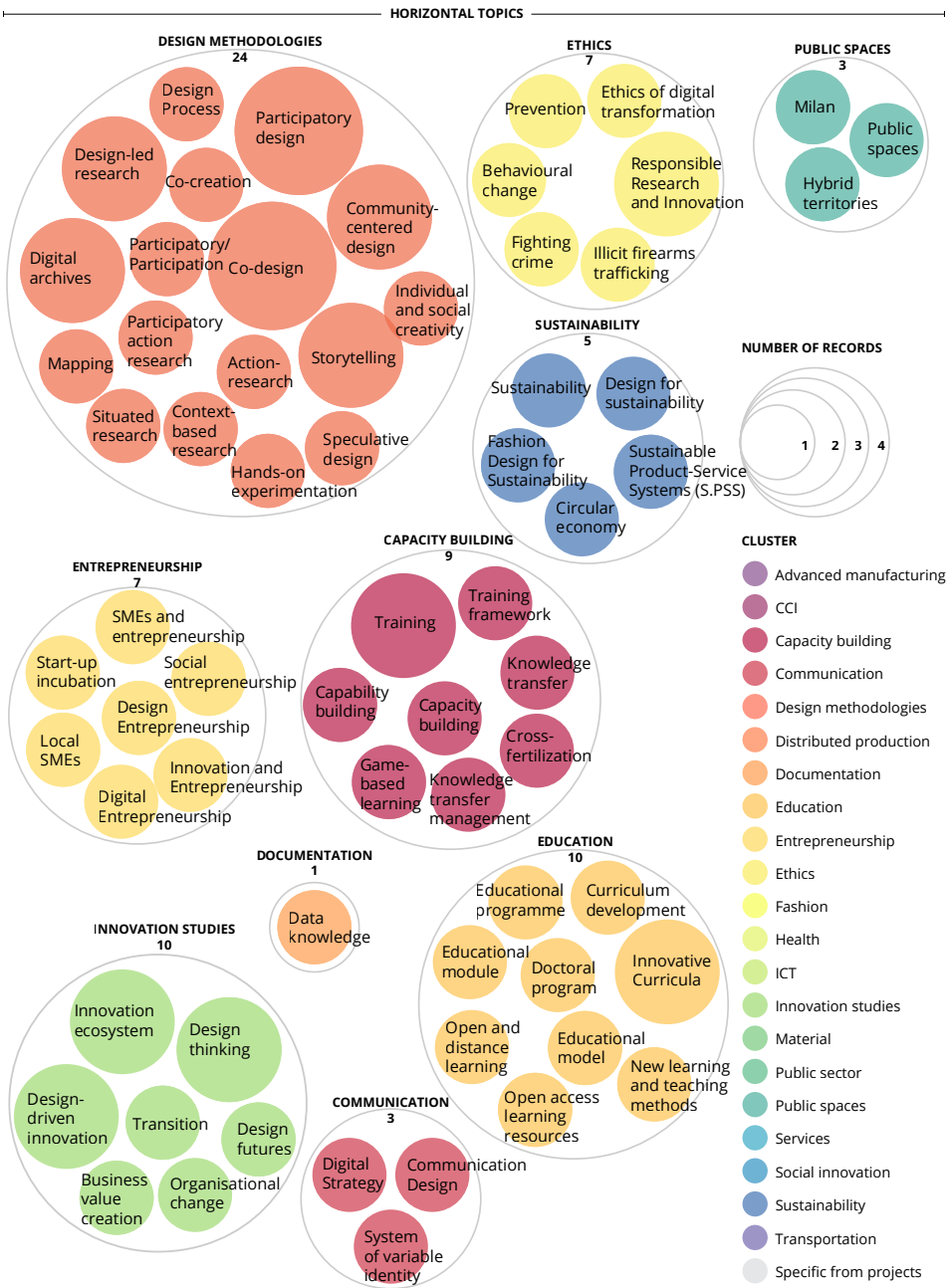
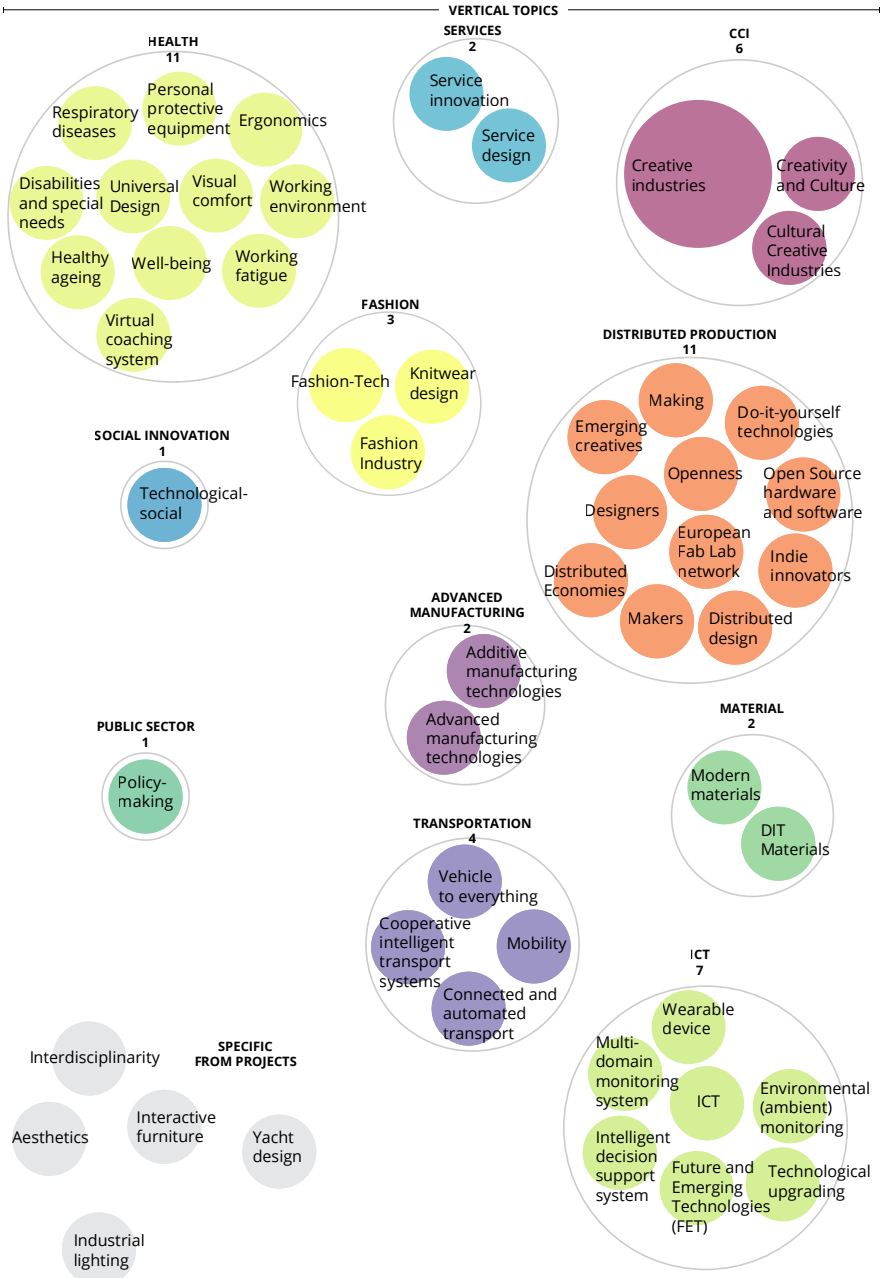


Fig. 6.11 – The distribution of the 22 clusters and the 154 keywords of the funded projects that have contributed to KIP #6 "Strengthening the uptake of innovation in society".



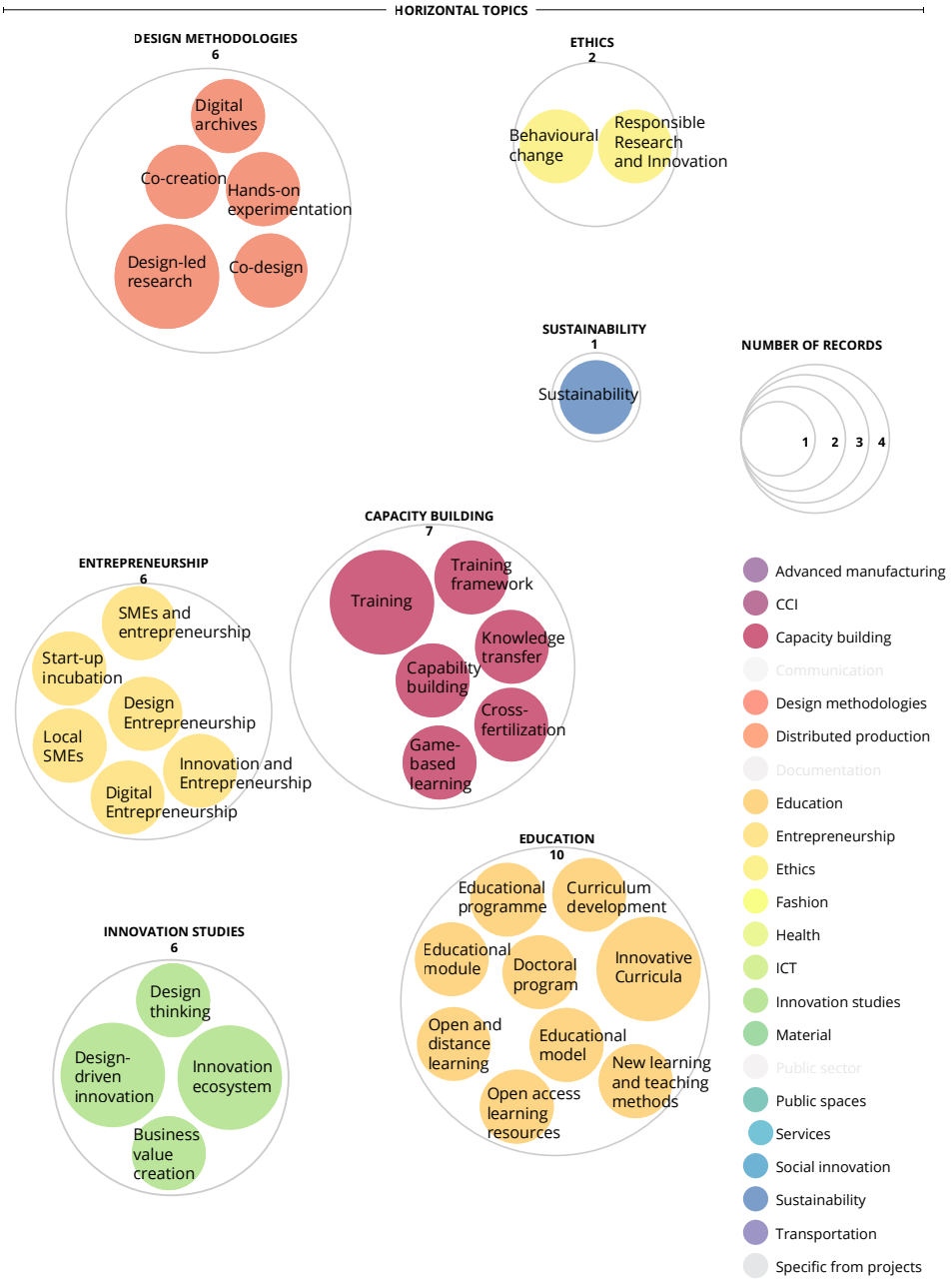
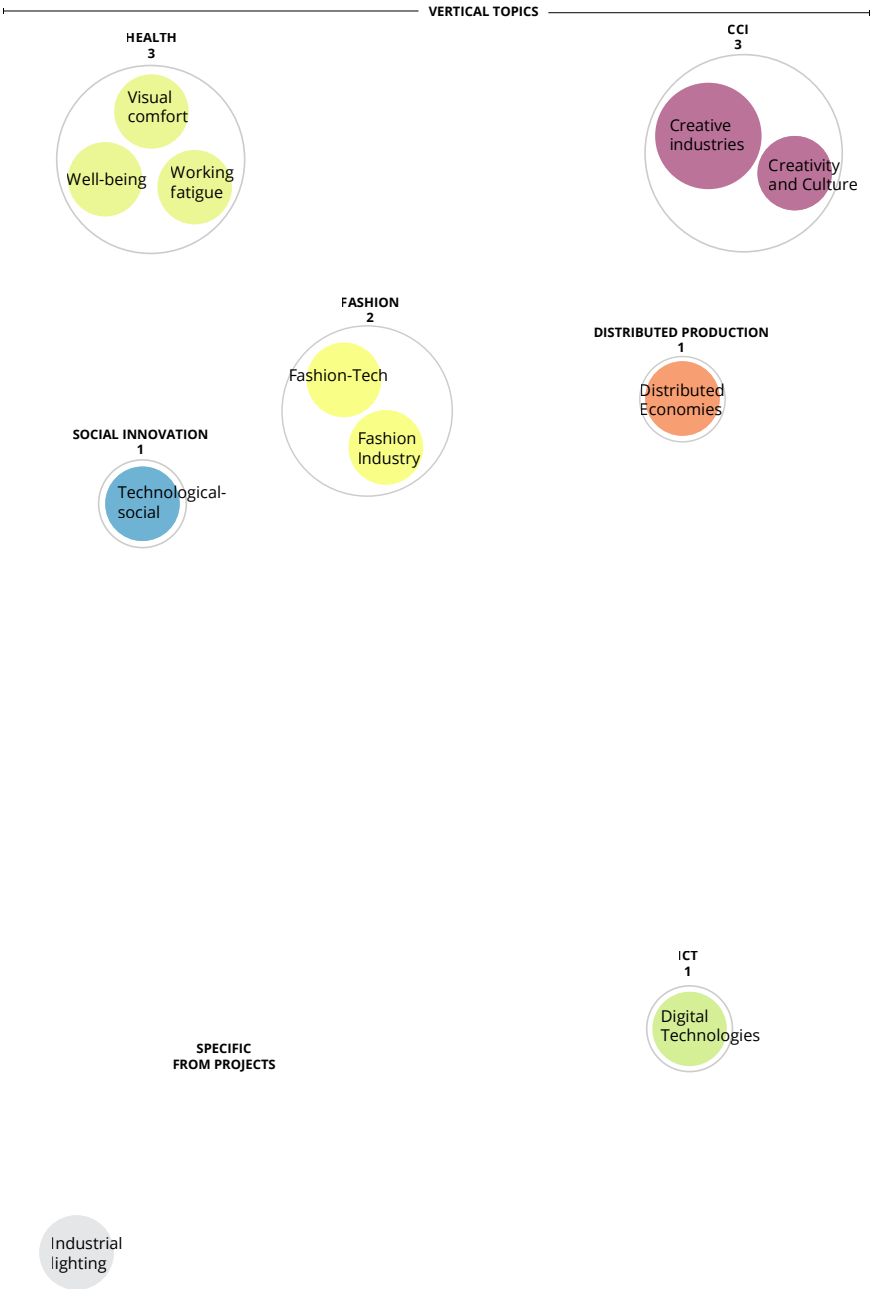


Fig. 6.12 – The distribution of the 19 clusters and the 85 keywords of the funded projects that have contributed to KIP #7 "Generating innovation-based growth".



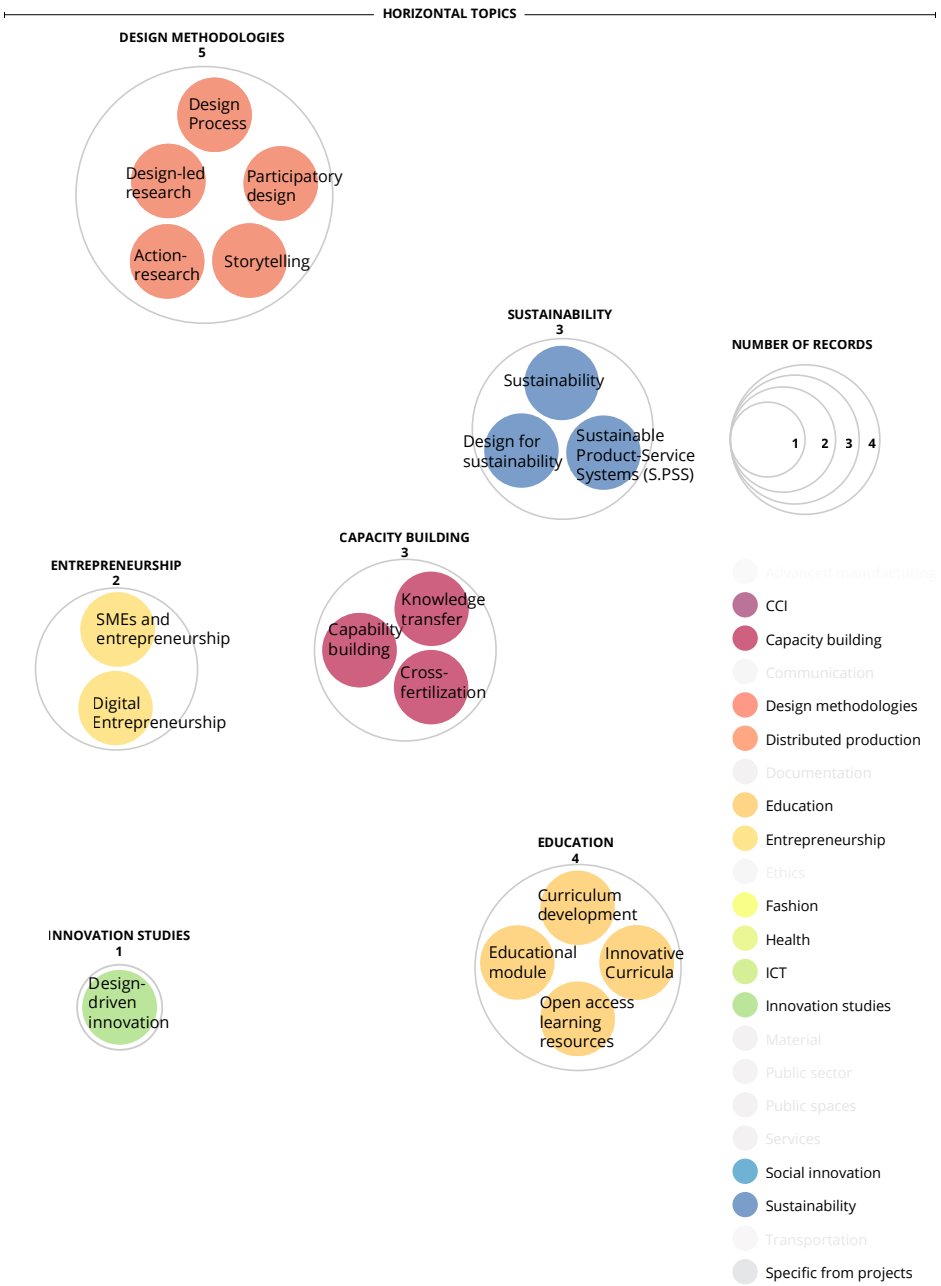
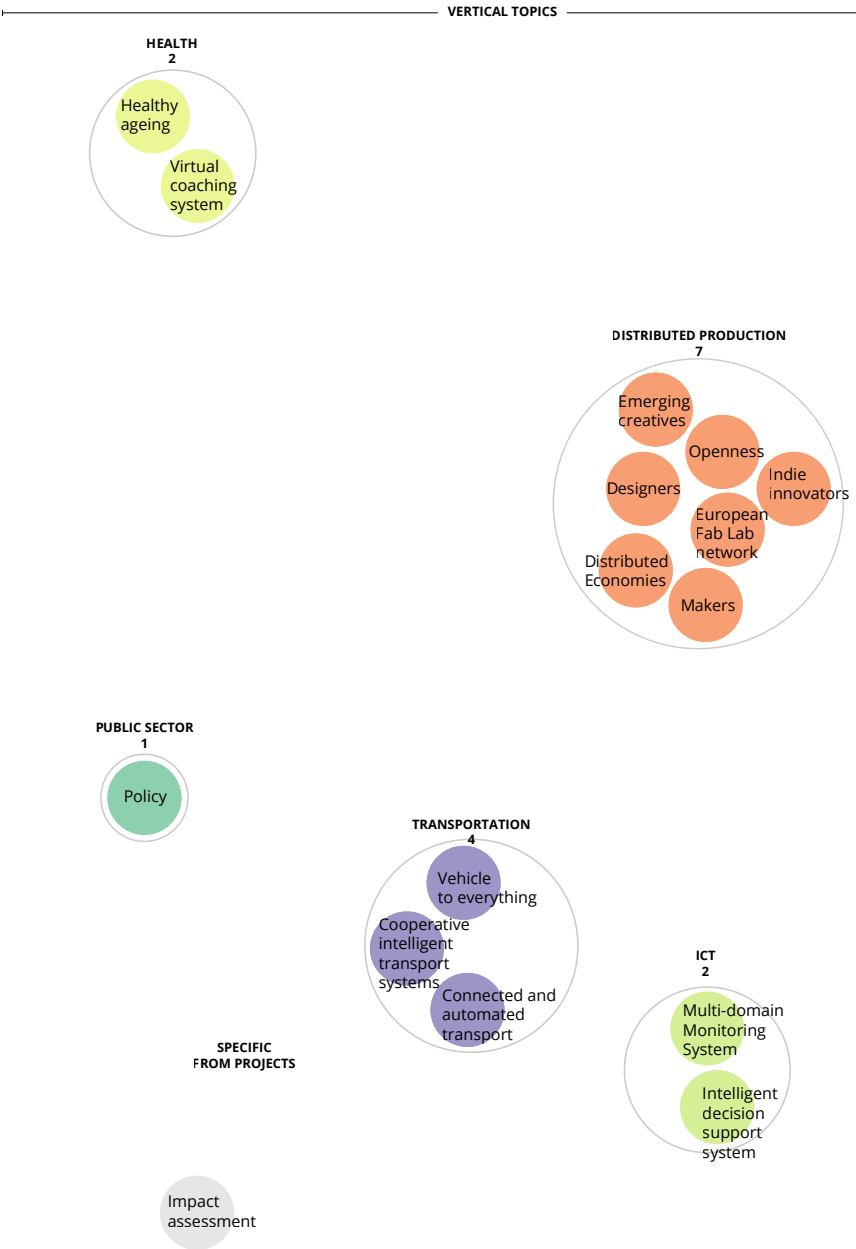


Fig. 6.13 – The distribution of the 13 clusters and the 30 keywords of the funded projects that have contributed to KIP #8 "Creating more and better jobs".



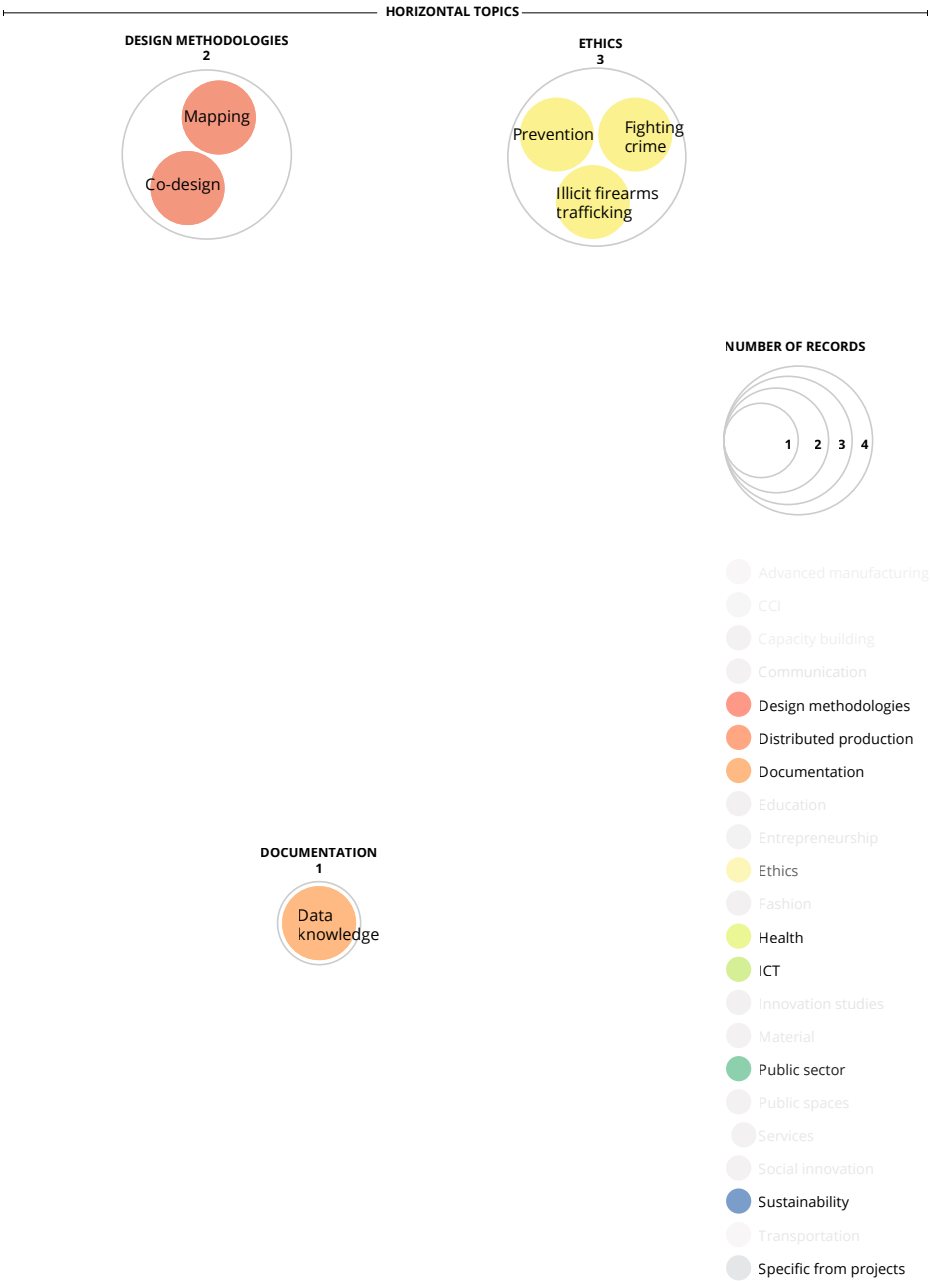


Fig. 6.14 – The distribution of the 9 clusters and the 23 keywords of the funded projects that have contributed to KIP #9 "Leveraging investments in R&I".

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7. Reflections on upcoming directions of design research

Alessandro Deserti
Department of Design, Politecnico di Milano

By analysing the Department of Design's research projects that have been funded and concluded, it has been possible to return a snapshot of the thematic areas that are most often manned, the type of output that the research produces, the results achieved under the funding program, and the long-term impacts that this can generate. This systematised information makes it possible to discover how the nature of design research projects has evolved to date, widening the mesh on the initial principals, to meet new challenges and respond to new needs for change suggested by the evolution of society, users, production processes, and policy inferences. How will this evolution continue? What will be the new challenges and new territories that our research will have to cover? And also, how will Design as a discipline be able to position itself and take directions of conscious development?

Building on the evidence gathered and presented in the previous parts of the book, this final chapter aims to discuss the possible futures. More than trying to anticipate in a forward-looking way what the future strategic trajectories of design research may be, the chapter will try to outline some emerging challenges to reflect on them critically. In this perspective, it will try to bridge past and present to possible futures, highlighting how they could affect design research and design practices, and the education of both researchers and practitioners.

7.1 Interdisciplinary collaboration as a means of transformation

One of the issues that emerge in the analysis of the whole body of the funded projects is that, in many cases, the contribution of the Department of Design focuses mainly on the use of design methods and tools to support

research in areas that are typical of other disciplines. With respect to this, it should be noted that, for example, the introduction of skills responding to the need to conduct experiments in real-life settings with the involvement of actors and stakeholders who express different points of view can bring with it a wider reorientation of research projects. In particular, entering into the merits of the objectives and contents of the projects, we see how the introduction of design methods and tools has caused the transition from the predominantly analytical approach that characterises, for example, many social sciences, to a more synthetic approach, focused on the use of experimentation to pilot innovative solutions and create new knowledge. Even if the evidence we draw from the analysis of the projects does not have a quantitative value, it seems that the quest for research that has a more direct connection with its impacts is sustaining the adoption of design as an approach. The use of design methodologies and tools is thus contributing to transformation of the kind of research conducted with researchers from other fields, who are pushed to move from the analysis and understanding of phenomena and problems to working on them, provoking transformations, verifying their impacts and possibly steering changes towards desirable outcomes. To think that this change occurred due to the introduction of design methods and tools would be very presumptuous and unrealistic. Rather, the change is determined in the first place by the demand of impact research aimed not only at analysing problems, but also at tackling them experimentally in order to prototype and assess innovative answers. In this new research landscape, the skills of the designers, who have always been oriented towards experimentally seeking these answers by involving a multiplicity of actors and competences, have proved useful for facing old and new challenges. While researchers from other disciplines often feel out of their comfort zone when experimentation in real-life settings and piloting are needed, designers operate in what for them is a natural environment: ill-defined and wicked problems (Simon, 1969, 1973; Cross, 2006; Lönngren & van Poeck, 2021; Peters, 2017; Head, 2022); need to use design experimentation not only to find solutions but also to explore the problem space (Kruger & Cross, 2006) and engage in a conversation subjects who have different and sometimes contradictory needs and points of view; ability to deal with unexpected questions; adoption of an approach largely based on trial and error and on redesign loops; use of prototypes as experimental verification tools (Camburn et al., 2017) and as boundary objects for transformation (Coughlan et al., 2007; Rhinow et al., 2012), etc. In most of the projects in which researchers from the Department of Design have been involved, problems and challenges are not only analysed, but also addressed by acting on them, albeit in an experimental way and on a small scale.

However, changes do not only occur within other disciplines. Design research is equally contaminated by the relationship in collaborative research with other methodologies and epistemologies. Thanks to this relationship, it introduces new points of view, methods and tools, and is pushed to deal with new questions. We will try to focus specifically on the latter issue, due to the consequences it is having on the widening of disciplinary boundaries, which for some it would be appropriate to keep tighter; on the knowledge needed to tackle the new areas, which is probably not always adequate; and on the tools that are put in place and tested, often borrowing them from other areas and adapting them. The latter have formed an increasingly large corpus that also emerges in its dimensions from the analysis of our research projects, which would require rationalisation and a sense-making operation. The new themes, methods and tools are posing important challenges for design research and their diffusion has already had effects on the training of researchers and designers, for whom even more important repercussions are seen in the future.

7.2 Change in the areas and objects of design

Beyond the changes affecting research tools and methods, collaborative research appears to have caused transformative effects that also affect design as a discipline and the fields in which it operates. Since the experiments to be conducted are often distant from the traditional domains of application of design knowledge, the object of design itself changes, becoming at times substantially different from those that have traditionally been the subject of interest of design researchers. This is a passage that probably initially took place in a not very conscious way, with reference to the experimentation objectives of the collaborative projects and the "objects" that they intended to manipulate in the experimentation. Hence the fact that while traditional design areas and objects are rarely the subject of research, new areas and objects emerge as subjects of research and experimentation, despite being little known or completely unknown to design researchers. Here the challenge for design researchers is sometimes immense due to the knowledge gaps they have to fill in order to deal with these new areas and objects of design research. Looking at the research carried out, there are many cases of this kind, in which areas and objects of design that are little known or unknown to designers emerge. In the following, I will try to cite some examples, without the aim of grasping and systematising all these new areas and objects of design, but rather with that of highlighting the transversal challenges and problems we face.

Policies. Designing new policies in an experimental way means delving into decades of debate on their formation and implementation, on the disconnection between intentions and results, on the methods adopted for monitoring and evaluating their impacts, and on many other issues studied by political scientists, lawyers, economists and sociologists (Deserti et al., 2020; Komatsu et al., 2021).

Non humans. Designers are increasingly confronted with the need to give shape to non-human agents, which are precisely one of the new objects of design. The term "nonhumans", introduced in the scientific debate mainly in the social sciences, and widespread in particular due to the success of the Actor Network Theory, is actually quite broad and ambiguous, and capable of including very different categories, from animals, plants, natural phenomena, inanimate objects, technical ones, material structures (Latour, 2005). It is a layered whole, which does not correspond to a precise definition, but which is rather the result of various contributions, which have accumulated and which have led to the inclusion of both natural and artificial objects, which according to ANT have a shared agency, which does not represent the distinctive element of humans compared to non-humans (Sayes, 2014). While recognizing that the design act has always involved the agency of non-humans, and that the artificial has always been the object of design, we must observe how today we are confronted with particular types of objects, characterised by a specific agency. In particular, this agency aims to replace the human one or to enhance it in a much more significant way than that which has characterised the traditional types of artefacts and machines, because it operates on the grip of decisions through calculation tools and learning mechanisms. Specifically, the development of artificial intelligence confronts us with the challenge of using increasingly refined calculation systems and algorithms, which must be developed, configured and tested, and which have become part of our daily life. Also in this case more traditional challenges arise, such as that of implementing a design process extended to the participation of subjects with very diversified skills and of the users of the products and services in support of which these agents are used, or that of designing the modes of interaction with AI; and new challenges, such as giving personality to non-human agents, addressing new technical problems but also new political and ethical issues (Komatsu et al., 2021). On the other hand, it is necessary to observe how non-human agents enter into a relationship with the design processes not only as subjects to whom form and behaviour must be attributed, but also as actors of the process itself. The shift in this case is from designing agents to interacting with them during the design

process, where the first challenge is to recognize them as such and understand their importance. The topic is not new in itself, and has been extensively covered both in the ANT and in the "material turn" of social theories (Law, 2009). What is new for designers, if anything, is the type of interaction that occurs with these new agents, and the ability they have to modify the design processes themselves. Let's imagine how an AI algorithm can, for example, provide data for design, but also give indications or become a subject that intervenes within a process or system that must be designed.

All this paradoxically intersects with human centricity, understood as a beacon that must guide the design process and as a fundamental point of view for an ethical development of technologies. In this regard, see the development of the debate that led the European Parliament and Council to the publication of the final proposal for the AI Act (artificialintelligenceact.eu/the-act). Already the discussion that led to the publication of the initial white paper added human centricity to trustworthiness, which had been identified as an objective to be ensured through the new legislation, linking the two objectives and leading to the guiding principles set out in the final version of the proposal: "Rules for AI available in the Union market or otherwise affecting people in the Union should therefore be human centric, so that people can trust that the technology is used in a way that is safe and compliant with the law, including the respect of fundamental rights" (European Commission, 2021, paragraph 1.1 "Reasons for and objectives of the proposal"). Certainly design is not the discipline most involved in the development of artificial intelligence, but its point of view is particularly interesting in the perspective of making it human centric. In fact, we are already committed in this direction with an important European training initiative linked to the introduction of AI in the public sector (ai4gov-master.eu), which is experimenting with project based learning models for the integration of technical and design skills, carefully taking ethical and regulatory aspects into consideration. Furthermore, entering into the merits of the research projects and piloting activities they have conducted, we find both the development of new services that use AI algorithms, and experimental activities that look at AI from original and unprecedented points of view. For example in SISCODE (siscodeproject.eu), a European research project coordinated by the Department, one of the co-creation labs has concentrated the experimentation on the realisation of an exhibition, conceived as a moment of reflection on the silent presence of AI is designed with algorithms in mind as spectators (Merzagora et al., 2022). The idea seems bizarre, but without realising it, we begin to be surrounded by information, which can take the most diverse forms, produced to be used only by AI algorithms.

Behaviours. The ANT also clarified unequivocally how the design of some tangible and intangible artefacts has political effects that regulate people's behaviour. The example of seat belts and warnings that make their use mandatory when starting the car, proposed by Latour (Latour, 1992), is in this sense simple and very clear, and raises interesting questions about where morality should be placed.

In general, every artefact has an impact on the behaviour of those who use it, and its design is therefore at the same time the design of a product, service or any other category of goods, and the design of the interaction with its users, which affects their behaviour.

More recently, however, behaviour itself, regardless of artefacts, has been explicitly identified as the primary design focus. In some ways, the condition is not unlike that placed on the designers of systems who aim to ensure that anyone who drives a car is forced to put on a seat belt, but the way the problem is posed to the designers, and how they approach it, change. Behavioural change as an objective is supported methodologically, and equipped with both a theoretical framework and operational tools. The theories of change, often built on the same logic models that have determined the European framework of impact research, have spread starting from the areas in which the moral drive appears most strongly, such as (design for) social innovation (Brown, 2020). The theories of change have often concerned the social sphere, with respect to which they are proposed as tools to guide the transformation, and more recently have tried to combine it with the environmental sphere (Shove, 2010). With respect to this, the moral drive that we have mentioned is inevitably connected to the idea of what is socially or environmentally right and appropriate, and seeks to orient individual behaviour in this direction. The questions that arise concern not only the knowledge and tools available to designers, but also the ethics of design, and how it can be managed when the goal is to intentionally change the behaviour of individuals and social groups. The decision as to what is socially or environmentally right can at any time conflict with the possibility that other points of view exist and with the freedom to express them. In this context, more solid theories of change and more refined tools risk being particularly critical if they are not accompanied by careful consideration of the ethical dimension of design research, which emerges strongly in relation to the involvement of people and the experimentation bound to their behaviours. Although this is not a new topic, also in this case the design researchers and designers seem less equipped than those who work in other fields, perhaps more explicitly touched by ethical aspects. Even considering the increasingly close relationships between design and some disciplines that carry out experiments that

by their nature pose ethical questions, the development of further knowledge and awareness on the ethics of design certainly emerges as a significant challenge that research must face.

Organisations. Some of the projects analysed, if read through the filter of the declared impact objectives, aim at changing organisations. The impact generation model proposed by the European research framework itself, forged on the basis of the logic model and brought back from the scale of the entire program to that of the single project, has probably led to the definition of broader and more ambitious overall objectives than those which size and limitations of individual projects made it possible to obtain. However, it is very interesting to observe how in some projects organisations are in several cases explicitly identified as objects that must be transformed, and how in many others they are implicit objects of transformation if we look at the expected impacts. To give just a few examples, the research work carried out to support the operationalisation of Responsible Research and Innovation (RRI) (Deserti et al., 2022) proposed to scale down the research already conducted on RRI, from the focus on national practices to that on the variety of local experiences in an international context, with the aim of moving from broad recommendations to experimentation with RRI practices within different local ecosystems, investigating the transformative impacts they can have on organisations and ecosystems. These objectives, in addition to being supported by the impact generation model proposed by the research framework, were fueled by research already carried out on the relationship between design and organisational change (Boland & Collopy, 2004; Buchanan, 2008; Junginger & Sangiorgi, 2009), and tried to address it experimentally, to support the transition from an implicit role of the design to the definition of methods and tools capable of supporting its explicit role of transformation agent of the organisation.

This experimentation has mainly focused on the project itself as a tool for organisational change and has addressed different areas and objects of design not only with the aim of developing new products, services or systems, or of improving existing ones, but also with that of transforming the processes of the organisations that took part in the experimentation, with the idea that the change of products and processes drives the change of the organisations themselves. Here it is appropriate to quote in a paradigmatic way the theme of the introduction of design in the public sector, which had already been the subject of analysis in the perspective of design as an agent of organisational change (Deserti & Rizzo, 2014). In this sector, design mainly works on well-established design objects (mainly services, but also on even more

consolidated objects such as communication artefacts) but begins to look at them in the perspective that they can be tools for the operationalization of policies – which become precisely the real goals and new objects of design – or for organisational change. If the change is not intended to be episodic but intentionally guided, knowledge of the organisation in a broad sense, and of a specific type of organisation which is the public one, becomes of fundamental importance. And once again extraordinarily wide knowledge gaps emerge, posing major challenges for designers and design researchers. If the change is not intended to be episodic but intentionally guided, knowledge of the organisation in a broad sense, and of a specific type of organisation which is the public one, becomes of fundamental importance. And once again extraordinarily wide knowledge gaps emerge, posing major challenges for designers and design researchers. A certain degree of unawareness and naivete may allow design researchers to express a fresh and unconditioned point of view, but at the same time set important limits when defining ambitious goals for cultural change in a sector in which even more structured disciplines have shown all their limitations.

Systems. The aforementioned theories of change are placed within a stream of thought that pays particular attention to systems and that looks at their complexity as one of the challenges that design research and design have to face. The relationship between design and cybernetics has developed on the premise that design can also be applied to change objectives that involve complex systems, characterised by non-linear relationships between causes and effects, and in which a local perturbation can have significant effects that are hardly predictable and controllable (Glanville, 2009; Krippendorff, 2007). Rittel and Webber discussed many years ago the idea of wicked problems, that affect planning and designing and that are more than just complex, questioning the idea that some problems can be addressed within an efficiency logic based on the development of solutions (Rittel & Webber, 1973). With respect to this, the two authors observe how problems that have a systemic nature imply difficulties in defining the problem itself. In their words, these problems present the intractable difficulty "*of knowing what distinguishes an observed condition from a desired condition*" (Ibidem, p. 159) and in locating where in the complex causal networks the trouble really lies. Moreover, the problem of identifying the actions that might effectively narrow the gap between what-is and what-ought-to-be appear equally intractable. Despite these not very comforting premises for design research, the challenge of design for systemic change has largely unfolded for some years, in connection with the aim of pushing designers to become aware of their

social and political role, and then was almost forgotten until recent years, in which mainly the emergence of the climatic and environmental issue, have brought the idea of design for systems back into the scientific debate. In particular, Norman and Stappers, with the idea of DesignX, have again placed their attention on complex systems, taking up and updating various considerations of historical literature (Norman & Stappers, 2015). Several projects collected and analysed here aspire to transformations at the system level and have operated experimentally on complex systems: transport, health, education, the city and others. In many cases, research projects have tried to link the dimension of experimentation, typically conducted on a small scale, with the enormous challenges posed by the change of these systems. For this reason, as well as due to the request to connect the actions developed experimentally in the projects with outcomes and impacts in real-life settings, part of the research focused on the scaling mechanisms of the innovations tested. This is a topic of particular interest, with respect to which, however, a challenge that arises is precisely that of causal links, which the theories of change often imply implicitly or explicitly, and whose identification difficulty is paradoxically one of the characteristics of complex systems. Here remain some basic questions to which the research has not given an answer, and are perhaps destined to remain without a single answer. In particular, we must ask whether systemic change can really be based on small-scale experiments which are then transformed into stable and scaled solutions in different ways. After years of experimental research and reflections, well documented here, we can honestly say that these experiments can make a contribution but that change also occurs in other ways and on another scale, which is currently being tested in new projects, that will hopefully offer new interesting contributions to the development of design knowledge for systemic change.

7.3 Reflections and trajectories for future work

The new themes and transformative challenges that characterise impact research seem to lead at the same time to the development of new knowledge, which is mainly the result of interdisciplinary collaboration, and the need for new knowledge and skills for all those who take part in it. In particular, while for researchers of other disciplines the need to operate experimentally on transformations in real life settings emerges, for design researchers the demand for knowledge of new objects that must be experimentally manipulated emerges. In particular, to use an analogy with the design of tangible products, the need emerges to know the "materials" and "components" of which

these objects are made, their transformation processes, and the ways in which change can be intentionally addressed. In several of the research presented here, the materials used to design a service or policy appear to be primarily data, while the components appear to be their aggregates. As we have seen, in some researches, individual and collective behaviours are objects that are experimentally modified as tools that contribute to the transformation of a system. Almost all research poses the challenge of understanding what are the new materials, components and transformation processes with which designers work, and what are the skills needed to manage them. Who should be and what skills the designer and the design researcher should have in these new contexts are the relatively simple questions we can ask. However, the answer is problematic and rather complex, so much so that we look at the design practice (Manzini, 2015) as much as we look at design research. On the one hand, the claim of knowledge of the methods and tools of the discipline emerges as a fundamental competence to act as designers and design researchers; on the other hand, the claim of knowledge of the design area and the object to be manipulated emerges, without which it is impossible to operate consciously on its transformation. And consequently: to face the change we need a designer or a design researcher to whom we must attribute knowledge about new design objects, or is it better to involve the specialists of these objects to whom we must give design skills? Impact research, as it is configured, is experimenting with the involvement of multiple figures who have distinct vertical skills but who are capable (or at least try) to collaborate. It is certainly not only an inevitable path, but also a harbinger of great enrichment and which is giving important transformative results. However, some questions still remain without satisfactory answers. In particular, those relating to the boundaries of design as a discipline and the knowledge of design researchers and designers. They are probably destined to remain basic issues on which it will be necessary to constantly formulate questions in the face of external changes, which require to reconcile both the ability to involve a multiplicity of knowledge, as well as that of updating and redirecting knowledge and the repertoire of methods and tools that design researchers and designers have at their disposal.

In the process of "scientificisation" of the discipline, design literature often referred to Simon's seminal studies, which extended the disciplinary boundaries far beyond those of the categories of goods and problems to which designers have historically dedicated themselves (Simon, 1969, 1988). His famous and most cited sentence "Everyone designs who devises courses of action aimed at changing existing situations into preferred ones" (Simon, 1969, p. 111) paved the way for the idea that design is first of all a

core human activity and a process that characterises the sciences concerned with "what ought to be" in contrast to the sciences which are concerned with "what is" (Kimbell, 2009). As important as it was, Herbert Simon's definition can nevertheless entail possible misunderstandings, because if on the one hand it defines the design dimension and the ability to intentionally act on reality as a characteristic of many human activities that require specific skills; on the other hand, it risks identifying all those who carry them out as designers. It should be noted in this regard that a surgeon who operates a patient or a politician who promulgates a new law, for example, fit perfectly with Simon's definition without either of them being properly a designer. Taking a cue from the second case, it is however interesting to observe how the recent opening of a line of research on policies as objects that can be designed, prototyped and experimentally verified, has created a new space for research, experimentation and theoretical reflection for design researchers, which raises questions relating to the necessary knowledge and the boundaries of the discipline. Therefore, if on the one hand the new areas and objects of design research are allowing to generate new knowledge, often also usefully brought back within the already consolidated fields, on the other hand they bring with them many challenges that we have tried to describe in a non-systematic way. A broader reflection on them is certainly necessary, not only and not so much to systematise, but to address the epistemological aspects of the discipline, creating a virtuous circle that relates impact research with theoretical elaboration, overcoming the sequential model "basic research / applied research / technology transfer" typical of other disciplines. In this, a young discipline like design, which does not have to carry the weight of a large historical corpus, can certainly propose itself as a precursor.

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Annex I.
Relationship between research projects, keywords, clusters, key impact pathways and impact categories

**PR = project name; ImPa= impact pathways; ImCa= impact categories*

PR	CLUSTERS	IMPACT	ImP	ImCat
C-Roads 5 keywords	Transportation, Specific from project	• Reinforcing/advancing knowledge on C-ITS and their possibilities • Contributing to develop a scientific community focused on the evaluation of the impact of C-ITS on mobility	#1	scientific impact
		• High recognizability and prominent role at National and International scale in measuring impacts of ITS/C-ITS technology on mobility • Advance of career: 1 position as RTDA	#2	
		• Informing the development of future vehicle control strategies and intelligent transport policies in EU	#4	societal impact
		• Increasing road safety • Contributing in decreasing congestion (sustainability)	#5	
		• Reinforcing/advancing knowledge on cooperative intelligent transport systems and their possibilities • Bringing new knowledge on C-ITS impact on drivers and social acceptance	#6	
		• Informing and nurturing the development and transferability of on-board technologies in the mobility sector	#7	technological /economic impact
		• Nurturing the development of harmonized strategies and C-ITS specifications for Europe	#9	
Cascina 9 5 keywords	Capacity building, Design methodologies, Social innovation	• Reinforcing the diffusion of co-design practices for social engagement and/for inclusion of migrants • Reinforcing knowledge and awareness on how to apply co-creation and social innovation processes • Further exploring of a research approach developing tools and methods replicable and scalable to other contexts	#1	scientific impact
		• Favouring capacity building and knowledge transfer to the local ecosystem about the application of co-creation for social innovation and social inclusion • Improving the quality of life of the Dergano neighborhood and reinforcing the sense of belonging of the community. • Reinforcing social engagement, inclusion, and	#6	societal impact

PR	CLUSTERS	IMPACT	ImP	ImCat
		integration of migrants and refugee, and other vulnerable groups • Empowering the local community transferring skills on digital strategies to cultural operators partners through capacity building and knowledge transfer • Increasing awareness and sensibilization towards the migrants/refugee experiences in the neighborhood • Reinforcing attitudes of social engagement and/for inclusion of migrants between HEI, local communities, cultural associations and organizations • Strengthening collaboration with cross-sector actors		
		• Supporting and boosting the local economic ecosystem, and activate virtuous behaviors	#8	technological /economic impact
Eupolis 5 keywords	Communication, Education, ICT, Innovation studies, Public sector	• Reinforcing cross-sector knowledge for supporting digital transformation in the PA sector	#1	scientific impact
		• Reinforcing understanding of social innovation processes and digital transformation in the PA • Favouring the operationalization of digital strategies for PA • Favouring the development of a solid relationship with the actors and stakeholders, and further collaborations between the higher education domain and the public sector	#2	
		• Reinforcing Regione Lombardia's knowledge on how to operationalize and apply corporate social responsibility in the PA • Informing policies for supporting a more efficient digital transformation in the Regione Lombardia	#4	societal impact
		• Strengthening knowledge transfer on the topic of communication, digital strategy, digital transformation • Favouring capacity building and impacting on power dynamics among the PA depts • Favouring organisational change and better communication within Regione Lombardia • Contributing to overcoming a siloed mentality with knowledge transfer among the triple helix actors • Increasing PA knowledge on how to strategically plan the communication of/within the organization	#6	
PUDCAD 5 keywords	Capacity building, Education, Health	• Contributing to the discourse on the advancement of CAD-based design modelling and its implementation, and the use of game-based learning for including universal design principles in design education	#1	scientific impact
		• Favouring capability building in HEIs students • Strengthening collaboration with cross-sector	#2	

PR	CLUSTERS	IMPACT	ImP	ImCat
		actors (researchers/academia, HEIs, associations/NGOs)		
		• Reinforcing collaboration, knowledge and experience exchange to include reasonings on special needs in design education across borders • Sharing open access knowledge on the topic of universal design principles	#3	
		• Strengthening the quality of design education implementing principles of Universal Design • Strengthening the awareness that reflection on accessibility and its impact on social exclusion need to be included in design education curricula • Enriching design curricula spreading new engaging approaches in CAD-based design development process • Exchanging cross-sector scholarship and know-how on how to embed UD principles in design education and HEIs • Favouring networking and reinforcing synergic cooperation between HEIs and NGOs dealing with disability	#6	societal impact
		• Supporting Universal Design Principles in HEIs through video game (software) and its supporting infrastructure	#7	technological /economic impact
LDI 5 keywords	Health, Sustainability, Specific from project	• Strengthening the cooperation with ENEA	#2	scientific impact
		• Providing open access to knowledge on the relevance of sustainable and better lighting	#3	
		• Supporting competitiveness and sustainable development of national lighting policy for improving working conditions	#4	societal impact
		• Improving the working environment impacting on work efficiency – new design of lighting system • Improving the quality of life of the workers • Favouring capacity building and knowledge transfer from academy to industry	#6	
		• Contributing to the development of optimized and more sustainable lighting ensuring workers' visual comfort	#7	technological /economic impact
		• New working position	#8	
FIRE 6 keywords	Design methodologies, Documentation, Ethics, Public sector	• Knowledge and the skills acquired have been applied in other contexts	#1	scientific impact
		• Strengthening the position of the research lab in data-intensive research projects.	#3	
		• Informing the policy framework to deal with and fight ITF • Reinforcing knowledge on firearms transfers as a foreign policy instrument to set security	#4	societal impact

PR	CLUSTERS	IMPACT	ImP	ImCat
		requirements and objectives • Providing indications for future initiatives, policies, strategies, and decision-making on ITF		
		• Building knowledge of ITF logics, actors, and channels • Impacting on EU security by informing the setting of tangible objectives towards reduction in firearms flows. • Bridging scholarship from different disciplines to provide new knowledge out of data spread online	#6	
		• Favoring knowledge transfer across sectors	#9	technological /economic impact
SISCODE 5 keywords	Design methodologies, Ethics, Innovation studies, Public sector	• Increasing knowledge of co-creation processes in diverse European contexts • Increasing cross-fertilization between Design and RRI field by introducing new drivers for responsible innovation in STI • Advancing reasoning on the need to include other forms of innovation in the science-based and tech-oriented RRI field	#1	scientific impact
		• Reinforcing collaboration between a multi-actors ecosystem at local-to-national level to boost knowledge uptake in policy-making • Strengthening knowledge on assessing the impact of co-creation in organizational/institutional change	#2	
		• Reinforcing knowledge on the role of stakeholder engagement in co-creation and co-production processes • Further developing a research group approach, feeding the debate on co-creation practices in STI policy making	#3	
		• Connecting different levels of policymaking for reinforcing knowledge and spreading approaches to multi-level governance • Contributing to overcoming a siloed approach for better integrating co-creation in policymaking	#4	societal impact
		• Contributing to overcoming researchers, innovators, and policy makers prejudices and preventions on co-creation in STI	#5	
		• Providing guidance to cope with organizational barriers and resistance to change preventing concrete implementation of RRI solutions and policies • Contributing to mitigating the gap between ideation and implementation in the co-creation of RRI policies and solutions • Favouring the introduction of a pragmatic culture a largely theoretical sector (RRI) • Providing guidance towards better ways to engage	#6	

PR	CLUSTERS	IMPACT	ImP	ImCat
		stakeholders & civic society in STI • Reinforcing knowledge on how co-creation for RRI can impact organizations • Providing guidance to concretely support the implementation of co-creation in RRI solutions and policies • Strengthening cross-sector capacity building an knowledge transfer on the application of design methods for co-creation • Improving the capacity to design appropriate citizen science and other co-creation processes in RRI field • Contributing to mitigate the gap between theory and practice in STI domain • Increasing the understanding of dynamics and circumstances that favor or hinder co-creation for RRI • Contributing to diffuse the culture of co-creation in R&I communities and in the industry • Contributing to better integrating the voice of society in science and innovation. • Favouring the uptake of co-creation to effectively engage society in science, technology and innovation.		
		• Supporting therapists and families of impaired children for home rehabilitation.	#7	technological /economic impact
campUS 5 keywords	Capacity building, Design methodologies, Social innovation	• Deepening and expanding knowledge on practice-based experimentations in design for social innovation research	#1	Scientific impact
		• Enriching design curricula, with an emphasis on students' active participation and engagement • Strengthening collaboration with cross-sector actors	#2	
		• Scaling-up of the co-creation processes towards a systemic approach in the urban context • Reinforcing synergies between university and civil society through knowledge transfer on transformation of the public spaces • Reinforcing the advancement of knowledge and diffusion of strategies for quality transformation • Reinforcing collaboration with a multi-actors ecosystem at local level for further collaborations • Further developing a research group approach for participatory action research methodologies in design for social innovation	#3	
		• Strengthening the exploitation of the co-creation processes of public spaces to provide evidence-based policy options	#4	societal impact
		• Boosting the proactive engagement of the civil society in the transformation of the public spaces	#5	

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Boosting the proactive engagement and participation of the civil society in co-creation processes • Empowering NEETs with know-how to transfer specialised knowledge with the purpose of strengthening their employment potential • Exploring the replicability of the approach and of the modus operandi of the methodology applied and of the multi-actors network of local stakeholders towards a long-term uptake in society	#6	
Human Cities 5 keywords	Design methodologies, Public spaces, Social innovation	• Deepening and expanding knowledge on practice-based experimentations in design for social innovation research	#1	scientific impact
		• Strengthening collaboration with cross-sector actors internationally and with international entities • Enriching design curricula, with an emphasis on students' active participation and engagement	#2	
		• Scaling-up of the co-creation processes towards a systemic approach in the urban context • Reinforcing collaboration between a multi-actors ecosystem at local level with higher education/design centers • Increasing the understanding of dynamics and circumstances that favor co-creation processes in participatory design for urban public spaces • Further developing a research group approach for participatory action research methodologies in design for social innovation	#3	
		• Exploring the replicability of the approach and of the modus operandi of the methodology applied and of the multi-actors network of local stakeholders towards a long-term uptake in society • Boosting the proactive engagement and participation of the civil society in co-creation processes • Improving the civic engagement of vulnerable groups for encouraging and facilitating active participation and for improving integration • Strengthening the impact and the quality of design education in order to reinforce training strategies of design educators	#6	societal impact
Tango-Down	Design methodologies, Innovation studies,	• Contributing to the discourse on the cross-fertilization and integration between the design discipline and Future Studies, Anticipation and Future Narration perspectives	#1	scientific impact

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Deepening and expanding knowledge on practice-based experimentations in design for social innovation research		
		• Promoting a cross-fertilization between the design discipline and creative writing/theatre towards promoting the contribution of cultural heritage to social cohesion and inclusion • Contributing to the discourse on the cross-fertilization and integration between the design discipline and Future Studies, Anticipation and Future Narration perspectives	#3	
		• Identifying and overcoming social barriers and divisions among citizens for re-invigorating and enhancing the public dialogue linked to local cultural heritage and identity • Contributing to the capacity building to university students enhancing the impact of design education in social innovation environment	#6	societal impact
CIMULACT 4 keywords	Design methodologies, Ethics, Public sector	• Deepening and expanding knowledge on the theme "Design for Policy" and participatory design methodologies in co-design processes	#1	scientific impact
		• Further developing a research team approach and skills improvement in designing the interaction in co-design sessions for the engagement of citizens and multiple stakeholders • Reinforcing group knowledge and expanding the research team	#2	
		• Increasing the diffusion of research scenarios in education	#3	
		• Deepening of "co-creation" and "validation" issues in the field of "Design for Policy" • Informing the development of future policies on the next EU Research and Innovation agendas	#4	societal impact
		• Developing strategies to address the demands and needs of citizens expressed in other, non-electoral forms of political participation • Boosting the capability building and the engagement of civil society in processes of direct democracy by establishing genuine dialogue between citizens, stakeholders, scientists, and policymakers • Facilitating the dialogue and shared understanding between policymakers, citizens, and stakeholders for the uptake of R&I in society • Foster participants' personal development and awareness for the others and for the ongoing scientific debate	#6	
SDIN 5 terms	Capacity building, Education, Services,	• Reinforcing and advancing knowledge on interdisciplinary contributions to service design and innovation	#1	scientific impact

PR	CLUSTERS	IMPACT	ImP	ImCat
	Specific from project	• Improving the research skills of early career researchers towards increased individual impact of application of service design approaches • Developing interdisciplinary competencies in the key service design for innovation area and in key service sectors • Developing and reinforcing group knowledge and skills improvement in key service sectors • Reinforcing group knowledge and networking towards the further development of research areas and topics	#2	
		• Integrating the competences and infrastructures of key European universities and non-academic organisations for a European-wide doctoral program in service design for innovation • Reinforcing group networking in the service design scientific community	#3	
		• Increasing awareness and producing spillover effects to the other sectors of the economy and society linked to the service design for innovation area, contributing to EU smart specialization strategy • Strengthening the quality of PhD in design curricula in service design for innovation	#6	societal impact
		• Favouring the employability as a spillover effect of supporting ESRs to start building their own network of contacts outside academia	#7	technological /economic impact
L' architettura in Lombardia 5 keywords	CCI, Design methodologies, Documentation, ICT	• Reinforcing group knowledge and networking in the development of criteria for data collection and archives development	#2	scientific impact
		• Increasing the diffusion of open access knowledge about Lombard architecture of the late twentieth century • Promoting the diffusion of a renewed concept of "cultural heritage" to preservation or transformation of buildings • Reinforcing group networking in the service design scientific community	#3	
		• Increasing the diffusion of strategic cultural itineraries of modern/contemporary Italian architecture	#4	societal impact
DigiMooD 5 keywords	CCI, Design methodologies, Education, Entrepreneurship, Fashion	• Promotion of the culture of cross-fertilization between entrepreneurship, creative industries & ICT, considered as new drivers for innovation and growth	#1	scientific impact
		• Favouring capability building in HEIs students through new curricula that promote cross-sector knowledge among cultural and creative sectors, business, and technology disciplines in the Fashion industry • Strengthening the awareness, diffusion and uptake	#2	

PR	CLUSTERS	IMPACT	ImP	ImCat
		of the ideal profile for future fashion professionals • Reinforcing group knowledge and expanding the research team and subsequently attracting a PhD student		
		• Reinforcing cross-sector knowledge for supporting digital transformation in the Fashion Industry and education • Reinforcing collaboration and synergies between university and entrepreneurs through exchange on digital skill-set for CCIs	#3	
		• Strengthening the impact and quality of design education to get a mutual reinforcement between educators and working system • Strengthening the impact and the quality of design education in collaboration with entrepreneurs in fashion companies • Increasing the awareness of the culture of cross-fertilization in applying entrepreneurial culture within design as a driver for innovation and growth in the fashion system	#6	societal impact
		• Favouring the employability of design students in fashion design by improving their digital skill-set within the fashion system awareness in order to favour the industry growth	#7	technological /economic impact
		• Favouring the employability of design students in fashion design	#8	
DeFINE 4 keywords	CCI, Design methodologies, Entrepreneurship, Fashion	• Reinforcing and advancing knowledge on the design contributions to Fashion-Tech research and innovation	#1	scientific impact
		• Favouring capability building of innovators in Fashion-Tech to improve their access to finance and submit for mentoring • Reinforcing group knowledge and expanding the research team and subsequently attracting a PhD student	#2	
		• Increasing awareness and innovation capacity of SMEs in Fashion-Tech industry and business support organisations	#3	
		• Nurturing policy development and entrepreneurial support dedicated to the Fashion-Tech sector	#4	societal impact
		• Favouring networking and reinforcing synergic cooperation of incubators, accelerators, and other business in Fashion-Tech industry with financiers to spread awareness about the value of investing in Fashion-Tech businesses • Increasing the awareness of the ecosystem of the Fashion-Tech sector as new driver in developing entrepreneurial business ideas for creating innovation and growth in the society	#6	

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Producing and sharing knowledge on the nature and opportunities of the fashion-tech sector		
		• Demonstrating the strategic value of the adoption of new technologies in the Fashion-Tech businesses for SMEs growth and competitiveness • Informing and nurturing the development and transferability of new technologies in the Fashion-Tech businesses • Shaping innovative visions into business opportunities and promoting the participation and preparation of innovators	#7	technological /economic impact
WeMi 5 keywords	Communication, Public spaces, Services	• Deepening and expanding knowledge of welfare sector and ecosystem through experimentation activities	#1	scientific impact
		• Strengthening adherence to system values to foster multi-actor collaboration at the local level and improve the welfare ecosystem	#3	
		• Aligning better policy priorities to the real needs of the local ecosystem. • Nurturing policy development dedicated to the welfare sector to improve the overall quality of services and the capacity to increase the rates of coverage of needs.	#4	societal impact
		• Boosting the proactive engagement of the civil society in the transformation of the public welfare system to reinforce inclusion and integration • Ensuring the implementation and development of a widespread welfare system capable of reaching more and more segments of the population • Promoting better quality of the offer and facilitating access to services by contributing to the welfare of citizens and workers.	#5	
		• Strengthening the listening and gathering of widespread needs in order to promote the emergence of unexpressed social demand and needs not (re)known by the system today • Improving the quality of life of citizens, supporting and boosting the local welfare ecosystem • Reinforcing inclusion of increasingly large sections of the population • Promoting the inclusion of the middle and upper income classes in welfare services, improving the quality of services and places, establishing economic support tools for lower income groups	#6	
CREA 5 keywords	CCI, Education, Entrepreneurship, ICT, Innovation studies	• Creating new knowledge of cross-fertilization among creative industries, ICT and entrepreneurship disciplines	#1	scientific impact
		• Promoting the culture and knowledge of cross-fertilization among creative industries, ICT and entrepreneurship disciplines	#3	

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Fundamental basis creation of CI.lab inside department • Reputation and recognition on the research topic: design-driven approach for business and innovation		
		• Strengthening the policy priority on enabling an innovative entrepreneurial ecosystem through the creation of a bottom-up approach	#4	societal impact
		• Capability building, empowering university and high school students to apply Creativity & Design-driven methods on ICT entrepreneurship to produce business ideas through Summer Academies. • Fostering the diffusion of the culture of cross-fertilization through implementing training activities	#6	
		• Increasing of the number of offered opportunities for entrepreneurs, new initiatives, more opportunities of collaboration between different actors	#7	technological /economic impact
CO-CREATE 5 keywords	Capacity building, CCI, Entrepreneurship, Innovation studies	• Creating new knowledge of cross-fertilization among creative industries and traditional industries	#1	scientific impact
		• Promoting and diffusing the culture and values of: 1) creative industries & design-driven innovation in the traditional sectors/clusters 2) cross-fertilization innovation method and tools in both creative industries (design-driven) and the traditional sectors/clusters • Scaling up the research line dedicated to cross-fertilisation between Creative Industries (especially the design-driven innovation approach) and individuals, SMEs and big organizations	#3	
		• Promoting the cross-sector innovation & cooperation policies to foster an environment and a new approach of innovation in local ecosystems	#4	societal impact
		• Promoting and diffusing the culture and values of: 1) creative industries & design-driven innovation in the traditional sectors/clusters 2) cross-fertilization innovation method and tools in both creative industries (design-driven) and the traditional sectors/clusters • Capacity building, empowering SMEs and managers in the traditional sectors to benefit from cross-fertilization & cross-sector collaboration with creative sector	#6	
		• Increasing the competitiveness and performance of SMEs in the traditional sectors • Facilitating and enhancing networking and collaboration opportunities among different sectors	#7	technological /economic impact
		• Increasing the new job offering in different local ecosystems	#8	

PR	CLUSTERS	IMPACT	ImP	ImCat
BRIEFING 4 keywords	Capacity building, ICT, Innovation studies	• Creating knowledge on FET ILP projects, future CSA projects to identify the needs of FET projects and design supporting activities	#1	scientific impact
		• Diffusing the knowledge of and awareness on commercialization and business opportunities in the FET community • Strengthening the research on developing design-driven approach & methods in training activities for new business opportunities • Gaining reputation and more opportunities on applying design-driven approach in different research communities and topics	#3	
		• Capacity building, transferring the mindset, methods and tools of identifying the innovation potential of FET research • Building up and promoting the diffusion of long-term innovation potential in Europe both from the abundance of novel ideas and the range of actors ready to take them forward	#6	societal impact
		• Building up the long-term innovation potential in Europe both from the abundance of novel ideas and the range of actors ready to take them forward	#7	technological /economic impact
LeNSin 5 keywords	Distributed production, Education, Sustainability	• Increasing the numbers and quality of courses on Design for Sustainability (DfS) in HEI internationally • Paying a leading role and having a very strong network and reputation in the research communities related to the topic • Design for Sustainability (DfS)	#2	scientific impact
		• Diffusing knowledge on Design for Sustainability (DfS) that benefits HEIs in design internationally • Growing a wider network and a strong reputation in the research communities related to the topic • Design for Sustainability (DfS)	#3	
		• Capacity building, empowering the teachers and students/future designers with both consolidated and cutting-edge knowledge on Design for Sustainability (DfS) • Building up the awareness and priority of sustainable development	#6	societal impact
		• Increasing opportunities for the employment of design graduates with skills on DfS and new joint projects for the society	#8	technological /economic impact
DiDIY 4 keywords	Design methodologies, Distributed production, Ethics	• Redefining the ways in which digital DIY tools can support and contribute to creativity process for innovation and project development	#1	scientific impact
		• Creating of a specific research topic: co-design in digital • Reputation on applying and diffusing the user-centred approach for DiDIY application in certain areas	#2	

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Promoting the diffusion, the adoption of a strategic approach and the human-centered mindset to the application of DIDIY technologies in 4 domains/areas	#3	
		• Strengthening the awareness of the importance of considering the human/users' aspect in the Digital DIY scenario • Formulating of the multidisciplinary perspective to approach the multifaceted issues related to Digital DIY scenario • Promoting the collaboration among diverse actors in the DiDIY community/ecosystem in the future • Promoting the diffusion the adoption of a strategic approach and the human-centered mindset to the application of DIDIY technologies in 4 domains/areas	#6	societal impact
DIGIKNIT 4 keyword keywo	Capacity building, CCI, Design methodologies, Fashion	• Reinforcing group knowledge and expanding the research team and subsequently attracting a Ph.D student • Creating a new and dedicated research line/direction	#2	scientific impact
		• Increasing educational quality for and the competitiveness of future designers in fashion-knitwear sector through training and direct collaborating with company	#3	
		• Diffusing and promoting the knowledge and practices of digitization of company archives	#5	societal impact
		• Increasing the awareness of the importance and values of digitization of company archives • Empowering future designers in fashion-knitwear sector with digital skills, tools and resources	#6	
		• Increasing the quality of offerings and the company's competitiveness	#7	technological /economic impact
TAMBALI FII 5 keywords	Advanced manufacturing, Capacity building, Entrepreneurship, Material, Social innovation	• Creating knowledge on new material composition for proposing to use in the fishing sector in Senegalese context • Creating knowledge on composition of materials and manufacturing in local industrial chain/sector	#1	scientific impact
		• Established relationship with local stakeholders and communities	#2	
		• Capacity building, empowering local students and actors in the fishing sector with obtained knowledge on innovative manufacturing technologies and composite materials • Fostering the diffusion of experiences and know-how of methods and techniques on innovative manufacturing technologies and composite materials • Reinforcing collaboration and synergies between	#6	societal impact

PR	CLUSTERS	IMPACT	ImP	ImCat
		research institutions, companies, and associations in italy and Senegal		
		• Strengthening and facilitating to create the local community and ecosystem for activating a new sustainable fishing chain and high engagement of local actors	#7	technological /economic impact
NUVOLE 5 keywords	Advanced manufacturing, Health, Material, Specific from project	• Creating knowledge on industrial design methods and strengthening the relationship between industrial design, material and manufacturing technologies	#1	scientific impact
		• Gaining specialized knowledge and reputation on industrial design and in the furniture & accessory industries	#2	
		• Promoting the diffusion of the specialized knowledge on industrial design in the furniture & accessory industries	#3	
		• Fostering the diffusion of experiences and know-how of methods and techniques on innovative manufacturing technologies and composite materials	#6	societal impact
		• Promoting the innovation opportunities in industrial design processes through studying new typologies of materials and manufacturing technologies • Strengthening the values of industrial design and offerings on the market	#7	technological /economic impact
Edu4FT 5 keywords	CCI, Design methodologies, Education, Fashion, ICT	• Creating knowledge on the culture of cross-fertilization on fashion-tech topic in academic and company fields • Creating new knowledge and expanding the definition of "Fashion-Tech"	#1	scientific impact
		• Reinforcing group knowledge and expanding the research team and subsequently attracting a Ph.D student	#2	
		• Reinforcing collaboration and synergies between university and entrepreneurs through knowledge transfer and cross-sector exchange • Raising transdisciplinary knowledge and improving the reputation of the research group at national and European level	#3	
		• Informing the development of future policies towards an entrepreneurial action-plan for the modernization of Higher Education	#4	societal impact
		• Strengthening the impact and the quality of design education in order to get a mutual reinforcement and to widen the visibility and academic influence	#6	

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Favouring the employability of design students in fashion design by improving their skill-set with fashion-tech awareness. • Increasing of the number of offered opportunities for early career researchers in the fashion-tech area	#8	technological /economic impact
FashionSEEDS 5 keywords	Education, Fashion, Innovation studies, Sustainability	• Developing a research and learning new pathway in the Fashion field, based on the dimensions of cultural, social, economic and environmental sustainability • Creating knowledge on Fashion Sustainability, and then integrating the new research theme by the group involved	#1	scientific impact
		• Strengthening the impact and the quality of design education by developing the field of fashion for sustainability, enhancing and expanding academic visibility and influence • Reinforcing group knowledge and expanding the research team and subsequently attracting a Ph.D student	#2	
		• Reinforcing collaboration and synergies between university and entrepreneurs through knowledge transfer and cross-sector exchange. • Raising transdisciplinary knowledge and improving the reputation of the research group at the national and European level	#3	
		• Informing the development of future policies towards an entrepreneurial action-plan and regional innovation score for the modernization of Higher Education	#4	societal impact
		• Fostering new sustainable behaviors in consumers, who gain access to products derived from the new holistic view of sustainability	#5	
		• Strengthening the perception of the importance the sustainability in the Fashion field, as a holistic element	#6	
MaDe 5 keywords	Design methodologies, Material, Sustainability	• Reinforcing knowledge on the culture of cross-fertilization on materials designers topic in academic and educational fields • Creating knowledge on “Materials Designers” topic and bring another research proposal	#1	scientific impact
		• Reinforcing group knowledge and expanding the research team and subsequently attracting a Ph.D student	#2	
		• Reinforcing collaboration and synergies between university and entrepreneurs through knowledge transfer and cross-sector exchange on sustainable materials • Sharing open access knowledge on the topic of materials designers	#3	

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Enriching design curricula by spreading new experimental approaches for the implementation of knowledge and skills in the material designer field • Fostering new sustainable and circular approaches in materials designer, who create the substance from which the products of the future will be made • Deploying design-related material culture to overcome Specialist Materials Designers skills gaps • Strengthening the importance of exploring new materials and related possibilities even by non-experts of chemical and physical materials properties	#6	societal impact
POD 6 keywords	Ethics, Health, ICT	• Creating knowledge on “Design through prototyping” topic, which led to create the FARB project "The Role of the Prototype"	#1	scientific impact
		• Reinforcing group knowledge and expanding the research team and subsequently attracting a Ph.D student	#2	
		• Strengthening the design for behavioural change theme in the technical domain of the “persuasive technologies” • Fostering the importance of research through prototyping to a broad audience • Raising transdisciplinary knowledge and improving the reputation of the research group at the national and European level	#3	
		• Fostering better quality and safety at work, and also increasing the overall workers' health condition	#5	societal impact
		• Strengthening the importance of the research-based innovative solutions created, to a broad audience • Increasing and/or building new awareness in workers towards personal protection and care to promote job security and reduce the impact in the healthcare industry	#6	
		• Sustaining technology transfer between diversified sectors	#7	technological /economic impact
DesFromIdeasToMarket 5 keywords	Design methodologies, Distributed production, Entrepreneurship, ICT, Specific from project	• Enhancing the impact and the quality of design education with new forms of innovative teaching methods	#2	scientific impact
		• Raising learning-by-doing knowledge and improving the technical reputation of the research group	#3	
		• Increase awareness and innovation capacity of SMEs in a technological and socio-cultural innovation	#6	societal impact

PR	CLUSTERS	IMPACT	ImP	ImCat
		space • Empowering design-related making culture for an advancement of digital fabrication knowledge • Strengthening the perception of the importance of digital fabrication for production to a broad audience		
		• Demonstrating the strategic value of digital fabrication for SMEs growth in terms of innovation capabilities	#7	technological /economic impact
DDMP 7 keywords	Distributed production	• Creating knowledge and clarifying the definition of distributed design	#1	scientific impact
		• Expanding the research team and the Fab Lab's internal community	#2	
		• Strengthening the contribution of design and digital fabrication in patient innovation to meet the needs of both patients and caregivers • Reinforcing collaboration between makers/designers and patients/caregivers	#3	
		• Strengthening and spreading the co-creation culture in research and innovation for healthcare solution • Boosting the uptake of co-creation to effectively engage society in science, technology and innovation • Deploying design-related making culture for the advancement of digital fabrication knowledge and open and distributed design possibilities • Building awareness in patient innovation through design and digital fabrication adoption • Strengthening the importance of the distributed design innovative solutions created, to a broad audience • Reinforcing and improving the reputation of the research group in the field of innovation through design driven digital production	#6	societal impact
		• Informing and nurturing the development and transferability of innovative solutions by overcoming geographical and know-how limitations • Strengthening the footprint of the European Fab Labs network in direct and distributed manufacturing	#7	technological /economic impact
		• Fostering the development of a design-led innovation strategy through the use of digital fabrication	#9	
Includi.Mi 5 keywords	Entrepreneurship, Public sector, Public spaces, Social innovation	• Fostering the proposal, advocacy, and experimentation of a pragmatic policy making model, and implementing a new model of policy making • Deepening and expanding knowledge on the theme "Design for Policy" and policies for Social Innovation in urban contexts	#1	scientific impact

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Expanding the research team and subsequently attracting a Ph.D student	#2	
		• Raising transdisciplinary knowledge and improving the reputation of the research group at the national level • Promoting and sharing "Design for Policy" for academic research	#3	
		• Strengthening of social innovation policies, linked to civil servants for an improvement of the local social innovation ecosystem • Understanding better the barriers in PA procedures to support social innovation • Aligning better policy priorities to the real needs of the local social innovation ecosystem.	#4	societal impact
		• Strengthening the perception of the importance of social entrepreneurship for the management of public assets and the provision of social services • Strengthening social innovation among the different subjects involved, for better inclusion of various competences	#6	
NESTORE 5 keywords	Design methodologies, Health, ICT	• Increasing knowledge of healthy ageing design-based solutions in diverse European contexts	#1	scientific impact
		• Expanding the research group • Reinforcing and improving the reputation of the research group in the field of innovation through design driven digital production	#2	
		• Better understanding of co-design processes for developing strategies, methods and tools to better support the healthy ageing • Better understanding of strategies, methods, and tools to measure usability, acceptance and user experience of ICT solutions for the elderly	#3	
		• Improving the development of strategies and methods to manage personal data in research and innovation processes, that complies with the GDPR • Fostering the development of a design-led innovation strategy for promoting and supporting healthy lifestyle	#5	societal impact
		• Knowledge sharing/transfer and increased exchanges among those who are active in PM-15 projects • Better understanding of social determinants, factors and conditions • Spreading the culture of co-design and bridge the gap between ideation and implementation of ICT solutions for elderly • Guidance to promote healthy ageing through multi-domains coaching activities and ICT solutions	#6	

PR	CLUSTERS	IMPACT	ImP	ImCat
		• Implementing ICT innovative solutions for elderly, through co-design actions, for new possible application	#7	technological /economic impact
		• Improving the approach and the strategies to promote healthy ageing across a wide range of population	#9	

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Annex II.
Projects' impact pathway sheets

The contents of Annex II can be downloaded from the link:
https://series.francoangeli.it/index.php/oa/catalog/book/888.

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Authors

Francesca Rizzo (editor), Ph.D. in Electronics and Telecommunications Engineering, is Professor at Politecnico di Milano, Department of Design where she serves as delegate of Director for the research activity. She is expert in Participatory Design (PD) applied to the fields of service design, social innovation, and public sector innovation. She has been actively working as researcher for various EU projects in the FP7 programme and in H2020 (Peripheria, My Neighborhood, Smart Campus, Life 2.0, SIC, SISCODE, easyRights, NetZeroCities). She will serve as coordinator of ORBIS under HEurope (2023-2026). She is author of many publications in journals and conference.

Patrizia Bolzan, Ph.D. in Design, is Researcher at the Department of Design of Politecnico di Milano. She investigates the ratio between digital fabrication, with particular attention on additive manufacturing technologies, and Design in practices and processes. She deals with circularity in product system design and technological integration in prototypes. She has participated in several research projects, and she is the coordinator of De-Forma (Design Explorations on Biofabricated Organic Materials) project, funded by the Department of Design, with the basic research grant. Since 2015 she has been on the permanent staff of Polifactory, interdepartmental makerspace and FabLab).

Alessandro Deserti is Professor in Design at the Politecnico di Milano, where he is currently leading the Department of Design. His main research lines deal with design-enabled innovation processes, methods and tools and ways in which they combine with systemic and organization change. He investigated the application of design methods and tools in diverse contexts, such as human smart cites, social innovation, responsible research, and in-

novation (RRI), public sector innovation (PSI), business model innovation. He has been actively working as researcher for various EU projects in the FP7 and in H2020. He is currently involved in DESIRE a HEurope project demonstrator for the New European Bauhaus initiative. He is author of many publications in journals and conference.

Annalinda De Rosa is Post-doc Research Fellow at the Department of Design of Politecnico di Milano; adjunct professor at the School of Design, and the MSc Innovation and Technology Management of Università Cattolica del Sacro Cuore. Her research concerns the relationship between spatial and service design, specifically focusing on design-driven models for incubating innovative processes for the CCS to improve social cohesion through participatory design in urban and rural areas. Member of the Polimi DESIS Lab within the international DESIS Network (Design for Social Innovation and Sustainability). She is the project manager of Human Cities/Smoties – Creative works with small and remote places research project (Creative Europe program).

Venere Ferraro, Ph.D. in Design, is an Associate Professor at the Department of Design of the Politecnico di Milano. She participated in several International and National research; she has been the coordinator of the research project "POD" (SAFERA 2014 joint call) and the European research project "DATEMATS" (KA2-2018). What characterizes her research is human-centred design. The research interests lie in the domain of interaction design, more in detail: the role of wearable technologies, emerging materials, and big data in designing experiential systems for digital care, with particular attention to tools and methods for changing user behaviour.

Ilaria Mariani, Ph.D. in Design, is Researcher at Politecnico di Milano, Department of Design, where she is part of the team supporting the research activity. Her research interests are at the intersection of interaction, communication, and service design. Her research addresses games and complex interactive systems for communication and speculation, social change and innovation, focusing on comprehending their impact on users. In recent years she moved her focus to digital transformation and design-led innovation in the public sector. She actively participates in various research projects on these topics, such as the H2020 SISCODE and easyRights, the CEF AI4GOV, the ESPON Digiser, and the HEU ORBIS.

Marzia Mortati, Ph.D., is Associate Professor in Service Design at the Department of Design of Politecnico di Milano. She is Vice-Director of the

International Master in AI for Public Services and one of the executive directors of the European Academy of Design. Her research focuses on the design process, service design, public sector innovation, and new technologies. She has worked on numerous international research projects and has authored several articles in international scientific journals (i.e., Design Issues, Technovation, Design Management Review, The Design Journal, Policy Science, International Journal of Entrepreneurial Research and Behaviour) and conferences since 2008.

Xue Pei is a Post-doc Research Fellow at the Department of Design of Politecnico di Milano, where she obtained her Ph.D. in design management. Her research and design practices focus on applying design (thinking) approach, methods, and tools to foster innovation in organisations in both private and non-profit sectors. She has developed expertise in design research, strategic scenario building, and service system design. She has participated in a number of European and national research projects (Horizon 2020, Interreg, Fondazione Cariplo), and co-led several strategic and service design research projects with private funding. She also conducts didactic activities in public universities and private institutions.

Davide Spallazzo has a Ph.D. in Design and is an Associate professor at the Department of Design of Politecnico di Milano. His research sets in the interaction design field, particularly in UX, aesthetics, and meaning-making. He has been coordinating research projects in the field of cultural heritage and serious gaming. In recent years he moved his attention to the intersection of AI and Design, coordinating the Meet-AI research project aimed at eliciting the design qualities of AI-infused products and defining a new UX assessment method. He is currently serving as deputy coordinator of the Ph.D. program in Design and as secretary of the MSc in Digital & Interaction Design at Politecnico di Milano.

Which are the main research funds currently accessed by the Department of Design? What are the topics explored through them and which are the interconnections with the Department core research activities? Also, what are the research products delivered, the reached outcomes, and the expected impacts BY these research projects?

The book synthesises the results of a qualitative analysis conducted over 32 research (out of 96) projects coordinated or participated in by the researchers of the Department in the timeframe 2014-mid 2021.

The results of the analysis confirm the high-level attractiveness of the Department research profile on core topics such as design methodology, service design, and health.

However, more interestingly, the analysis shows a significant variety of new topics and themes that emerge as new research questions for the Department, such as the role of design in public sector innovation, ethics, or policy design.

The publication provides a snapshot of the topics addressed through the competitive research projects, the dimension of such strands of investigations, the typology and features of results achieved, as well as their relationship to the Department's basic research lines.

The relationship and interplay among the outputs, outcomes, and impacts of the funded research is then elaborated in impact pathways, opening up reflections about the upcoming and future of Design research. The findings of the analysis aim to capture the present to understand future directions in terms of scientific, societal, technological and economic aspects.

The volume addresses an academic audience from long terms researchers the field of design and other closely related scientific-disciplinary fields at the national and international levels, to young researchers approaching the world of design research.

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