

MECHANICAL ENGINEERING / PHYSICS /  
PRESERVATION OF THE ARCHITECTURAL  
HERITAGE / STRUCTURAL, SEISMIC AND  
GEOTECHNICAL ENGINEERING / URBAN  
PLANNING, DESIGN AND POLICY / AEROSPACE  
ENGINEERING / ARCHITECTURE, BUILT  
ENVIRONMENT AND CONSTRUCTION  
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CHEMICAL ENGINEERING / INFORMATION  
TECHNOLOGY / **MANAGEMENT ENGINEERING** /  
MATERIALS ENGINEERING / MATHEMATICAL  
MODELS AND METHODS IN ENGINEERING

# DOCTORAL PROGRAM IN MANAGEMENT ENGINEERING

Dean

Prof. Michela Arnaboldi

## INTRODUCTION

The Doctoral Program in Management Engineering (DRIG) offers students advanced training and preparation to conduct research in the field of management, economics and industrial engineering. It aims at training professionals who are able to carry out high-quality research in the fields of management, economics and industrial engineering at universities or other research institutions. Ph.D. graduates from DRIG are also well equipped with distinctive skills and advanced knowledge to pursue a professional career in manufacturing and service companies, regulatory authorities and other public bodies. The program allows the student to develop a sound methodological background and multidisciplinary knowledge by attending courses designed to provide a multiplicity of visions, theories and approaches, a broad cultural panorama. The program emphasizes the benefit of studying problems in an innovative manner, combining various analytical approaches and research methodologies.

The commitment of the Department of Management, Economics and Industrial Engineering (DIG) to research and scientific cooperation with other academic institutions, major industrial companies and other organisations results into an ideal environment in which for students to acquire leading-edge knowledge and cultivate their own research interests in a broad range of research subjects.

## PH.D. PROGRAM STRUCTURE AND CONTENTS

The Full Time doctoral program covers three years, whereas the Executive Program lasts four years. They are entirely taught in English.

The Faculty of DRIG includes, in addition to professors of the Department of Management, Economics and Industrial Engineering, several international scholars: Rodney Turner, Editor of the International Journal of Project Management; Mike Wright, Imperial College London, UK; Irvine Lapsley, University of Edinburgh, UK; Hans De Bruijn, Delft University of Technology, The Netherlands; Abraham B. Rami Shani, California Polytechnic University, USA; Christopher Worley, University of Southern California, USA; David Coghlan, Trinity College Dublin, Ireland; Donald Huisingsh, University of Tennessee, USA; Tobias Kretschmer, Ludwig-Maximilians-Universität München, Germany.

The program covers three main types of training activities.

## Main courses

Mandatory courses in Literature Review and Academic Publishing.

Methodological courses, addressing specific research methodologies and related skills relevant to research in management, economics and industrial engineering;

Thematic courses, aiming at introducing students to the reference theoretical background and the cutting edge research in specific disciplines, such as Entrepreneurship and Entrepreneurial Finance, Innovation Economics and Management, Supply Chain Management, Organisational Theory and Design, Service

Operations Management, Enterprise and Operations Risk Management, Sustainability and Social Challenges in Industrial Systems.

## Elective courses and training on specific themes

Elective training activities are customised according to the specific needs and research interests of students. The aim is to strengthen the scientific knowledge of students in very specific topics and to introduce them to the international research community through their active participation to international scientific conferences and PhD schools.

## Thesis

The aim of the Ph.D. programs at Politecnico di Milano is to instil in candidates a research-oriented mind-set, along with expertise and skills relating to a specific research topic. To develop a research-oriented mentality, candidates must acquire the ability to solve complex problems, including a thorough analysis of the problem, identification of an original solution and the ability to evaluate the solution and its applicability in given contexts. Ph.D. s who possess these abilities will have greater opportunities for advancement in research positions, both in the academic environment as well as in public and private organisations.

The main goal is the development of an original research contribution. The Ph.D. thesis should help increase knowledge in the applicant's research field. It also needs to be consistent with the research topics studied at the Department. The final thesis can be submitted in the form of either a monograph or an edited compilation of papers. The research projects presented in the following section are typical examples of the research work carried out by DRIG students.

## SCIENTIFIC AND INDUSTRIAL COLLABORATIONS

Students are required to spend at least one semester in a foreign research institution. In addition, students are encouraged to attend doctoral schools and workshops organized by other institutions and to participate in international scientific conferences. The presentation of an original research work in an international conference is mandatory for admission to the final exam. To his end, students are granted of a personal research budget, covering a three years research period, and have access to mobility support measures aimed at promoting international collaborations between the doctoral programs in Europe and overseas.

In addition, Double Degree agreements are in place at the Ph.D. level:

- Double Degree Programme with the Pontificia Universidad Católica de Valparaíso (Chile), Escuela de Ingeniería Industrial, Doctorado en Ingeniería Industrial.
- Double Degree Programme with the Copenhagen Business School (CBS, Denmark), PhD School in Economics and Management.
- Double Degree Programme with the University of Reading, Henley Business School (United Kingdom), PhD in Management.
- Double Degree Programme with the National Research University Higher School of Economics in Moscow (Russia).
- Double Degree Programme with TuDelft (The Netherlands).
- Double Degree Programme with Universidad Politécnica de Madrid – UPM (Spain)

DRIG has also developed several research collaborations with private manufacturing and service firms, regulatory bodies, and other public research institutions to fund PhD oriented research. In recent years, the following organisations supported DRIG Scholarships: Value Partners, TXT e-solutions, IBM, Siemens, Telecom Italia, Windesheim University of Applied Sciences, Fondazione Brescia Musei,

## PROFESSIONAL OPPORTUNITIES AND THE JOB MARKET

Typical career opportunities opened up by the doctoral program include:

- Post Docs, research fellows and young lecturers at Italian and foreign universities;
- Researchers and scholars in Management Engineering at public and private organisations;
- Highly qualified personnel at research and training

institutions, or at technology transfer centres in Italy and abroad;

- Professionals at leading management and strategic consulting firms who can provide deep and advanced insights into companies' business areas;
- High-level professional roles at national and international public institutions;
- Managerial roles at multinational companies with a strong focus on innovation;
- Entrepreneurs in contexts characterised by a high level of innovation.

Support actions for placement are provided with the purpose of sharing experiences, services and information through a number of initiatives fitting the different types of career opportunities. Particular emphasis is given to career development in the Management Engineering area.

# COMBINING DIFFERENT ARTIFICIAL INTELLIGENCE TECHNIQUES FOR MULTIMODAL SENTIMENT AND EMOTION RECOGNITION

Keith April Araño - Supervisors: Carlo Vercellis, Carlotta Orsenigo

## 1. Research problem and motivation

The recent advances in deep learning, hardware, and data collection have led to the development of numerous intelligent systems that are capable of automatically recognizing human sentiments and emotions. Although significant progress has been made in the field of Affective Computing, sentiment analysis and emotion recognition remain to be challenging tasks. In particular, the research community and practitioners continue to face challenges related to the complexity of processing a plethora of data in various multimodal forms such as text, audio, visual and more recently, physiological data. The main open challenges in Sentiment Analysis and Emotion Recognition are primarily aimed at improving the robustness of the prediction models by finding effective features and training machine learning models that can generalize well in various real-world applications. These tasks continue to be a difficult undertaking. Moreover, most of the widely used classification algorithms in this field heavily rely on highly scarce labeled datasets that often incur significant amount of investments to build in terms of cost, time, and human resources. Motivated by these open challenges within the research community and by the ever-increasing demand for commercial applications in the industry, the main overarching

goal of this research is to gain an understanding of the use of multimodal data and various machine learning approaches to affect prediction tasks. There are key areas that drive the success of affect recognition systems: dataset, feature processing, and classification algorithms. These core areas are addressed in this research by finding the modality, feature processing methods, and classification algorithms that can perform well in different application areas.

## 2. Research methodology

The manuscript is a consolidated PhD thesis by papers, consisting of four original papers. The four manuscripts differ in certain experimental details. However, the following methodological choices apply across all papers.

**Classification Task:** Two main affect recognition tasks are addressed: sentiment analysis and emotion recognition. In the special case of Papers 1 and 2 however, mood prediction was also performed.

**Dataset:** For the papers that required the use of benchmark datasets, the selection of datasets for the empirical experiments was primarily motivated by the size, sentiment/emotion labels, accessibility, and their popularity among the research community. These criteria ensure that comprehensive experiments can be easily carried out and that results can be replicated

and compared with other existing approaches in the literature.

### Training, Validation, and Test

**Protocol:** The dataset is split into a training, validation, and test set. The published results are taken from the prediction performance on the test set.

**Performance Metric:** Prediction performances were primarily measured in terms of accuracy, but other metrics are also used, contingent upon the nature of the dataset and the paper's objectives. Regardless of the metric that was used, the imbalances among the classes were taken into account.

## 3. Research contributions

The main contributions of this thesis are formalized in a collection of four papers.

**Paper 1:** The main objective of this paper is to investigate the effectiveness of a smartwatch-based system to collect labeled data and to use machine learning approaches to predict certain mood variables that are relevant in a classroom lecture setting.

**Paper 2:** The main goal of this paper is to demonstrate the effective use of a smartwatch-based system to track and predict the affect of actors and audience in a theater play using machine learning methods. Physiological, environmental, visual, and audio data from both the actors and the audience were collected during a theater performance and machine learning models were

trained to make mood and emotion predictions.

**Paper 3:** This paper primarily aims to investigate a new features processing approach to classify emotions from speech signals. Empirical experiments were carried out by combining conventional MFCCs with image features extracted by a pre-trained CNN from spectrograms, along with two classification algorithms (i.e. SVM and LSTM).

**Paper 4:** The main goal of this paper is to demonstrate the effectiveness of a novel method which introduces hyperbolic layers in a neural network for the tasks of sentiment analysis and emotion recognition from audio, text, and visual data. Two sets of experiments were carried out to (1) analyse at what extent introducing a hyperbolic structure in the network architecture is beneficial in terms of classification accuracy and to (2) investigate the performance of different combinations of hyperbolic and Euclidean layers.

## 4. Conclusions and implications for theory and practice

The availability of a large enough dataset to train robust prediction models is fundamental when building affect recognition systems. While in most cases the research community relies on publicly available labeled datasets, this work demonstrates that sensor technologies can be leveraged to automatically collect labeled data

that can be tailored to almost any application. The implications of this novel data collection approach are two-fold: on one hand it addresses the problem of the lack of labeled data and on the other hand, it solves the problem of domain adaptation and model generalizability since the approach can be customized according to the targeted application area. These translate to savings in terms of cost, time, and human resources since traditional methods of labeling datasets often incur significant amount of investments to build.

While most prior studies on multimodal affect recognition have focused on elaborate features fusion approaches, this work demonstrates that a straightforward concatenation of features also results in competitive prediction performance. Such insight is useful for practitioners when it comes to building affect recognition systems in which computational cost is a critical performance metric. It can also be concluded that when multiple modalities are involved, instead of fusing the features together, analyzing them individually can be useful to gain insights on the roles of each modality. So, while in theory fusing as many modalities as possible to enhance performance is deemed favorable, when it comes to commercial applications, models that can adapt to whichever modality is available are more useful. These findings are useful

for real-world applications where not all forms of modality are available such as speech-based virtual assistants. While most of the current approaches applied in affect recognition tasks are focused on building sophisticated deep neural network architectures which often suffer from an exponentially increasing computational cost, this work demonstrates that classical methods can yield superior performances over more complex techniques. So, while it is imperative to have accurate prediction systems, computational complexity is equally important especially in commercial applications where speed is essential. Hence, when building machine learning models, emphasis should be placed on the appropriate performance metrics. In applications where computational complexity is a critical measure, the practical implications of the proposed hyperbolic models which provide competitive results in smaller dimensions are twofold. First, accurate but less complex hyperbolic models can potentially speed up the life cycle of building machine learning systems and enable faster deployment to production. Second, less computationally intensive and less parameterized models can enhance the scalability of machine learning systems.

# SERVICE INNOVATION OF MEANING: A RESOURCE INTEGRATION PERSPECTIVE

Federico Artusi

The innovation of meaning framework has been conceptualized in the early 2000s' to grasp the way companies can propose new meanings through their offerings. The innovation of meaning aims at soliciting "profound changes in sociocultural regimes in the same way as radical technological innovations, which solicit profound changes in technological regimes" (Verganti, 2009, p: 441), to provide people with a new "reason why" for using a product/service (Verganti, 2017). Thus, innovation of meaning is radical in nature, and it is based on the ability to envision how society is changing to envision new meanings. Being rooted in the product-oriented literature, the innovation of meaning framework has been developed following the new product development and design fields. The implementation of a new meaning has been described in the literature as based on the product language, the physical and tangible characteristics (shape, form, color) that constitute a good (Brunner et al., 2016; Cautela et al., 2018). However, the same doesn't apply to services, characterized by being intangible (Zeithaml et al., 2006), and require the meaning to be communicated in different ways. Moreover, meaning-making activities have a heterogeneous and individual nature (Kazmierczak, 2003). Indeed, the interpretation of meaning is characterized by a certain degree of individual freedom that

is only partially mediated by culture (McCraken, 1986).

In the thesis, I leverage the dominant paradigm in the service literature, the service-dominant logic (Vargo and Lusch, 2004; 2008), to explore applying the innovation of meaning framework to a service domain. Thus, I defined the following main research question:

- How can companies develop an innovation of meaning into new service solutions?

To address such a broad research question, I adopted a service-dominant perspective on innovation of meaning to develop it into four sub-research questions further:

- How can the innovation of meaning framework be refined through the application of a service-dominant logic perspective?
- How can the service concept be shaped to effectively embody new meaning in a new service?
- How can front-line employees be engaged and contribute to implement a new vision into new service solutions?
- How can companies convey an innovation of meaning through business model design?

To study the phenomenon under the different perspectives identified, I leveraged various methodologies, both qualitative and quantitative.

The first paper of the thesis is a conceptual article that draws on a systematic literature review.

The second paper is based on a laboratory experiment, while the third and fourth papers leverage case studies. Moreover, I built case studies combining different methods, like interviews, ethnography, topic modeling on customer reviews. This allowed me to generate a broad range of findings and analyze the topic under investigation from different angles.

The first article is a conceptual paper that aims at pushing the innovation of meaning framework (Verganti, 2017) toward its application to a service domain. Leveraging the service-dominant logic, I conceptualize the innovation of meaning framework as a sum of resource integration activities aimed at proposing a new meaning to customers, who will interpret and co-create it during the customer experience. This allowed me to define a research agenda for the development of the innovation of meaning framework following the SDL principles, identifying four main avenues for future research:

- Co-creation of meanings: detailing the micro-processes intervening at the experience level that determines the meaning perceived by customers.
- Resource integration for the innovation of meaning process: understanding how companies

and customers may integrate resources to guide meaning co-creation.

- Meanings and institutions: investigating the link between the (co)creation of new meaning and the evolution of market institutions.
- Meaning and value: characterizing and explaining the difference between value and meaning.

The thesis focuses on the second research direction.

The second article starts tackling the resource integration perspective for the innovation of meaning by investigating how the service concept should be shaped to allow effective transmission of the new meaning downstream.

In the article, I design a new concepting technique, named "Moment of meaning," which is specifically designed for the innovation of meaning framework. The moment of meaning is based on the micro-design of one single moment, or interaction, in the service experience that brings the new meaning to the customers, to be interpreted and perceived. The moment of meaning is then tested against the customer journey mapping for the performances of alignment of the development team and scalability of the concept. The experiment confirmed my hypotheses: the moment of meaning is a tool that can synthesize the descriptive function of more detailed tools with the representational purpose of more abstract strategic tools used in the definition of a new meaning, such as metaphors. Doing so allows switching from the strategic to the development phases of the innovation, keeping teams aligned over the meaning, and

facilitating its proposal to the final customers.

The third article analyzes human resources' role in designing the new service and bringing new meaning to customers. The issue identified is twofold: on one side, understanding how to engage the front-line employees in the process, assuring they understand and share the new meaning; On another side, preventing the innovation from only being incremental and enabling a radical change in the service designed. The article is based on a single, in-depth case study of a leading Italian network of pharmacies. The findings show that the process of engagement and development of new practices is initially triggered by the company management, who is in charge of defining a sharing the new vision or meaning. If the new vision is aligned with the organizational values, the rest of the process happens without the direct involvement of managers. Front-line employees started to autonomously gather to discuss the new meaning, develop new practices based on that, and test them into the stores. The process naturally unfolded and allowed to develop, test, and scale up new practices as an accumulation of more minor innovations. Managers were involved in monitoring the process and the freezing of the most interesting practices to be scaled up over the whole network. The last empirical paper addresses the configuration of a service's architectural elements (store layout, customer experience offered) to understand how they can be shaped to facilitate the proposition of a new meaning to customers. The findings show that the service front-end plays a key role in guiding

the meaning perception by customers. Companies need to design the different business model dimensions to operationalize a meaning. The way the service architecture is shaped is based on the translation made from the intended to the constructed meaning and influences the translation, which brings to the re-constructed (perceived) meaning. Using a service-dominant logic perspective, how the architectural resources are configured leads to a different way of meaning co-creation between the company and customers. By combining the findings, my thesis is a first conceptualization of the more downstream phases in the innovation of meaning process, which were previously neglected in the literature (Eling and Herstatt, 2017). Moreover, this is the first work exploring the innovation of meaning in a service domain, aligning to the dominant thinking in the service literature (Vargo and Lush, 2008). This, in turn, allows solving the contrast between the inside-out generation of new meaning (Verganti, 2009) and the fact that meaning is partly individual (Kurzman, 2008) and phenomenological (McCraken, 1986). On a practical side, this work generates actionable knowledge to manage the innovation of meaning processes. The conceptualization of new tools and processes to implement the meaning into a service solution is of fundamental importance for companies aiming to pursue the process..

## PAIRS IN INNOVATION: WHEN SENSEMAKING HAPPEN IN THE INTIMACY OF TWO INNOVATORS

Paola Bellis - Supervisor: Roberto Verganti

Why do significant innovations that have changed our life in significant ways get initiated and developed by pairs of individuals? Jobs and Wozniak for the personal computer, Ek and Lorentzon for Spotify, Page, and Brin for Google are only a portion of the pairs who developed some of our times' greatest innovations. Not by chance, in recent years, scholars highlight how not only pairs but also other small-scale forms of organization such as radical and collaborative circles represent suitable units for the maturation of meaningful innovation. Traditionally, cross-functional teams have been considered the primary organizational form for envisioning and developing innovation. For a long time, teams have been promoted as enablers for combining different competencies, resources, technical skills, perspectives, and ideas. Still, phenomena such as one of the pairs seem to suggest that in a fast-changing world, completed overwhelmed by ideas and opportunities, the development of meaningful innovation relies not only on the exchange of competencies and resources. In a way, it also requires time, immersion, and reflection. Moreover, perspectives, cultures, and mental frames enter into play. Somehow, the development of innovation can also be considered a collaborative sensemaking process, which requires interdependence

and creative abrasion that mediates the transformation of individual knowledge into collective knowledge. Scholars found how such aspects of the innovation process unfold when collaborating in small numbers, such as the pairs. Therefore, by leveraging the theories of sensemaking, the present thesis explores the dynamics and relational traits that characterize collaboration in innovation when it unfolds in the simplest constellation possible: the pair. Specifically, the thesis investigates how sensemaking unfolds when collaborating in two towards developing meaningful innovation focusing on three key aspects. First, it examines whether the pair effectively outperforms larger teams when dealing with collaborative sensemaking processes in innovation. It emerges how the delicate intersubjective process of meaning creation benefits from the intimate space provided by the pair, where a comfortable environment for the disclosure of tacit knowledge is provided. In a way, individuals are more open in listening to one another and open to creative abrasion, which mediates the transformation of individual knowledge into collective knowledge, leading to a meaningful outcome. In addition, even when pairs merge into teams after pair working the perception of meaningfulness was shown to be higher for teams where

people previous collaborated in pair rather than in teams directly formed. Second, the thesis deepens the concept of intimacy as a central characteristic of both pairs' collaboration and effective collaborative sensemaking. By leveraging on real exemplar cases the thesis proposes a theoretical model that looks at the pair as the third space for innovation. As single individuals act, on one side, as the bearers of breakthrough ideas and teams act, on the other side, as bearers of resources and competences, the study proposes that the pair acts as a third space that bears a safe and intimate space of reflection. This space is tapped only occasionally throughout the project, but these occasional moments are crucial for moving innovation further. Therefore, the pair results as the beaten heart of innovation, providing a safe and intimate space of reflection while facing the hurdles required by innovation. The study concludes that at the core of innovation projects may lie an "intimate space" where two key players perform breakthrough collaborative sensemaking that they could not perform in front of larger audiences. Within the boundary of the space, they find the courage to sharing unorthodox and blasphemous directions; nurture a dynamic of creative abrasion and critical reflection; find the resilience to overcome the

inevitable implementation failures and discouragements of complex transformation projects. Finally, the thesis explores the dynamics that lead two individuals to the development of innovative outcomes. Through content analysis of pair's work, it has been possible to unveil how a pair can lead to innovative outcomes both when the final results come from both the individuals involved and both when it is driven mainly by one of two. More importantly, the thesis found how what ultimately leads to innovation is the ability of individuals to leave their own beliefs and ideas in favour of a reframed and more robust one. Finally, this last study shows how such dynamics are not so evident when considering larger forms of collaboration, where people tend to be rigid in their position. The thesis aims to contribute both to theory and practice, suggesting avenues for further research and possible areas of interest to practitioners. From a theoretical perspective, the thesis seeks to contribute to the literature of innovation from the standpoint of sensemaking. Indeed, in a world that is rapidly changing, innovation is not more seen only as a set of activities or competencies to be managed, but as a process where people as humans play an essential role. It implies that, on top of competences and skills, emotions, values, and perspectives

are playing their part in the envisioning and shaping of innovative scenarios. To understand how to deal with these emerging factors is essential not only for the theory of innovation but also for companies and managers. The paradigms of sensemaking provide a stimulating perspective to deal with these topics and look at people dynamics in a context of innovation. Also, the study of such dynamics by focusing on pairs enriches the literature related to collaboration in innovation by showing how the pair might be a proper organizational form to nurture innovation. Somehow, within complex organizational settings, working in pair promotes moments of intimate reflection that facilitate people to embrace more meaningful direction to be pursued in the innovation journey. Besides, the thesis aims to explain which are the dynamics that take place when two individuals collaborate and how they reach the proper intimacy for innovation. In this way, the thesis aims to contribute to making light on the underestimated phenomenon of duos in innovation. From a managerial perspective, this thesis aims to support managers to provide a better understanding of how people embrace innovation challenges and make sense of them. Indeed, sensemaking is a micro-mechanism that produces macro-changes over time. To be aware of those micro-mechanisms can help

managers and companies to better support people in embracing the change and make the path toward innovation a little bit softer but, at the same time valuable for the company. Besides, this thesis aims to contribute by making light on a micro phenomenon, pairs collaboration, which can bring significant impact within an organization when dealing with innovation. Thesis's findings suggest how the pair may outperform both individuals and larger teams when dealing with innovation, debunking the myth of numerous cross-functional teams for innovative outcomes. More precisely, the thesis advises managers to leverage actively on pair collaboration when asking people to collaborate in innovation initiatives. Despite the advantages which accrue when collaborating in two for innovation purposes do not come without a price: dyad combination's results in a loss of available cognitive diversity, which can lead to uniformity of thoughts, and collaborative fixation. Still, this thesis suggests that the elsewhere reported performances and features of dyads might largely overcome this loss, which is more than compensated by the synergies previously mentioned.



# EVALUATING THE IMPACT OF HIGHER EDUCATION SYSTEMS ON REGIONAL ECONOMIC DEVELOPMENT

Alice Bertoletti – Supervisor: Tommaso Agasisti

During the last decades, higher education (HE) has significantly expanded, both in terms of broader access and in terms of a wider differentiation of HE institutions. This process has led to the achievement of a mass higher education, which nowadays represents a core feature of society. This remarkable expansion is the result of a common policy view that higher education is a instrument to foster better social and economic outcomes. Indeed, higher education is expected to foster local and regional development by means of several channels. On one hand, universities generate high-qualified human capital, offering students the most adequate skills to compete in today global economy; on the other, academic research and third-mission activities drive innovation processes, sparking knowledge spillovers. Led by this common expectation, governments have undertaken significant public investments to support universities, aiming at enhancing participation in higher education. However, despite the centrality of the issue, the specific role of universities in contributing to economic development is still scarcely investigated in the literature. The dissertation addresses this topic by providing a comprehensive evaluation of the contribution of higher education systems (HESs) to the economic development of European regions. Following this

objective, the three papers of the thesis generate original evidence to innovate the literature in the field, which provides still fragmented results on the local economic contribution of higher education systems. In detail, the available papers tend to focus on one-country data, while the few cross-country analyses take into account only a reduced number of HES dimensions – mainly limited to the presence of universities or the number of students. In this sense, it emerges the lack of a sound framework to fully model HESs and their features. A further critical aspect concerns the way through which the relationships between HESs and regional economic development are modelled. On one hand, it is important to take into account the mechanisms through which different outputs of education can enhance the local economy. On the other, the empirical analyses in the literature could be too restrictive in forcing a linear relationship between HESs and regional economic development. Indeed, there is no strong a priori reasons to force a linear dependence between education and economic performance, and this assumption could not fit the high complexity of HESs - which are made of several dimensions strongly correlated with each other. All three papers in the collection bring new evidence to overcome these

limitations. In Paper 1, I provided a framework modelling HESs, their performance (i.e. teaching, research, and third mission performance) and the factors influencing them. The framework has been tested empirically by examining data on 29 European countries and employing a Structural Equation Modelling approach. In this way, the paper contributes significantly to the literature that offers only a fragmented representation of HESs and their performance. The framework of factors and HES indicators provided in the article also represents important insight for Paper 2 and Paper 3, which rely on this evidence to model the interactions between HESs and regional economy. In Paper 2, I analysed the effects of HES performance on the growth in the GDP per capita of 284 European (NUTS-2) regions, in a time-span of 18 years. The causal impacts have been estimated by employing the Generalised Method of Moments, which allows controlling for the endogeneity of the regressors. The findings shed light on the relevance of the mechanisms through which higher education systems can enhance local economic growth. In detail, the “innovation channel” emerges as the preferred way to contribute to the local economy, fostered by research performance and subject specialisation into the STEM field of universities.

Lastly, in Paper 3, I focused on the role of heterogeneity of HESs in influencing the regional economic development of regions. With this aim, the research examines the relationships between a comprehensive set of HES features (i.e. 16 indicators) and the level of the GDP per capita in 649 NUTS-3 regions in Europe. As a main element of novelty, the paper employs a novel methodological approach that combines econometric models with machine learning techniques. In detail, the second stage of empirical analyses was based on random forest, which allows detecting nonlinear relationships between the GDP per capita and HESs variables, handling also the presence of many and high-correlated covariates. The findings have revealed the existence of nonlinear relationships between regional GDP per capita and most of the HES indicators, proving the value of using non-parametric techniques in the analyses of economic contributions of HESs. The collection brings major contributions to advance the state-of-art of literature in the field, aiming at offering a comprehensive estimate of the impact of HESs on the economic development of European regions. Indeed, the dissertation pointed out the relevance of fully modelling the complexity of HESs, by using an adequate framework of dimensions and indicators. The

findings presented here show that the mere presence of universities or students in a region cannot explain alone the economic impact of HESs, which is instead closely related to the way through which universities carry out their activities and implement their strategies. These empirical findings ground on the three novel datasets (one for each paper of the collection), which gather data on HES and economic variables at three distinct levels of analysis (country, NUTS 2 and NUTS 3). The datasets are the results of significant efforts in collecting and processing information from several sources and represent, thus, central by-products of the doctoral dissertation. Moreover, the research employs different analytical approaches that range from statistic and econometric techniques. In this sense, the collection advances the knowledge in the field by proposing a novel methodological strategy that introduces the use of machine learning methods in the context of macroeconomic analyses – which are still scarcely employed in this area of studies. Finally, the collection generates useful insights to understand the mechanisms driving the local economic contributions of HESs. These findings can be particularly useful for setting effective policy actions able to promote the economic development of the territory by leveraging on educational systems. In a

broader perspective, the dissertation significantly contributes to the policy debate by informing governments on the most relevant factors of higher education systems influencing local economic development. In this way, the research seeks to offer new instruments for helping policymakers to understand and possibly tackle the causes of interregional economic disparities - which are particularly evident within European countries.

# SHEDDING LIGHT ON LEAN 4.0: EXPLORING THE INTERPLAY BETWEEN LEAN MANAGEMENT AND INDUSTRY 4.0

Fabiana Dafne Cifone – Supervisors: Alberto Portioli Staudacher, Paolo Trucco

Manufacturing world is rapidly changing. From 2011, Industry 4.0 has been absorbed into common speech, referring to a joint implementation of several digital technologies aimed at the creation of an inter-connected and automated factory (Koh et al., 2019). They have rightfully captured the imagination of practitioners and academicians alike how they offer new challenges and opportunities to companies (Benitez et al., 2020). While there is a common agreement on the paramount innovation that they represent in the manufacturing context, so far it is blurred either how companies should effectively implement the aforementioned technologies. However, being digital without continuously improving processes, and hence implementing lean, endangers to result in pure advanced automation, that will digitalise wastes and inefficient processes as well. On the contrary, being lean without exploiting digital technologies is anachronistic, and it risks to jeopardize lean benefits themselves. Here comes the Lean 4.0 paradigm, defined as the joint implementation of lean practices and digital technologies. How to well integrate lean and Industry 4.0? How to create Lean 4.0? Even though there is consensus on Lean 4.0 potentials and it is easy to conceive areas where the interplay between lean and Industry 4.0 is strongly valuable, much of this discourse is conceptual

in nature and lacks any empirical confirmation (Chiarini et al., 2020). While it is obvious that operational performance improvements attributed to Lean 4.0 (Gillani et al., 2020) will bring a strong motivation for both studying and implementing it, we are still far away from the full awareness of what is Lean 4.0. There is also little doubt that digital technologies have much to offer to operations management in the long run, and that their rate of adoption is only going to accelerate further. This PhD thesis takes a step back, aimed at understanding how it is possible to create Lean 4.0, and which are its characteristics, shedding thus light on Lean 4.0. More in detail, this study seeks to understand how digital technologies support lean (RQ1), how lean management influence Industry 4.0 and digital technologies implementation (RQ2), and which application space mostly fits Lean 4.0 (RQ3). Different 'modules' of studies are designed to address systematically each research question. Predominantly multimethod approach is embraced in order to pursue the research objective, with a combination of quantitative and qualitative methods. This PhD thesis contributes one of the first empirical perspectives to the ongoing debate, by identifying and measuring the relative importance how digital technologies will improve manufacturing operations (RQ1).

The exploratory survey confirms the positive effects of Lean 4.0 on operational performance, but it even shows that companies are still not digital mature. This means that this is the right moment to provide companies with guidelines on how successfully embrace Lean 4.0. Whilst coupling lean and Industry 4.0 is generally reasonable, not all digital technologies are adding value equally here. Companies willing to embrace Industry 4.0 to support their lean initiatives should purposively select the digital technologies to strengthen the improvements they are seeking. There are mainly two ways how digital technologies can support lean: *by enhancing operational execution*, and *by improving operational decision-making*. The former includes increased precision and speed in execution, as well as improved flexibility in time and space, while the latter includes enhanced visibility, feedback, engagement and prevention. They are named *digital waste reduction mechanisms*, and are the way through which digital technologies impact on lean or process improvement in general. However, the relative importance of these digital waste reduction mechanisms varies greatly, and this must be considered by companies when deciding which technology might be the right one for the outcome they are willing to achieve. Even though digital waste

reduction mechanisms encourage practitioners in embracing their digital transformation and confirm the wide scope of Industry 4.0 in supporting lean, companies should be aware that each digital technology serves a bespoke set of mechanisms. In this sense, digital transformation should start by considering which is the objective a company is willing to achieve, rather than what is technically feasible. Aligning their desired improvement goals with the mechanisms that each technology enables will result in the greatest success. On the other hand, it is not enough to implement the right technology to achieve a successful Lean 4.0. Companies should consider their own intrinsic characteristics when starting the digital transformation, and being lean beforehand distinctly marks a pattern (RQ2). There are two main digital transformation patterns according to lean maturity, named after the innovation glossary as *sustaining digital transformation pattern*, typical of companies with strong lean and process improvement culture, and *disruptive digital transformation pattern*, typical of companies with lower commitment to lean. The first is characterized by a series of small and incremental digital technologies implementations with short/medium pay-back time. They occur even simultaneously within different departments, enhancing

the collaboration among them. On the other hand, the second digital transformation pattern is characterized by radical digital changes with medium/long pay-back time. Massive investments are designed with complex and integrated plans, usually vertical and specific in the production department. Among other contextual variables already studied by scientific community (Rossini et al., 2019), companies production strategies is a characteristic worthy to be investigated before moving towards Lean 4.0 (RQ3). Considering there is no mystery that traditional lean is more effective in repetitive companies, non-repetitive ones can be prevented to embrace even the new paradigm of Lean 4.0. However, this must not be the case. Any type of company, regardless its production strategy, will benefit from Lean 4.0 from an operational performance point of view. Lean 4.0 is more accessible than traditional lean, even if it is still more likely that repetitive companies achieve better performance improvement. This provides a first sense of effective application space of Lean 4.0, and more importantly remarks the fact that companies should take into strong consideration their own and intrinsic characteristics while starting their digital transformation in order to align their expectation accordingly. These are prime pillars

for the Lean 4.0 success. Not having clear improvement goals in mind and overlooking their intrinsic characteristics as well as their readiness to embrace the change may lead companies to pure digitalization, rather than to Lean 4.0. This is risky: while it may bring benefits in the short term, it will make processes and system more rigid. Even if Industry 4.0 and digital technologies may make companies more efficient, yet this view is too simplistic. An overreliance on digital technologies bears the danger of removing people from processes, which in turn inhibits the kaizen approach so central for lean management. The role of skills, and the potential de-skilling and impediments to process improvement related to Industry 4.0 and digital technologies need to be analysed further. Using digital technologies to substitute for skills may create barriers for workers to act freely, and to be empowered within the process. This is an important area of tension that requires to be deepened in the future.



# PRODUCT TRACEABILITY IN THE PHARMACEUTICAL SECTOR A CONTINGENCY AND MULTI-STAKEHOLDER COLLABORATION APPROACH TO IMPLEMENTATION: THE CASE OF THE EU FALSIFIED MEDICINES DIRECTIVE (FMD)

Marco Farinelli - Supervisor: Federico Caniato

## Research Background and Framework

Medicines falsification is a growing concern on the agenda of governments, regulators/authorities and industry. The World Health Organization (WHO) estimates a market share of up to 1% for falsified medicines in industrialized countries, while the European Commission has estimated that approximately 1.5 million falsified packs make it in the legal supply chain every year. To strengthen anti-counterfeiting measures in the pharmaceutical supply chain, the European Commission has issued new regulations on product traceability known as the Falsified Medicines Directive (FMD), which requires the implementation of product serialisation together with a common European medicines product verification system used by the whole sector and implemented in February 2019 which involves more than 150.000 players in the supply chain (SC).

Such a setting has enabled the conduct of timely and relevant research into a contemporary phenomenon, product traceability implementation, which is the topic of this executive PhD thesis. Based on a systematic literature review, a research framework is developed which relates the benefits of traceability to its successful implementation. Two theoretical

lenses are applied to conduct this research. Through Contingency Theory the implementation of FMD is related to how the players involved respond, through the implementation process, to contingent factors, enablers & barriers, while, applying Stakeholder Theory, the implementation process itself is impacted by the multi-stakeholder collaboration enacted by the working mechanisms of the specific governance structure of FMD, with particular reference to a stakeholder mapping based on power, legitimacy and urgency to characterise each stakeholder and the use of the common stakeholder orientation model based on inclusiveness, authenticity and consequentiality. This is the first research on digital transformation at the level of an entire sector and is also the first to consider

multi-stakeholder collaboration as a key element in the implementation process. The context of study is not limited to single firms or dyadic relationships but it unfolds a the level of meta-organisations, through the active involvement of trade associations in the process, that represent each stakeholder in the collaboration.

## Research Questions and Methodology

This research objectives are investigating which are the key factors impacting the implementation of traceability in such context and the expected benefits and risks, how stakeholders position themselves and respond to these factors during implementation, and how multi-stakeholder collaboration is enacted through governance.

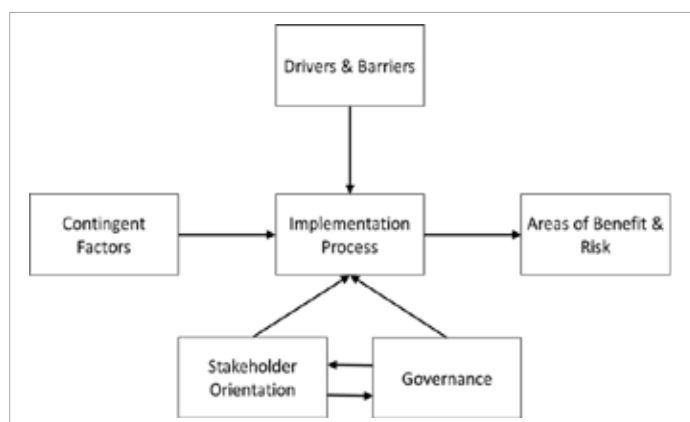


Fig. 1 - Framework of research

The following research questions with reference to the research framework are addressed through the research.

**RQ1:** What are the most important contingent factors, drivers and barriers impacting the traceability system implementation process for each stakeholder in the European pharmaceutical supply chain?

**RQ2:** How are stakeholders influencing the effectiveness of FMD implementation process through their response to the contingent factors and their dynamics of interaction in terms of power, legitimacy and urgency?

**RQ3:** Which are the most impactful factors among inclusiveness, authenticity and consequentiality that influence the creation of a common stakeholder orientation which supports FMD implementation process?

**RQ4:** Which are the benefits, future opportunities and risks expected from the implementation of FMD by the different stakeholders? And how do they relate to a common stakeholder orientation?

**RQ5:** How does a common stakeholder orientation among SC stakeholders at a sector level enable

an effective governance of the FMD implementation process?

In terms of methodology, both a multiple case study, involving three European countries (RQ1-4), and an Insider Action Research (IAR) (RQ5) are performed to answer the research questions arising from the application of the research framework to this new and specific context.

Considering that usually the AR cycle is performed within single organizations, with the aim of understanding how an AR process needs to be run in multi-stakeholder collaboration projects, a sixth research question was developed for this research:

**RQ6:** What adaptations does the traditional AR cycle need, to help develop a common stakeholder orientation during a SC digitalization process at a sector level?

## Key Findings and Implications

The research provides several findings on the key factors impacting the implementation of traceability across an entire sector, such as high customer service levels, regulation, level of visibility, and provides the main areas of response to these

factors by the SC players, such as process re-design, IT integration and visibility improvements. Also the critical role of the new SC stakeholders, legitimised by their role in the governance, is identified and explained as they achieve common stakeholder orientation across the SC stakeholders; furthermore, the elements for ensuring constant stakeholder alignment through the process are discussed in details and operationalised during the research. The research identifies the key benefits from the implementation, such as SC digitalisation, operational efficiency, increased levels of trust, patient safety together with emerging risks such as cybersecurity. Furthermore, this research has developed a revised AR cycle based on elements of stakeholder alignment, identifying new steps needed in the pre-cycle and new mechanisms and roles to iterate action/reflection across the different levels.

Finally this research adds to current knowledge by having extended at a sector level elements of contingency theory and stakeholder theory, having operationalised latest contingency models and contributed to the extant literature through the findings on stakeholder interaction and alignment. It also provides a new approach to improve relational governance, while on practical contribution this study has developed key business processes during the IAR and provides relevant insights to business leaders implementing traceability at sector level.

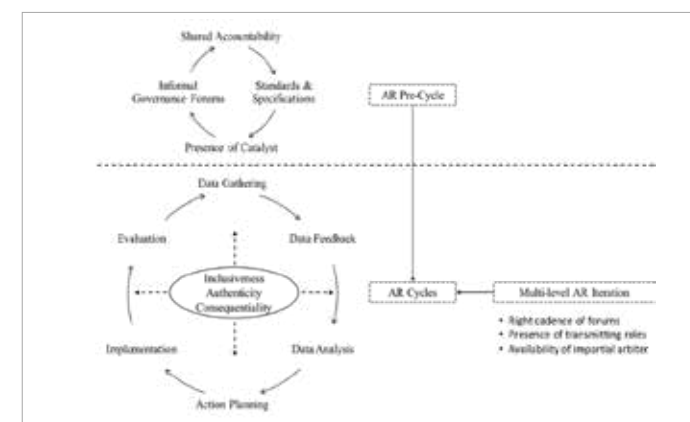


Fig. 2 - Revised AR Cycle

# A FRAMEWORK FOR THE OPTIMIZATION OF THE DIGITAL FLOW IN THE CONSTRUCTION SUPPLY CHAIN

**Alessio Domenico Leto - Supervisor: Mauro Mancini**

**Co-supervisors: Bruno Daniotti, Alberto Pavan, Mattias Roupé**

The interest of academics and practitioners towards the information digitization has largely grown during the last years and meets full implementation in the manufacturing sector. Conversely, in the construction sector the fragmented supply chain characterized by many actors involved in the different project stages entails a slow penetration and dissemination of the information digitization. Even though in recent years new technologies and digital methodologies are spreading also in the construction industry, e.g., Building Information Modelling (BIM), the characteristics of the construction sector require a rethinking of the operating processes to perfectly join the design and execution project stages. Indeed, the only dissemination of new technologies is not satisfactory to increment the productivity, but it is necessary to reconsider the information flow among all the project stakeholders. Consequently, important changes will characterize enterprise organizations from both the strategic and operational point of view through the introduction of appropriate software and hardware, and through staff training efforts. This research is founded on two phases: a preliminary phase based on a qualitative questionnaire and preliminary interviews, and a second phase based on case studies. Indeed, after the collection of the enterprises needs for the information

flow optimisation by means of 35 responses from the questionnaire and from 4 preliminary interviews, another 16 interviews were conducted among 5 contractors to understand what the current internal and external information flow is (RQ1) and what the digital information flow could be for the contractors and their stakeholders in the next future (RQ2). The collection of data has allowed the creation of an optimized supply chain framework based on the principles of industry 4.0. The framework has been validated by one of building contractors interviewed. The research provides several contributions for practitioners and academics. Indeed, the study contributes to the theoretical and practical knowledge by answering the research questions and offering some academic publications. The supply chain framework proposed in this study is based on the use of a Stage 3 BIM platform. The stage 3 BIM platform reaches its objective of an efficient digital information flow if it can manage the correct level of information in accordance with the ISO 19560-1:2018. So, it was needed to define the minimum information to put inside the projects along the various construction phases. Furthermore, a list of essential objects attributes was defined: according to the enterprises interviewed, these attributes must be always present and clearly visible during

the information exchange as a label that characterises the objects. In addition, the platform BIMReL was launched to provide a common data structure on which is possible to define the level of information need. Finally, the research offered a tool for the enterprises associated to the Italian building contractors Association (ANCE) for the evaluation of their digital maturity. This tool allows to identify the enterprise areas that need major investments and suggests some corrective actions to improve the current state of company digitalisation.

# E-SUPPLY CHAIN COLLABORATION: INVESTIGATION OF THE SOLUTIONS IN THE GROCERY INDUSTRY

Camillo Loro

Supply chain collaboration (SCC) has gained a lot of attention in the field of supply chain management, considered as an important research topic. Supply chain collaboration can be defined as “*a strategy, a unique dynamic capability and the highest form of long-term, trust-based relationship, characterised by joint planning and decision-making regarding strategic and operational matters, resource, process, information and risk sharing, and mutual understanding, working towards shared goals and achieving optimal solutions*”.

In this context, Information and Communication Technology (ICT) plays a crucial role and positively influences the SCC. Technology can enable specific projects of collaboration. These initiatives include continuous replenishment program (CRP), vendor managed inventory (VMI), efficient consumer response (ECR) and collaborative planning, forecasting, and replenishment (CPFR). When technology is used to implement collaboration between partners of business in a supply chain, we refer to electronic supply chain collaboration (e-SCC). Knowledge about e-SCC is still abstract in the academic field and a clear understanding about the adoption of e-collaboration practices for the firms seems to be missing. Despite the claimed benefits, the e-SCC implementation within the industries is much less prominent

than expected and its diffusion in different sectors greatly varies. Every single supply chain has a peculiar configuration and is composed of different actors that interact among each other. Therefore, to perform effective and deep analyses, it is necessary to study different supply chains separately.

The present thesis is one of the first attempts to study the implementation of some under-adopted collaborative solutions in the grocery industry, trying to boost their usage among practitioners and fill some gaps in the literature. The study identifies two different prominent collaborative solutions: optimal shelf availability (OSA) and vendor managed inventory (VMI) and highlight the role of emarketplace in the Business-to-business (B2b) relations, to help enterprises make their process more efficient, reach savings on costs, and deal with some critical situations.

The research questions can be summarised as follows:

**RQ1a.** *How do qualitative and quantitative decision factors impact the VMI implementation decision of the grocery industry stakeholders and how they change after the implementation?*

**RQ1b.** *How do stakeholders make the VMI implementation decision in case of conflicting variation of cost and value factors?*

**RQ2a.** *What are the main activities impacted by the optimal shelf*

*availability and how they can be modelled?*

**RQ2b.** *What are the benefits generated by the implementation of the optimal shelf availability project for the actors involved in the grocery industry?*

**RQ3a.** *What are the main activities impacted by the use of an e-marketplace in a Business-to-business relationship?*

**RQ3b.** *What benefits can be achieved from the adoption of B2b e-marketplace for retailers, distributors, manufacturers, and the overall supply chain?*

The research process is made up of three main stages. More in detail, the literature review (LR) part aims to identify the e-SCC projects implemented in the grocery supply chain and select the ones to be analysed in the subsequent steps. Once the gaps emerged, the three research questions (RQ) presented are addressed through the quantification of the expected cost reduction stemming from the implementation of such solutions. The steps of this second phase were repeated for each of the three selected solutions. The aim of this part is to compare the impact of the e-SCC projects on the business processes with the traditional way of working.

The analysis of the solutions is composed by two main steps:

- definition of the state of the art of the selected solution (i.e., a

focussed analysis targeting one solution at a time);

- analytical modelling of the impact of the specific solution on the business processes. In the analytical part the impact of the e-SCC solution compared to the traditional situation (i.e., without using VMI, OSA; marketplace) is assessed.

This thesis is characterised by the implementation of several methodologies, both quantitative and qualitative. The main advantages of qualitative research are: (i) addressing “how” questions, (ii) understanding the world from the informants’ perspective, and (iii) analysing and articulating processes. Quantitative assessment of the potential costs and benefits of the analysed phenomena, instead, is crucial to foster practitioners’ awareness.

As results, the answers to the research questions addressed by this thesis are summarised below:

**RQ1:** for the manufacturer, there are three main factors that can boost the implementation of VMI: customer satisfaction, supply chain visibility, and orders flexibility.

A greater information exchange from Point of Sales allows a better visibility of downstream demand and this leads to a reduction of the bullwhip effect. Therefore, there is an improvement of the service level, thanks to a higher products’ availability, leading to a greater customer satisfaction. On the retailer side, customer satisfaction (i.e., the self-evaluation of the own satisfaction as a client), and communication level have had the highest improvement in the usage of such solution. The improvement of customer satisfaction is in line with the evaluation given by manufacturers, whereas the

communication level is improved as the nature of VMI requires to stakeholders to improve their dependency and intensify their communication. Overall, retailers and manufacturers take advantage on value categories thanks to the VMI implementation.

**RQ2:** seven categories of costs are impacted by OSA projects, namely: stock-out costs, transportation costs, speculative purchasing costs, penalty costs, inventory carrying costs, handling costs, administrative costs. By applying the described analytical assessment model to the Italian grocery supply chain, it emerges that total costs can be reduced of about 12%. The highest benefit comes from the reduction of stock-out costs (-55.89%), followed by inventory carrying costs (-41.13%).

**RQ3:** the findings reveal that beyond stock-out costs and inventory levels also other operating costs (i.e., transportation, penalty, and administrative costs) play a significant role in determining overall impacts of B2b e-marketplace, and as such should be considered by managers in their process of emarketplace evaluation, selection and performance optimization. The model shows that compared with the offline scenario the B2b e-marketplace is expected to bring value to the overall supply chain, which tends to increase as the share of e-sales penetration is increased, ranging from a cost reduction of 0.1% (€ 229.2k) in the base-case of 10% e-sales adoption, up to 0.9% (€ -2.2M) in case of full emarketplace adoption.

The implications of this research are both academic and managerial. On one side, it makes some steps forward in the academic literature while investigating some of the most

promising collaborative projects. Moreover, it combines different research methods, to develop useful model still missing in the literature and thus filling the related gaps in this specific topic. On the other side, due to this interconnection with a well-rooted initiative in the practitioner world, this thesis can boost companies use the solutions discussed and help its implementation in the strategic/decision process. It could be used at a first strategic level, since it presents an overview of the e-SCC projects and allows to identify the type of processes supported and its functioning. Moreover, it identifies the potential cost savings enterprises can achieve by implementing them. These results could be used in a second and more focussed decision-making step, to estimate the potential saving stemming from the implementation of the selected solutions.

# HOW CAN INNOVATION ECOSYSTEMS CREATE SHARED VALUE? UNCOVERING INFLUENCING FACTORS AND EXPLAINING HETEROGENEITY

Giulia Piantoni - Supervisor: Marika Arena

## Co-supervisor: Giovanni Azzone

The thesis, written as a monography, investigates Shared Value (SV) creation in Innovation Ecosystems (IEs), a concept increasingly adopted referring to structures of interconnected entities, that, thanks to dynamic horizontal relations, support new grounding and strengthening of dispersed competences and resources to create innovations. They are composed by independent and interdependent actors, that co-opete, dynamically tying relations defining IE structure, which usually does not overlap with sectoral, administrative, or geographical borders.

The goal of IEs is creating value for diverse stakeholders in a multidimensional and multidirectional way, thus improving their own actors' results and generating collective impacts for the territory and the society to a higher extent respect to what entities alone can do. Thus, they have the potentiality of creating SV, expanding socio-economic benefits jointly created by (and for) companies and communities. However, the relations between IEs and SV have not been structurally studied, yet.

Thus, this thesis uncovers how IEs create SV, applying a process-based logic focused on outputs, strategies, mechanisms, answering to a first research question (RQ): *how can SV be created in IEs, in terms of outputs, strategies, mechanisms?*

RQ1 is then decomposed in sub-RQs:

1.1) *Which are the outputs of SV creation in IEs?*

1.2) *What strategies can be put in place to produce / improve such outputs?*

1.3) *Which internal mechanisms support such strategies?*

1.4) *To what extent is it possible to find some IE archetypes that display coherent configurations in terms of SV outputs, strategies, mechanisms?*

In studying this issue, IEs' fuzziness must be considered, bringing to the second RQ, that is then broken up in four sub-RQs:

RQ 2) *How do SV creation mechanisms, strategies and outputs vary in IE archetypes?*

2.1) *To what extent is the actual functioning of the archetypes in line with their expected behaviour in connection to SV creation?*

2.2) *Which are the strengths and weaknesses of these archetypes in creating SV?*

2.3) *How can the individuated weaknesses be overcome?*

2.4) *How do further factors (archetype or case specific) impact the answer to weaknesses and enhance strengths?*

To answer them, a recursive approach was applied, linking literature and empirics in iterative cycles. First a scoping literature review highlighted the fuzziness of the object, and individuated dimensions further explored in a systematic review (120 papers), which corroborated that SV in

IEs can be studied focusing on output spheres (economic, environmental, social, innovation), performances (rapidity, intensity, resilience), alignment and cooperation strategies, formalization, and openness of mechanisms.

Reviewed contributions displayed controversies, traceable back to elements of IE heterogeneity: *actors, structure* (structural characteristics), *governance, flows* (operational characteristics).

Considering combinations of structural characteristics, IE archetypes emerged: *Hub & Chain-Driven, Place-Driven, Competence & Issue Driven*. They display coherent configurations of operational characteristics as well.

*Hub & Chain-Driven IEs* are characterised by a placed-based nature and low geographical width, they are composed by a few actors overlapped with value and supply chains, centred around a hub. The hub affects governance and flows, occurring mainly internally.

*Place-Driven IEs* have a placed-based structure and heterogeneous actors. Therefore, very diverse entities coexist in a system with well-defined "geographical" boundaries. Governance grounds on partnerships and flows are bidirectional, including the context.

*Competence & Issue-Driven IEs* are characterised by the presence of numerous, dispersed and diverse actors, nodes of a system driven by

an issue or key competences. Actors - highly independent - are mainly linked through distant platforms and flows are not easily traceable.

An exploration of archetypes was conducted through a multiple case study analysis, accessing data from diverse sources (primary and secondary), keeping an embedded unit of analysis with a major focus at IE level.

The investigation developed in two steps. Step 1 answered RQ 2.1 and 2.2: by studying one representative case per archetype (theoretical sample), it individuated how SV creation works in archetypes, tracing strengths, weaknesses and individuating emerging factors. Modalities to overcome weaknesses and factors (RQs 2.3 and 2.4) were uncovered in Step 2, which studied further 3 or 4 complementary cases per archetype, different in terms of location, sector, maturity, core actor.

The empirical analysis underlined strong differences on how archetypes create SV and leverage on induced factors (policy, context, lifecycle, innovation typology, assets). In *Hub & Chain Driven IEs*, value creation strongly bonds with capture: SV creation is primarily driven by the clients and then shaped by IE members. Alignment and cooperation are facilitated by proximity and by the hub, which orchestrates the system and enhances its reputation and trust, sustaining informal mechanisms.

In *Place-Driven IEs*, proximity and open spaces reinforce alignment and cooperation, while heterogeneity and context inclusion sustain reaching simultaneously diverse outputs and sharing rationally resources. Value capture partly bonds with creation. *Competence & Issue-Driven IEs* leverage on complementarities to reach intense outputs. A bit scattered and characterised by loose bonds between value creation and capture, this archetype demands the setting of a roadmap, guidelines, formal mechanisms to facilitate alignment and inclusion, mined by low proximity and high heterogeneity. The study contributes to conceptualizing dimensions (and sub-dimensions) of analysis and of elements of heterogeneity key in SV creation in IEs, thus not nor drowning into the complexity of the object. Hence, a simple but comprehensive model is provided, with the individuation and analysis of coherent archetypes and their SV creation modalities, constructs, propositions. Concerning practical implications, managers are supported in identifying dimensions to analyse the IE they belong to, align their strategy and leverage on real examples. Policy makers can gather insights to understand their role and possible leverages in different configurations. The simplification needed to conduct the study around such a fuzzy and complex issue has implications and

this is the main limitation of the work. Other limits pertain to papers and cases selection and analysis, that may have suffered from subjectivity. Moreover, case study analysis does not support generalization of findings. Stemming from these limitations, future research should validate the conceptualized dimensions and enrich findings (i.e., on emerging factors, performances, policies), through expert validation, survey, network analysis, longitudinal studies, counterfactual analysis. Focusing on the resilience of IEs in challenging periods, and on balancing technology and human capital in IEs would provide further tiles to grasp potentialities of IEs in creating socio-economic benefits, while facing complex challenges.

# DIGITAL TRANSFORMATION IN THE PUBLIC SECTOR: PERSPECTIVES ON ORGANIZATIONAL CHANGE AND SERVICE DELIVERY

Luca Tangi - Supervisor: Giuliano Noci

ICT is transforming the public sector. It affects public organizations in the way they are organized and in how they deliver public services. The usage of information technologies in public affairs has been debated over the past two decades. However, nowadays is becoming an extremely relevant and problematic theme. The potentialities of new technologies ask for a disruption of the *status quo*, challenging public organizations to develop a new way of conceiving their duties towards the administrated territory.

While in the private sector companies are rapidly rethinking their business models, innovating towards a digital way of delivering goods and services, in the public sector ICT implementation often gets stuck in the existing norms and bureaucratic practices, processes, and structures. With private companies, citizens are becoming accustomed to communicating fast, efficiently, and through digital channels, while when interacting with a public organization they often have to physically go to the counter to access the service. Moreover, the digitization process differs among countries but also different organizations within the same country. Citizens, depending on the territory they live in, have different possibilities for accessing public services.

This ongoing transformation observed both in the private and public sector,

even though with different speeds, has been recently labeled as 'digital transformation'. Digital transformation is an inclusive term for referring to the complex organizational transformation process that ICT is asking. Hence, digital transformation can be defined as 'a second-order organizational change enabled by digital technologies transforming the way organizations are structured and organized and resulting in a new state, from the point of view of processes, culture, roles, relationships, and possibly all aspects of the organization'.

The thesis aims at answering the following research question: *How digital technologies are triggering a transformation in the way a public body is organized?*

For doing that, on the one hand, the thesis focuses on how ICT redesigning the existing processes, procedures, and structures for making new digital technologies institutionalized and routinized into the organization. On the other hand, it explores how ICT is changing the way of interacting with final users, moving towards digital communication channels.

The main empirical setting for the analysis is the Italian context, where two surveys were distributed, and the case studies and focus groups were conducted. To ensure a comparative outlook to reinforce the validity of results, one survey was also distributed in the Netherlands.

The main unit of analysis is the local government, which in Italy is the type of public organization that delivers services to citizens and firms. Results show that digital transformation is a complex change, a combination of three categories: (i) the *inside*, i.e. the way a public body is internally organized (processes, structure, etc.), (ii) the *forefront*, i.e. the way a public body organize service delivery (delivery channels), (iii) the *outside*, i.e. the way a public body related with third parties, such as intermediaries, suppliers, other public bodies.

Looking at the *inside*, first, results stress the role of the management: the change management activities are the main driver for fostering organizational change. Moreover, the peculiarities of ICT ask for a renovation of the way of acting as a manager. For example in the planning phase, managers must be able to design a flexible plan open to failures, have the awareness that technological projects constantly change, and ensure that the digitization process does not become mere dematerialization.

Second, and counterintuitively, the change is also independent from the strength of the cultural barriers. Digital transformation in the public sector cannot be limited to internal transformation. It must look also at service delivery, where the presence of digital services is not *per se* a

'finish line'. This is the assumption behind the *forefront* category. Moving towards digital channels requires organizational transformation efforts, especially for ensuring citizens' adoption of digital services. New service delivery strategies must be adopted. First, users should be divided into several categories, where each category consists of users who, whether through personal features or environmental aspects, view the service's complexity and ambiguity similarly. Second, public services must be divided into different sub-tasks, with channel management interventions being put into action for each task. Third, suitable channels must be selected along with the actions that influence citizens' behavior. Thus, for 'traditional users', i.e. users with no specific needs, the digital channel can be mandatory, whereas public organizations must leave the opportunity to use physical channels exclusively for the exceptions (e.g. users affected by the digital divide, or foreign users). In the *outside* category, the pivotal role of intermediaries came out: ICT is asking public organizations to reconsider the role of intermediaries. Intermediaries play a central role in (partially) delivering the service and supporting users with little or no internet access. Local authorities must ensure that the intermediaries possess adequate digital skills and the proper knowledge of the digital

system and train them appropriately. The role of the manager is to involve the intermediaries since the beginning of the transformation, ensuring that they possess the required skills. Beyond these theoretical reflections and managerial implications, the thesis, thanks to quantitative analysis, offers an overview of the pervasiveness of the digital transformation in particular in the Italian context and partially in the Netherlands. *Inside* the organization, the technical system (process, people, and information systems) is the most impacted by the introduction of ICT. On the other side, the social system (culture and structure) is less affected by this transformation. Looking at the *forefront*, the service delivery, more than one-third of the Italian local governments have a low e-maturity level, corresponding to low or null service digitization. Citizens and companies can access the service uniquely through the physical counter. On the opposite, only 10% of the local governments have a high level of digitization of both G2C and G2B services.

This backwardness in the overall digital transformation process can be explained only partially by exogenous factors: the size of the administration can (partially) explain the phenomenon, even if with opposite trends. In fact, the size of the organization brings to a dichotomy

in digital transformation: bigger organizations can more easily develop and implement digital services but have more difficulties in changing the organization along with the requirement of ICT. This evidence brings to some policy reflection. Limiting to Italy, the country is characterized by a large number of local governments (around 8.000) the majority with small size (around 70% has less than 5.000 inhabitants). In this context, as a challenge for Italy, digital transformation national policies shall be aware of the aforementioned dichotomy. An overall effort shall be put to the digitization of the forefront, i.e. on digitizing service delivery: this is the aspect of digital transformation where the majority of Italian local governments face more difficulties. On the opposite internal transformation for the majority of the Italian local governments can be considered a more easy process, due to less complex organizations, only big local governments shall focus their efforts on it.