OPEN
INNO
TRAIN

INDUSTRY 4.0
CLEANTECH
FOODTECH
FINTECH

edited by
Anne-Laure Mention
Massimo Menichinelli

From Research to Innovation: Exploring the Translation Journey with OpenInnoTrain

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 823971

edited by
Anne-Laure Mention &
Massimo Menichinelli

From Research to Innovation: Exploring the Translation Journey with OpenInnoTrain

Mention, A.-L., Menichinelli, M. (Eds.), 2021. From Research to Innovation: Exploring the Translation Journey with OpenInnoTrain, 1st ed. RMIT University Press, Melbourne (Victoria), Australia. https://doi.org/10.5281/zenodo.5536932

Edited by Anne-Laure Mention & Massimo Menichinelli
Published by RMIT University Press, Melbourne (Victoria), Australia (2021)
ISBN (print version / PDF): 978-1-922016-75-1
ISBN (digital version): 978-1-922016-76-8
DOI: 10.5281/zenodo.5536932
https://doi.org/10.5281/zenodo.5536932
https://www.openinnotrain.eu/

This research has received funding from the Horizon 2020 Programme of the European Union within the OpenInnoTrain project under grant agreement n° 823971. The content of this publication does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the publication lies entirely with the author(s).

https://www.openinnotrain.eu/
https://cordis.europa.eu/project/id/823971

Table of Contents

Editors & co-authors

Anne-Laure Mention

Professor Anne-Laure Mention is the Director of the Global Business Innovation Enabling Capability Platform (GBI-ECP) and a (full) Professor of Management at RMIT University, Melbourne, Australia. Anne-Laure is visiting Professor at Université de Liège, Belgium; Deputy Head of the Centre d'Evaluation de la Performance des Entreprises; visiting Professor at Tampere University, Finland, and a Fintech & Blockchain Fellow at Singapore University of Social Sciences. Anne-Laure is currently leading several European H2020 projects as chief investigator and have raised over 6 M EUR in H2020 funding over 2018-2020. She sits on the scientific or advisory board of several international organisations in the field of technology and innovation management. For bridging industry-academia cooperation, Anne-Laure has been awarded the prestigious IBM Faculty Award twice for her research on innovation. Anne-Laure is one of the founding editors of the Journal of Innovation Management and was the Deputy Head of the ISPIM Advisory Board 2011-2018.

https://www.linkedin.com/in/annelauremention/

Massimo Menichinelli

Massimo Menichinelli, Doctor of Arts in New Media from Aalto University and Master of Science in Design from Politecnico di Milano, is a designer who researches and develops open, collaborative, and co-design projects and the systems that enable them since 2005. Massimo has published several scientific articles and books on the topics of Open Design, Digital Fabrication, Makers, Fab Labs and Social Innovation.

Massimo has lectured on Digital Fabrication and Open Design at Aalto University (Helsinki/Espoo, Finland) and Open Design at SUPSI (Lugano, Switzerland) and in the Fab Academy in the Opendot and WeMake fab labs (Milan, Italy). Massimo worked as a Director at Make In Italy Italian Fablab & Makers Foundation CDB, as a project manager for research projects at IAAC | Fab Lab Barcelona and now as a Research Fellow at RMIT University in the European hub in Barcelona and as Senior Resident Researcher at Politecnico di Milano – Polifactory.

https://www.linkedin.com/in/massimomenichinelli/

Authors

Desislava Kolarova

Desislava Kolarova is a project adviser at the European Commission's European Research Executive Agency. Her work involves management and monitoring of research and innovation projects. Previously she was working at the European Commission's Directorate for research and innovation and at the European Parliament. Her expertise lies in the developments of knowledge-based economies, research and innovation policy developments in the European Research Area and for regional development. Her scientific work covers strategic changes in transition economies towards knowledge and service based economies, with special emphasis on the development of business services. She holds a Ph.D. degree in Economics from the University Grenoble Alpes in Grenoble, France and an MA in Economics from the University of National and Word Economy in Sofia, Bulgaria. She has been visiting researcher in different countries (Australia, France, Austria and Bulgaria).

https://www.linkedin.com/in/desislava-kolarova-1306823/

Elia Vallejos Formatge

Èlia Vallejos Formatge is currently working as a Project Assistant at RMIT Europe, in Barcelona. She is a Translation and Interpreting graduate from UAB (Universitat Autonoma de Barcelona) with a year in UTA (University of Tampere, Finland); holding a master's degree in International Affairs from URL (Universitat Ramon Llull). At RMIT Europe, Elia is giving support to different H2020 projects, including OpenInnoTrain.

https://www.linkedin.com/in/elia-vallejos-formatge/

Hardik Bhimani

Hardik is a behavioural innovation researcher. He explores how human cognitive capabilities impact innovative behaviour in workplace. Hardik has qualifications and experience in information technology, psychology, applied finance and strategic management. He leads the Behavioural Innovation Research and Design Society (BIRDS) and the Gamified Research Translation (GREAT) projects at RMIT University, Australia where he is also completing this PhD. Hardik is also a Research Associate for the OpenInnoTrain project.

https://www.linkedin.com/in/hardikbhimani/

Elena Casprini

Elena Casprini is Senior Researcher at Department of Business and Law, University of Siena. During her Ph.D. in Management at Scuola Superiore Sant'Anna, she was a Visiting Ph.D. Student at Cass Business School (London, UK). Her research interests focus on business models innovation, open innovation and family firms. She is an expert in qualitative research methodologies, in particular case studies. She has published in international as well as national journals and she is involved in national and international research projects.

https://www.linkedin.com/in/elena-casprini-9836674b/

Tena Obradović

Tena Obradović is a Research Assistant at the Faculty of Economics and Business, University of Zagreb, at the Department of International Economics. Her Ph.D. research is supported by 'Croatian Science Foundation' – „Career Development Program for Young Researchers“ and her research activities are connected to the OpenInnoTrain project. Within the project, she was visiting researcher at RMIT Melbourne and at RMIT Barcelona.
Her paper on Open innovation in manufacturing industry appears in Technovation. The areas of her interest are related to study of open innovation, industry 4.0 and international business.

https://www.linkedin.com/in/tena-obradovic/

Božidar Vlačić

Assistant Professor at Católica Porto Business School and Distinguished Researcher at Research Centre in Management and Economics (CEGE), Universidade Católica Portuguesa (Portugal), visiting scholar at ISA Lille, Catholic University of Lille (France), visiting scholar at Faculty of Economics and Business, University of Zagreb (Croatia), visiting research fellow at RMIT University (Australia).
Since 2018, he holds an International Ph.D. with honors in Economic Analysis and Business Strategy from the University of Vigo, the University of Santiago and the University of A Coruña (Spain). His main contributions are published in journals such as J. of Business Research, Technovation, Journal of Small Business Management, IEEE Transactions on Engineering Management, J. of Intellectual Capital, and European J. of Int. Management. He is an active member of the IEEE Technology and Engineering Management Society, the European International Business Academy (EIBA), and the EIBA Early Career Network chair.

https://www.linkedin.com/in/bvlacic/

Marina Dabić

Associate Editor of the Technological Forecasting and Social Change, Department Editor for IEEE- Transactions on Engineering Management, and Associate Editor for Technology in Society. Papers appear in a wide variety of international journals, including the Journal of International Business Studies, Journal of World Business, Journal of Business Research, Technological Forecasting and Social Change, Small Business Economics, Organizational Dynamics, International Journal of Human Resource Management, IEEE- Transactions on Engineering Management, Journal of Transfer Technology among others. Member of board of Governors for IEEE-TEMS.

https://www.linkedin.com/in/marina-dabic-02910b14/

Shah Rukh Shakeel

Shah Rukh Shakeel is currently working as a researcher at the School of Marketing and Communication, and Innovation and Entrepreneurship InnoLab, University of Vaasa, Finland. Shakeel holds a PhD degree in Economics and Business Administration from the University of Vaasa. Dr. Shakeel has published in high-quality scientific journals and presented his work at international conferences. His research interests include renewable energy, technology development, development, cleantech, commercialisation, business models, innovation ecosystem and university-industry collaboration.

https://www.linkedin.com/in/shah-rukh-shakeel-26967a32/

Antje Gonera

Antje Gonera, Ph.D., is a senior scientist at the Norwegian food research institute Nofima in the Department of Innovation, Consumer and Sensory Science and leads the strategic research programme on innovation, consumer science and food technology. After her M.Sc. degree in Food Science at the Technical University in Dresden, Germany and Purdue University, USA she obtained a PhD in Food Science at the University of Braunschweig, Germany and Kochi University, Japan and as well an exec. MBA in Innovation Studies from the Business School in Oslo, Norway. Dr. Gonera previously has had international roles in in the consumer goods industry, biotechnology, and consulting spanning from product and technology development, consumer research, innovation management, supply chain optimisation, to organisational improvement. Her research focus is on the implementation and understanding of the use of design thinking, user focus and agile innovation methods into transdisciplinary academia-industry research collaborations and facilitating the transition to a more sustainable food system.

https://www.linkedin.com/in/dr-antje-gonera-62a3658/

Carsten Nico Hjortsø

Carsten Nico Hjortsø is an Associate Professor in Strategy & Entrepreneurship at Department Food and Resource Economics, Faculty of Science, University of Copenhagen. He has a PhD in conflict resolution in natural resource management and Nico has published scientific work on topics such as decision support tools, institutional innovation and change, agribusiness development, curriculum development in higher education, and research capacity building. His papers appear in international journals such as *Technovation*, *European Journal of Operations Research*, *Journal of Small Business Management Industrial Marketing Management, Agriculture and Human Values*, *Journal of Rural Studies*, *British Food Journal*, *Public Administration and Development and International Food and Agribusiness Management Review.* Nico's research has been conducted in the developing country and natural resource context. He has been engaged in research & research capacity strengthening projects in Latin America, African, Asia. Nico has been involved projects promoting innovation and entrepreneurship curriculum development and teaching at University of Copenhagen as well as in Kenya, Uganda, Ethiopia, Nigeria, Morocco, Benin.

https://www.linkedin.com/in/carsten-nico-hjorts%C3%B8-863b266/

Avni Misra

Avni Misra is a Researcher at RMIT University, College of Business. Her research focuses on innovation management with interest on digitalised innovation, business networks, and industrial marketing. Her qualitative research capabilities extend towards another key area of research that deals with the issues and management of gender equality. Additionally, Avni is a lecturer of product innovation, management and B2B Marketing at RMIT University, key work integrated learning courses as a part of the Bachelor of Business degree. Some of her current research is towards examining role of business networks in technology commercialisation. Furthermore, in the gender equality space, she is involved in multiple projects investigating the impact of gender as key variable that influences decision-making in different organisational operations in different industries. She received her master's in biotechnology from India and her second master's degree in business marketing and her PhD in innovation and industrial marketing from RMIT University. Apart from academia, Dr. Misra is also a marketing consultant working on several service-oriented projects in the technology industry and has over six years of experience working for different marketing firms in India and clients in Australia.

https://www.linkedin.com/in/avni-misra-l-phd-6939912a/

Ahmad Alaassar

Ahmad Alaassar is a researcher and business developer in the fields of entrepreneurship and innovation. He is currently awaiting the outcome of his PhD examination – a double degree PhD from RMIT University and the University of Agder. In his PhD, Ahmad explored a support instrument called the regulatory sandbox that is established by regulators to help fintech start-ups in the financial sector. His research additionally explored the social dynamics of business incubation and entrepreneurial ecosystems. Ahmad's publications have been featured in Technovation, Technological Forecasting and Social Change, Small Business Economics (forthcoming) and International Journal of Innovation Management. Professionally, he has worked as a business developer in a business incubator, assisting entrepreneurs with the commercialisation of innovative solutions. At his core education, Ahmad leverages his bachelor's in mechatronics engineering and master's in technology management to adopt multi-disciplinary approaches in his research and professional work activities.

https://www.linkedin.com/in/ahmad-alaassar/

Pauline Rasera

Pauline Rasera is working as European Project Manager at RMIT Europe, the European hub of RMIT University in Barcelona, and forms part of the OpenInnoTrain project coordination team. Pauline holds a Master's degree in European Studies from the University of Aix-Marseille (France). She has over 8 years of experience in managing research and innovation projects funded under EU and national programmes (H2020, FP7, COST, Interreg, Erasmus, ANR…) in Spain, Australia, France and Slovenia.

https://www.linkedin.com/in/pauline-rasera/

Foreword

Desislava Kolarova*

Working for the European Research Executive Agency (REA) that funds the MSCA schemes under H2020, I am very happy to be the project adviser in charge of the RISE (MSCA) project OpenInnoTrain. My related work involves monitoring the project's progress, as well as advising and assisting the project coordinator whenever necessary on technical/implementation matters such as reporting, payments, amendments and project communication.

Being an economist, I am equally glad to be able to follow the project's topic on Open Innovation and Translation of research results between academia and industry, focusing on four important areas: FinTech, Industry 4.0, CleanTech and FoodTech.

I have completed myself a Ph.D. in industrial economics, and I have been visiting researcher in different countries (i.e. Australia, France, Austria and Bulgaria). Therefore, I perfectly understand and appreciate the importance of international staff exchanges, the transfer/sharing of knowledge among researchers, and the opportunities that meeting new people presents for getting to know new cultures, new organisational/institutional systems, and exploring new career perspectives.

From the "Stories from the secondees", it is clear that the OpenInoTrain project has the potential to contribute to the main objective of the MSCA RISE scheme, which is to equip researchers with new knowledge and skills via cross-border and cross-sectorial mobility in view of better future career opportunities. The project aims to develop the basis for a sustainable collaboration framework among different organisations from the academic and non-academic sectors (in particular SMEs), in Europe and Australia in order to increase the research and innovation capacities of the participating organisations, with a great potential to be further exploited in the years to come.

The project has been running during the very challenging period of the world pandemic and has needed some re-adjustments of the planning and implementation modalities. Nonetheless, the mid-term meeting showed that, despite the difficulties and constraints, the project has kept its focus and has tackled the challenges posed in the last 16 months. I encourage the consortium to continue its efforts to ensure that the project delivers on its main objectives and the participating organisations make the most of the wonderful opportunities offered by the RISE scheme.

---

* All views expressed in this foreword are strictly those of the author and may under no circumstances be regarded as an official position of the European Research Executive Agency or the European Commission.

Introduction

Anne-Laure Mention, Massimo Menichinelli

The importance of innovation through university-industry cooperation has rarely been more acute than it is today. Over the last 18 months, we have experienced unprecedented circumstances in our lifetime that have demonstrated the critical role of knowledge creation and transmission across industries and disciplines. Identifying, developing and scaling-up breakthrough technologies, and converting them into incremental, radical or disruptive innovations that are widely accepted by, and available to beneficiaries, users, customers and communities is of paramount importance. However, turning research outputs into novelties for the benefits of wider society seldom occurs spontaneously.

Numerous mechanisms – such as stakeholder engagement and co-creation processes – can assist in creating framework conditions to foster the development and adoption of novelties that address current and future societal needs. The European funded OpenInnoTrain project precisely aims to explore those mechanisms, across four specific contemporary settings, so to as equip researchers and practitioners with actionable knowledge to support their research and innovation journeys.

As we cross the 2-year mark of the project, our intent is to provide glimpses into our current reflections and achievements with a variety of illustrations featuring activities across the consortium and beyond. These initiatives and results could not have been achieved without the commitment, passion and dedication of our OpenInnoTrain secondees, partners, and work package leaders – whom we sincerely want to thank for making this journey so fruitful and rewarding.

The 11 chapters of the book can be conceptually grouped into 4 sections: the first 4 chapters (1-4) present an introduction to the project and its achievement during its first two years of life; then the following two chapters (5-6) introduce to the topic of Research Translation; four chapters then (7-10) introduce the 4 sectors where OpenInnoTrain works: FinTech, Industry 4.0, CleanTech and Food Tech. Finally, the last chapter (11) reports the first Summer School of the OpenInnoTrain project that revolved around the topic of impact of research.

In the first chapter (*The OpenInnoTrain project*), Anne-Laure Mention introduces the OpenInnoTrain project, its rationale and the consortium. In the second chapter (*The OpenInnoTrain events so far*) Elia Vallejos Formatge provides an overview of the main events organised during the first two years of the project. Chapter 3 (*The first two years and half of OpenInnoTrain*) recollects an edited version of the messages sent monthly by Anne-Laure Mention, the Principal Investigator of the OpenInnoTrain project, to the consortium, documenting thus the development of the project so far. An important part of the project consists of secondments and

Chapter 4 (*Stories from the Secondees*) collects interviews with several OpenInnoTrain Secondees, providing an overview of their profile and experience in such secondments.

In the second conceptual section, 2 chapters discuss the phenomenon of Research Translation. Chapter 5 (*State of Play in UIC and Research Translation in Europe and Australia*) analyses Research Translation and its status in Europe and Australia. It is a reprint of a deliverable from the OpenInnoTrain project, D1.1, written by Anne-Laure Mention, Hardik Bhimani and Massimo Menichinelli, and is a foundational element for future actions of the project. In Chapter 6 (*A research template for understanding Research Translation cases*) Massimo Menichinelli and Elena Casprini propose a template for analysing case studies of Research Translation in terms of actors, flows and ecosystems.

In the third conceptual section, 5 chapters then describe each one of the sectors of OpenInnoTrain. Chapter 7 (*The Age of FinTech: Implications for Research, Policy and Practice*) introduces FinTech with a reprint of an article published by Anne-Laure Mention in the The Journal of FinTech. Chapter 8 introduces the sector of Industry 4.0 with a reprint of an article by Tena Obradović, Božidar Vlačić, and Marina Dabić (*Open innovation in the manufacturing industry: A review and research agenda*) originally published in the Technovation journal. CleanTech is then introduced in Chapter 9 (*CleanTech: Prospects & Challenges*) by Shah Rukh Shakeel and an overview of FoodTech is provided in Chapter 10 (*Approaching FoodTech: some preliminary considerations*) by Elena Casprini, Antje Gonera, Carsten Nico Hjortsø and in Chapter 11 (*Exploring the Food Value Chain Using an OI Approach: A Bibliometric Review of the Literature*) by Avni Misra and Anne-Laure Mention.

Finally, in the fourth section, Chapter 12 (*Exploring how to plan and manage the impact of research: the first OpenInnoTrain Summer School*) by Anne-Laure Mention, Avni Misra, Massimo Menichinelli, Ahmad Alaassar, and Pauline Rasera, reports on the first OpenInnoTrain Summer School that took place in May 2021. The Summer School focused on strategies, tactics, techniques, canvasses and tools to design and implement impact-focused research agendas.

Part I: OpenInnoTrain

1 The OpenInnoTrain project

Anne-Laure Mention

The OpenInnoTrain project aims to explore the theory and practice of Research Translation, which is viewed as a means to foster University-Industry Cooperation and more broadly, as an instrument to increase the adoption of Open Innovation practices. As a Research and Innovation Staff Exchange project (MSCA[1] - RISE[2]), OpenInnoTrain intends to form and nurture an international and inter-sectoral network of organisations with a shared interest in Research Translation, University-Industry Cooperation and Open Innovation, across four contemporary areas: FinTech, Industry 4.0, CleanTech, and FoodTech.

Through the mobility (secondments) enabled by the Research and Innovation Staff Exchange (MSCA-RISE) format of the project, participating staff members[3] develop new skills and become able to challenge the status-quo by being exposed to a new environment and thus have their career perspectives widened. Such mobility often provides mind-opening opportunities for academic staff and supports their career trajectories by widening their horizons and exposing them to dynamic and global environments. Likewise, professional staff involved in secondments gain exposure to a wide range of new contexts, cultures, methods, and disciplines. Advances in knowledge exchange across sectors and countries are made more accessible through the relationships developed and nurtured during secondments. Cross-fertilisation of ideas and knowledge occurs and unlocks innovation potential and market opportunities.

The Open Innovation paradigm focuses on how innovation does not occur in isolation but results from knowledge flows across organisational boundaries. Innovation, in its simplest conceptualisation, is the introduction of new ideas, products or ways of doing things. The openness nature of the innovation process has wide-ranging implications on how knowledge is generated across industries, and on how research outputs (such as academic publications, tools, methods) can be converted or translated into research outcomes (such as new or improved products and services), with the intent to ultimately generate an impact from research at societal level. By studying these knowledge conversion processes, in the specific setting of University-Industry Cooperation, OpenInnoTrain aims to broaden our understanding of this complex phenomenon, but also to develop a

[1] https://ec.europa.eu/research/mariecurieactions/
[2] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/msca-rise-2018
The Horizon 2020 RISE action was renamed as SE in Horizon Europe: https://ec.europa.eu/research/mariecurieactions/actions/staff-exchanges
[3] https://www.openinnotrain.eu/researchers/

unique set of tools and methods to facilitate and accelerate the translation of research results.

Granted funding of up to €2.5M for up to 540 person-months of secondments, OpenInnoTrain benefits from the depth and breadth of expertise of a consortium of 22 partners across several European countries and Australia. Researchers and professional innovation staff in Europe and Australia will have the opportunity to spend from one month up to a year in Australia and in several European countries including Austria, Croatia, Denmark, Finland, Germany, Italy, the Netherlands, Norway, Portugal, Slovenia, UK, and Spain. This is the first project that connects European and Australian research at this scale within such a global network of industrial partners and academic institutions.

In addition to staff mobility, the project will also include workshops, summer schools, masterclasses, seminars, and hackathons in different locations across Europe with project partners.

At the core of the project is the intent to foster better ways for academia and industry to work together to translate research into products and services that benefit society. Through its implementation, it will bring together global experts from research centres, industry groups and universities to make a real and positive difference to our communities.

The project has involved organisations across Europe and Australia (Fig. 1):

1. RMIT Europe[4] (RMIT EU) (Barcelona, Spain)
2. Merinova[5] (Vaasa, Finland)
3. Leibniz-Institut für Photonische Technologien[6] (IPHT) (Jena, Germany)
4. KONČAR[7] (Zagreb, Croatia)
5. Nederlandse Organisatie voor toegepast-natuurwetenschappelijk Onderzoek (TNO)[8] (Netherlands)
6. Technische Universität Hamburg (TUHH)[9] (Hamburg, Germany)
7. Universitat Politècnica de Catalunya (UPC)[10] (Barcelona, Spain)
8. University of Agder (UiA)[11] (Kristiansand, Norway)
9. University of Siena (UNISI)[12] (Siena, Italy)
10. University of Copenhagen (UCPH)[13] (Copenhagen, Denmark)

[4] http://www.rmit.eu/
[5] https://www.merinova.fi/en/
[6] https://www.leibniz-ipht.de/en/homepage/
[7] https://www.koncar.hr/en/
[8] https://www.tno.nl/en/
[9] https://www.tuhh.de/alt/tuhh/startpage.html
[10] https://www.upc.edu/en
[11] https://www.uia.no/en
[12] https://en.unisi.it/
[13] https://www.ku.dk/english/

11. University of Zagreb – Faculty of Economics & Business (UniZAG)[14] (Zagreb, Croatia)
12. INESC TEC – Institute for Systems and Computer Engineering, Technology and Science (INESC TEC)[15] (Porto, Portugal)
13. University of Vaasa (UVA)[16] (Vaasa, Finland)
14. International Software Consulting Network (ISCN)[17] (Graz, Austria)
15. Radical Innovations Group (RIG)[18] (Vaasa, Finland)
16. Carlsberg[19] (Copenhagen, Denmark)
17. Salcheto[20] (Montepulciano, Italy)
18. TU Graz[21] (TUG) (Graz, Austria)
19. Lorit Consultancy (Lorit)[22] (Edinburgh, Scotland – UK)
20. Nofima[23] (Tromsø – Norway)
21. RMIT University (RMIT)[24] (Melbourne, Australia)

[14] https://www.efzg.unizg.hr/en
[15] http://inesctec.pt/en
[16] https://www.uwasa.fi/en
[17] https://www.iscn.com/
[18] https://www.rigv.fi/
[19] https://www.carlsberg.com/en/
[20] https://salcheto.it/
[21] https://www.tugraz.at/en/home/
[22] https://lorit-consultancy.com/en/
[23] https://nofima.no/en/
[24] https://www.rmit.edu.au/

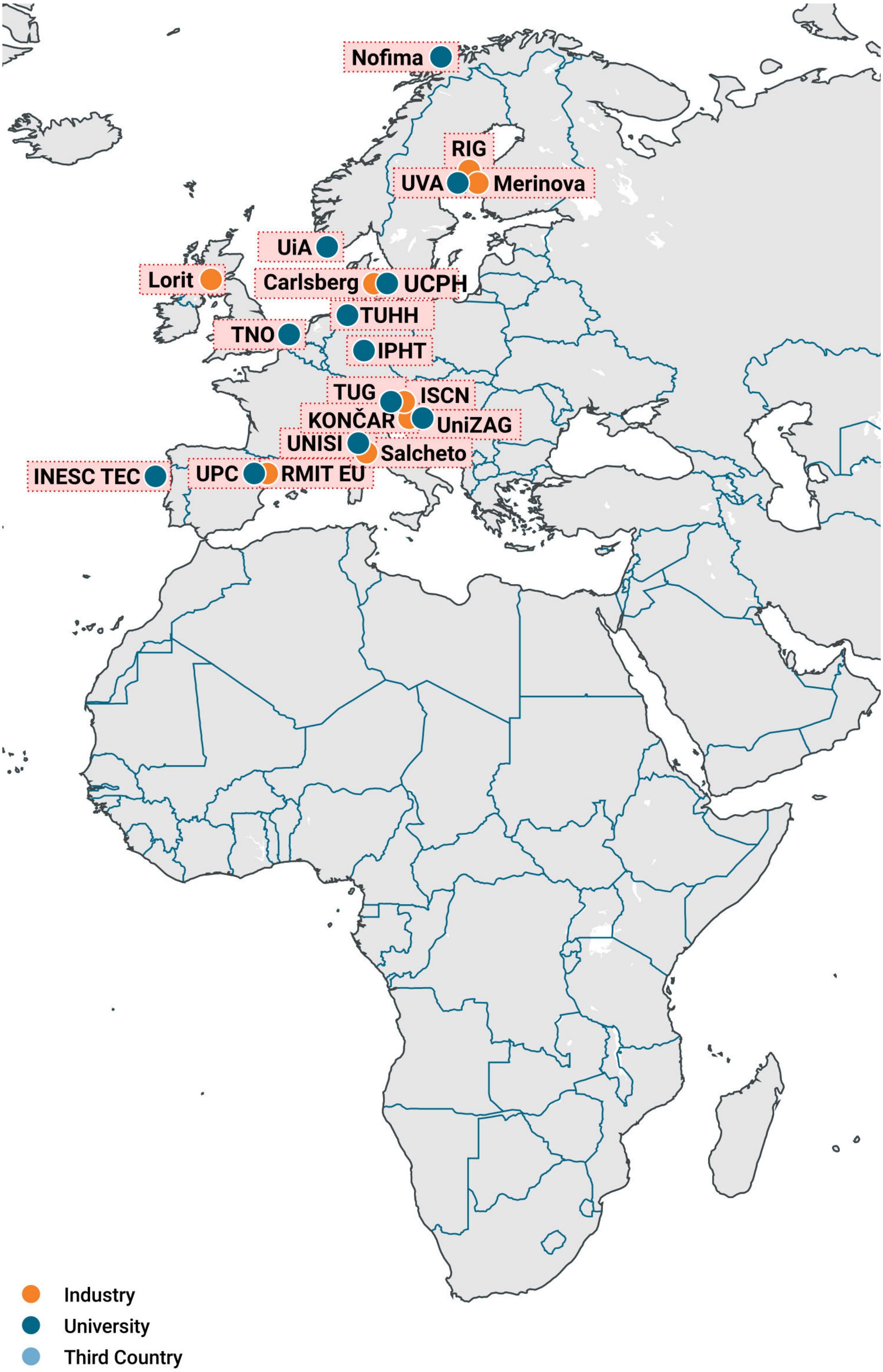


Figure 1 Partners of the OpenInnoTrain project


RMIT

2 The OpenInnoTrain events so far

Elia Vallejos Formatge, Anne-Laure Mention, Massimo Menichinelli, Pauline Rasera

1 Introduction

Events are fundamental for the development of the project. They can be useful for making the project known, expanding its network, reaching more people, training researchers and as a meeting point for experts to share information and knowledge. There are many types of events to be organised, or to participate in, depending on the audience, topic, duration, and interaction:

- **Seminar / Conference sessions**: Within many conferences, which have a topic of interest related to the project, OpenInnoTrain participates in presentations, seminars, panels, or workshops. Hence, these events are brief sessions taking place within broader conferences, where usually many organisations, institutions and projects from different countries interact and share knowledge. These events have a duration of approximately 1-2 hours. An example would be the session by OpenInnoTrain within the 6th Annual World Open Innovation Conference (WOIC).
- **STREMs (Students/Research/Managers Seminar):** These events focus on specific topics, usually run for a full-day and have a multilevel network approach to professional, researchers and students coming together.
- **Masterclass**: These events are usually organised as a place for innovation professionals and industry leaders to share ideas and perspectives within different application settings, with a typical duration of 1-2 days. An example would be the event entitled: "*How to analyse Research Translation cases in University-Industry Cooperation*" held the 20th and 27th of October 2020.
- **Workshops**: With an audience of industry professionals and experienced researchers, workshops aim at training participants in most recent developments of the applications settings, and at creating networking opportunities. Their duration is usually about 1-2 days and they serve as a place to obtain feedback and achieve enriching interaction among industry and academia. A clear example of a workshop is the one held in Siena on 13-14/06/2019 "*Open Innovation Challenges for FoodTech and CleanTech*".
- **Hackathons**: With a duration of 1-3 days, these events are competitions where participants (often in teams) try to solve a well-defined challenge (often defined by industry). Participants are supported by mentors and

present their work in a final pitch: prizes are awarded to the winners (voted by a jury).

- **Summer Schools**: The typical length of a Summer School is around 4-5 days. They are events aimed at informing Early Stage Researchers (ESR) about recent research developments while having the opportunity to learn from experienced researchers. Organised around a specific topic, Summer Schools support PhD students on developing their research and on creating valuable networks. OpenInnoTrain has organised one Summer School from 17th to 21st of May 2021.

In this chapter you can find a brief summary of the main events held so far.

2 Events

Following the brief introduction on the types of events within the project, since its beginning in 2019, OpenInnoTrain has organised and participated in several events with many different interesting topics and with the collaboration of various organisations and experts. Below is a brief summary of each event held so far:

2.1 Open Innovation challenges for FoodTech and CleanTech (Siena, 13-14/06/2019)

Organised by UNISI[1], this workshop aimed to identify the open innovation challenges in the FoodTech and CleanTech sectors through interaction between academic and industrial actors. The program comprised 2-days of activities with sessions involving agri-food companies, other FoodTech partners, as well as CleanTech companies and institutions. The workshop included a visit to Salcheto winery, where participants could see how the winery innovated its activities, focusing on sustainability issues and involving several stakeholders. With participants split over two working tables, the key challenges deriving from the previous activities were summarised, and the workshop was concluded with a plenary session (Figures 1-3).

[1] https://www.openinnotrain.eu/events/oi-challenges-foodtech-cleantech-siena-2019/

Figure 1 Open Innovation challenges for FoodTech and CleanTech (Siena, 13-14/06/2019)

Figure 2 Open Innovation challenges for FoodTech and CleanTech (Siena, 13-14/06/2019)

Figure 3 Open Innovation challenges for FoodTech and CleanTech (Siena, 13-14/06/2019)

Figure 4 Open Innovation for Digitalisation: Industry 4.0, Internet of Things, CleanTech and Energy Systems (Vaasa, 05-06/09/2019)

Figure 5 Open Innovation for Digitalisation: Industry 4.0, Internet of Things, CleanTech and Energy Systems (Vaasa, 05-06/09/2019)

2.2 Open Innovation for Digitalization: Industry 4.0, Internet of Things, CleanTech and Energy Systems (Vaasa, 05-06/09/2019)

Organised by Merinova[2], (and held in Vaasa, home of the largest energy technology cluster of the Nordic Countries), this workshop enabled OpenInnoTrain partners, companies and researchers to meet and discuss Open Innovation, Research Translation and University-Industry Cooperation. The workshop included presentations from industry and research, panel discussions and industry visits to OpenInnoTrain partners, local companies in IoT and energy systems (Figures 4-5).

2.3 OpenInnoTrain session at WOIC 2019 (Rome, 13/12/2019)

OpenInnoTrain participated with a workshop[3] by Prof. Anne-Laure Mention on how Open Innovation and Research Translation can be facilitated between academia

[2] https://www.openinnotrain.eu/events/oi-digitalization-i40-cleantech-vaasa-2019/
[3] https://www.openinnotrain.eu/events/6th-annual-world-open-innovation-conference/

and industry within the University-Industry Cooperation (UIC). It explored how this Open Innovation approach framework for Research Translation is the prerequisite for societal impact through value creation by embedding research-generated knowledge into practices, transforming knowledge made available in academic publications to new or improved products and services and behavioural changes (Figure 6).

Figure 6 OpenInnoTrain session at WOIC 2019 (Rome, 13/12/2019)

2.4 OpenInnoTrain session at XXXI ISPIM 2020 (Online, 08/06/2020)

OpenInnoTrain was featured at ISPIM Virtual 2020 with a workshop[4] organised by RMIT Europe with Anne-Laure Mention (RMIT), Massimo Menichinelli (RMIT Europe), Elena Casprini (UNISI) and Tor Helge Aas (UiA); moderated by Bruno Woeran (Merinova). The session was dedicated to the role and impact of research mobility and translation in the OpenInnoTrain project (Figure 7).

[4] https://www.openinnotrain.eu/events/xxxi-ispim-innovation-conference-virtual-event/

Figure 7 OpenInnoTrain session at XXXI ISPIM 2020 (Online, 08/06/2020)

Figure 8 Panel at ESOF2020 (Online, 03/09/2020)

2.5 Panel at ESOF2020 (Online, 03/09/2020)

OpenInnoTrain participated at the ESOF2020 Science to Business program within a workshop under the 4th Industrial Revolution theme[5]. The Euro Science Open Forum (ESOF) is a biennial, pan-European, general science conference dedicated to scientific research and innovation. Each conference aims to deliver stimulating

[5] https://www.openinnotrain.eu/events/euro-science-open-forum-esof2020/

content and lively debate around the latest advancements and discoveries in the sciences, humanities, and social sciences (Figure 8).

2.6 OpenInnoTrain session at EuroSPI 2020 (Online, 10/09/2020)

Organised by ISCN, EuroSPI's 2020 traditional Innovation workshop series were focused on business innovation, as well as on democratizing innovation through stakeholder empowerment. In this event, OpenInnoTrain participated with two sessions at the Recent Innovations Workshop[6] (Figure 9).

2.7 OpenInnoTrain 2020 PhD Workshop: How to publish a research paper successfully? (Online, 24/09/2020)

Organised by UniZAG, the OpenInnoTrain PhD Workshop[7] was an activity for doctoral students and early stage researchers. It represented a great opportunity to explore new knowledge with the experienced professors from the Faculty of Economics and Business Zagreb and RMIT Melbourne. Also, students had the opportunity to send their paper abstract and get feedback from qualified researchers and practitioners from different fields (Figure 10).

Figure 9 OpenInnoTrain session at EuroSPI 2020 (Online, 10/09/2020)

[6] https://www.openinnotrain.eu/events/eurospi-dusseldorf-workshop-series/
[7] https://www.openinnotrain.eu/events/openinnotrain-2020-phd-workshop-how-to-publish-a-research-paper-successfully/

Figure 10 OpenInnoTrain 2020 PhD Workshop: How to publish a research paper successfully? (Online, 24/09/2020)

2.8 Grand opportunities and challenges for Industry 4.0 and FoodTech – building the bridges through Open Innovation (Online, 25/09/2020)

UniZAG organised a workshop[8] for identifying the open innovation challenges in Industry 4.0 and the Food Industry and to participate in the online panel with experienced academics and practitioners. Participants could enjoy two panel discussions on the following topics: "*The impact of collaboration between industry and academia on Industry 4.0 and FoodTech*" and "*The impact of COVID-19 on Industry 4.0 and FoodTech – challenges and opportunities for collaboration*" (Figure 11).

[8] https://www.openinnotrain.eu/events/new-date-grand-opportunities-and-challenges-for-industry-4-0-and-foodtech-building-the-bridges-through-open-innovation/

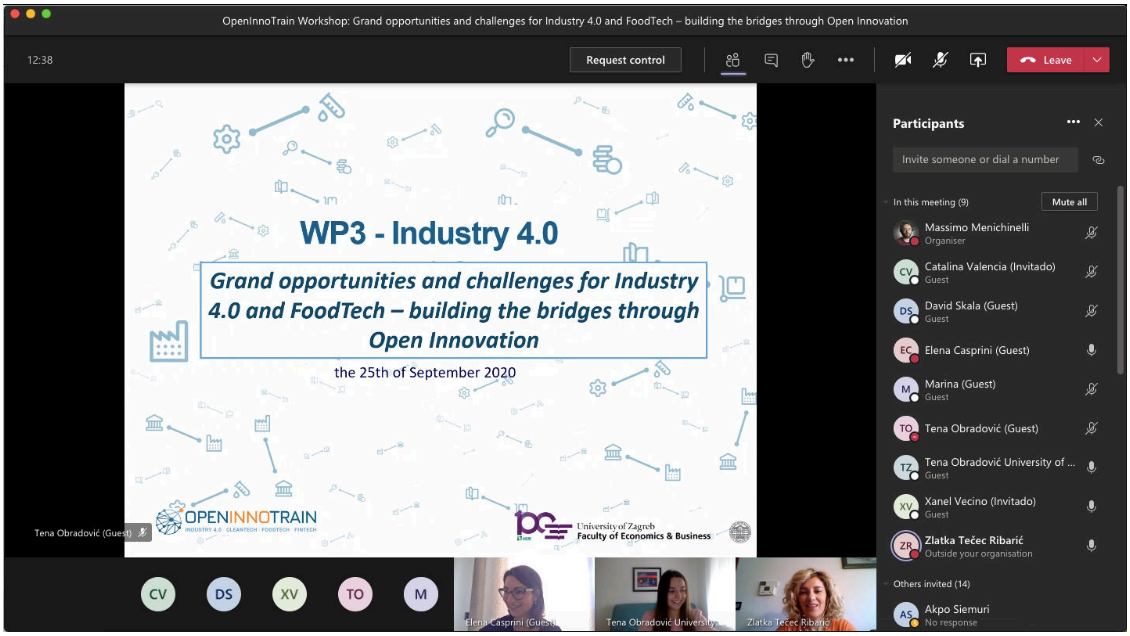


Figure 11 Grand opportunities and challenges for Industry 4.0 and FoodTech – building the bridges through Open Innovation (Online, 25/09/2020)

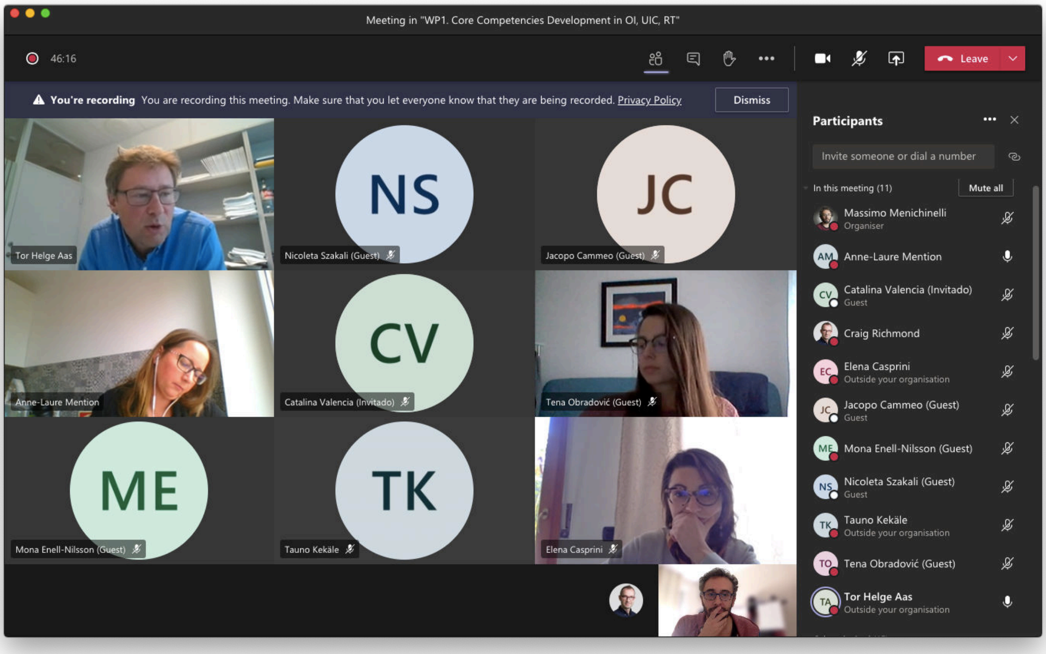


Figure 12 Masterclass: How to analyse Research Translation cases in University-Industry Cooperation (Online, 20 and 27/10/2020)

2.9 Masterclass: How to analyse Research Translation cases in University-Industry Cooperation (Online, 20 and 27/10/2020)

RMIT Europe organised a masterclass[9] for identifying and analysing Open Innovation cases developed between universities and industries within the emerging approach of Research Translation, in the sector of FinTech, Industry 4.0, CleanTech and FoodTech. The goal of this masterclass was to share and learn new approaches for understanding cases of Open Innovation that take place between University and Industry through Research Translation (Figure 12).

2.10 Coopetition workshop: How to collaborate with competitors for innovation? (Online, 06/11/2020)

The University of Agder (UiA) in collaboration with GCE NODE and with OpenInnoTrain as a partner, organised a workshop[10] aimed at bringing together key insights from researchers and inspiring new ideas and thoughts for future collaborations. The workshop was a part of the dissemination of the results of the ongoing PhD project "Management of challenges in collaboration between competitors for innovation" (Figure 13).

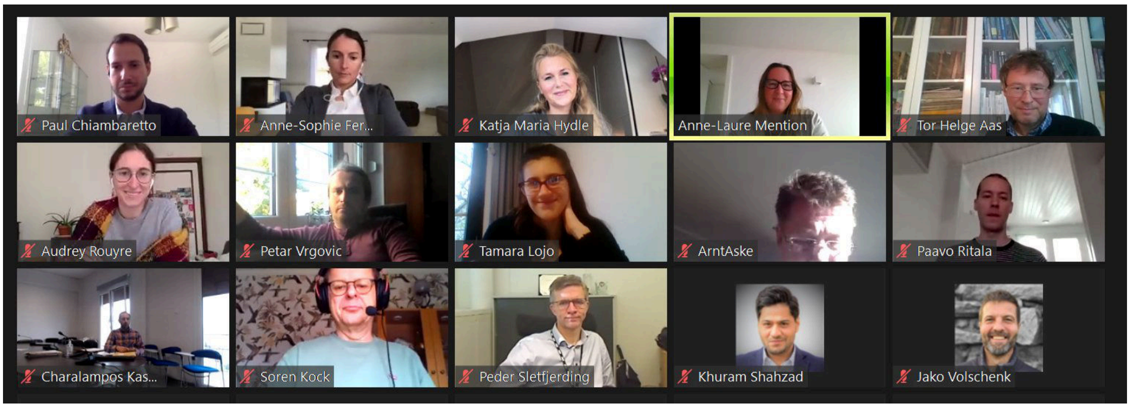


Figure 13 Coopetition workshop: How to collaborate with competitors for innovation? (Online, 06/11/2020)

[9] https://www.openinnotrain.eu/events/masterclass-how-to-analyse-research-translation-cases-in-university-industry-cooperation/
[10] https://www.openinnotrain.eu/events/coopetition-workshop-how-to-collaborate-with-competitors-for-innovation/

2.11 Paper Development Session for the special issue "Co-design and collaborative innovation for grand challenges" (Online, 18/11/2020)

For the special issue on *Co-design and collaborative innovation for grand challenges* in IEEE Transactions on Engineering Management, the guest editors provided prospective authors the opportunity to receive feedback on (preliminary) extended abstracts of their papers. For this purpose, co-authors Anne-Laure Mention, Pierre-Jean Barlatier and Sjoerd (Georges) Romme, conducted an online meeting on November 18th, 2020, organised by RMIT[11].

2.12 Innovation success in price sensitive markets with frugal solutions (Online, 25/11/2020)

TUHH organised a workshop on the topic: "*Does innovation always have to mean High – Tech?*". In order to achieve long-term success in emerging countries such as India and China, but also in Germany, frugal innovations in the company portfolio are increasingly indispensable. But what do the innovation drivers in German industry think about this? The event was conducted in German and there were participants from German companies attending via Zoom and Youtube stream. This was the first session on a seminar series on Frugal Innovation led by TUHH, from which other sessions took place in 2021, such as an online seminar called Frugal innovation for social benefit: how responsive entrepreneurs can create affordable excellence.

2.13 Open Access, Open Science and Horizon 2020 projects (Online, 14/12/2020)

Organised by RMIT Europe, this session by Massimo Menichinelli discussed what it is, how it works and how it fits into Open Science and the Horizon 2020 framework. The 1-hour session (webinar)[12] took place online on Microsoft Teams. The webinar explored how publishing scientific articles and other publications as Open Access has become an established practice so much that it is now even a requirement for peer-reviewed publications in Horizon 2020 projects. And it analysed the many doubts and questions about how to adopt the Open Access approach in the most useful and strategic way for each researcher.

[11] https://www.openinnotrain.eu/events/paper-development-session-for-the-special-issue-co-design-and-collaborative-innovation-for-grand-challenges/
[12] https://www.openinnotrain.eu/events/open-access-open-science-and-horizon-2020-projects/

2.14 First Summer School (Online, 17-21/05/2021)

The first OpenInnoTrain Summer School, organised by RMIT Europe and RMIT[13], focused on teaching researchers at different levels of their research careers about the importance of research impact in both academia and industry and about the ways in which impact can be delivered at different stages of research. The Summer School aimed to provide an understanding about the established research pathways for conducting and delivering impactful research and to understand how to implement the tools and techniques required for generating impact through research. See Chapter 13: *Exploring how to plan and manage the impact of research: the first OpenInnoTrain Summer School* for an in-depth description of the event.

2.15 IEEE TEMSCOM - Panel "Digitalisation and Industry 5.0 – Implications on different domains" (Online, 20/05/2021)

Organised by TUG, the 4th day of TEMSCON EUROPE 2021[14] conducted by IEEE TEMS in collaboration with the Faculty of Economics & Business, University of Zagreb, Department of Economics and Business, University of Dubrovnik, was a grand success and it was enriched with top personalities from different fields of Tech and Management (Figure 14).

2.16 Sessions at ISPIM 2021 (Online, 21-23/06/20201)

At ISPIM 2021[15], OpenInnoTrain participated through three sessions. The first one, called *Industry 5.0 – the Next Frontier*, led by Anne-Laure Mention, explored the conceptual boundaries of Industry 5.0, the way it related to Society 5.0 and the global state of play with respect to the adoption of its underlying principles through a high-level pitch from each panellist. The second session was entitled *Communicating your Research: The Beyond Publishing Panel*, a workshop presented by Enrique Orduña (University of Valencia), which explored the new challenges faced by journals. The last session was called *Collaboration for innovation in financial services*, moderated by Tor Helge Aas from UiA with a great line-up of experts representing academia, industry and policy, who delivered short presentations introducing their experiences, perceptions and perspectives on collaboration for innovation in financial services (Figures 15-17).

[13] https://www.openinnotrain.eu/events/summer-school-2021-creating-impact-through-research/
[14] https://2021.europe.temscon.org/
[15] https://www.ispim-innovation-conference.com/

Figure 14 IEEE TEMSCOM - Panel "Digitalisation and Industry 5.0 – Implications on different domains" (Online, 20/05/2021)

2.17 OpenInnoTrain participation at DRIVES Workshop (Online, 02/07/2021)

Innovation Agent was a workshop organised by ISCN built on the field studies of EU Blueprint projects like DRIVES[16], where the association of manufacturers and suppliers in Europe cooperated to identify the major drivers of change which will influence how Europe will look in 2030 (Figure 18).

2.18 R&D Management Conference 2021 - online session entitled "Frugal innovation and digitalisation: Crossing boundaries and creating impact" (Online, 07-08/07/2021)

On July 7, the Institute for Technology and Innovation Management (TIM) at TUHH, via its Center for Frugal Innovation, co-organised a special track on the theme of "*Frugal Innovation and Digitalisation: Crossing Boundaries and Creating Impact*"[17] at the recently concluded R&D Management Conference 2021 ("RADMA"). RADMA took place in an online format in 2021 after its postponement in the previous year due to COVID-19 related disruptions.

16 https://www.project-drives.eu/en/home
17 https://www.rnd2021.org/Conference-Tracks/id/409

Figure 15 Sessions at ISPIM 2021 (Online, 21-23/06/20201): part of the online workshop *The Beyond Publishing Panel*, presented by Enrique Orduña

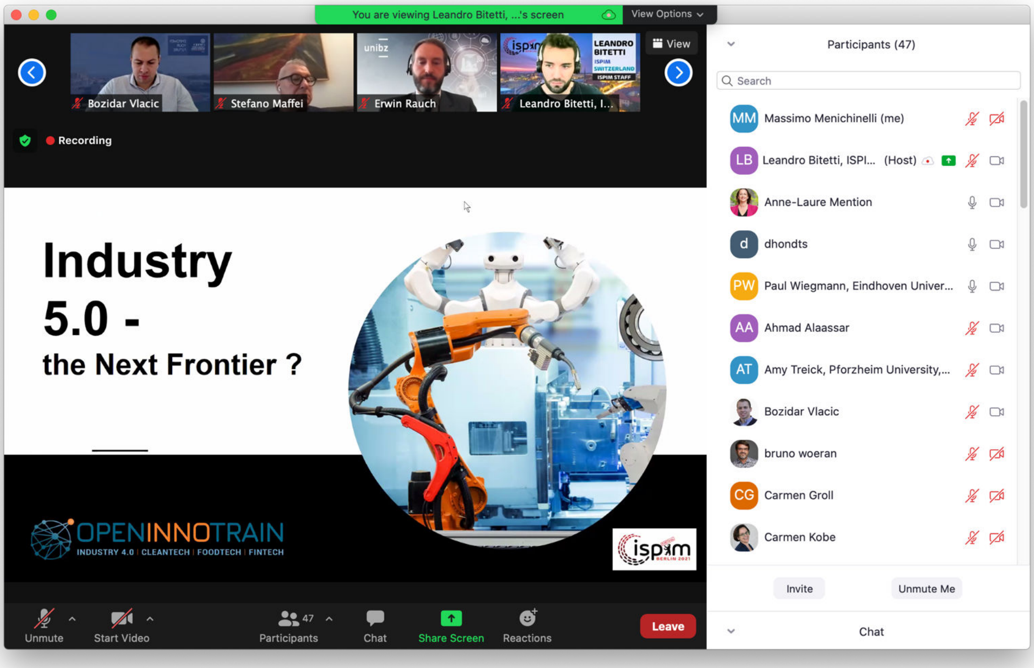


Figure 16 Sessions at ISPIM 2021 (Online, 21-23/06/20201): part of the online presentation called *Industry 5.0 – the Next Frontier*, led by Anne-Laure Mention

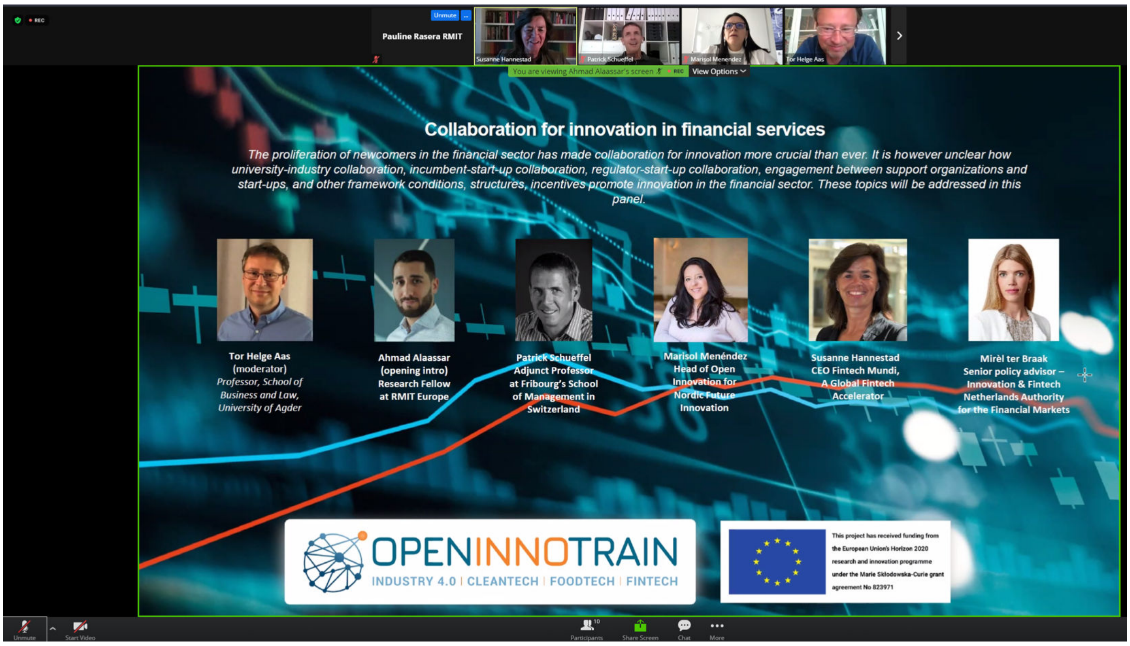


Figure 17 Sessions at ISPIM 2021 (Online, 21-23/06/20201): part of the online session *Collaboration for innovation in financial services*, moderated by Tor Helge Aas

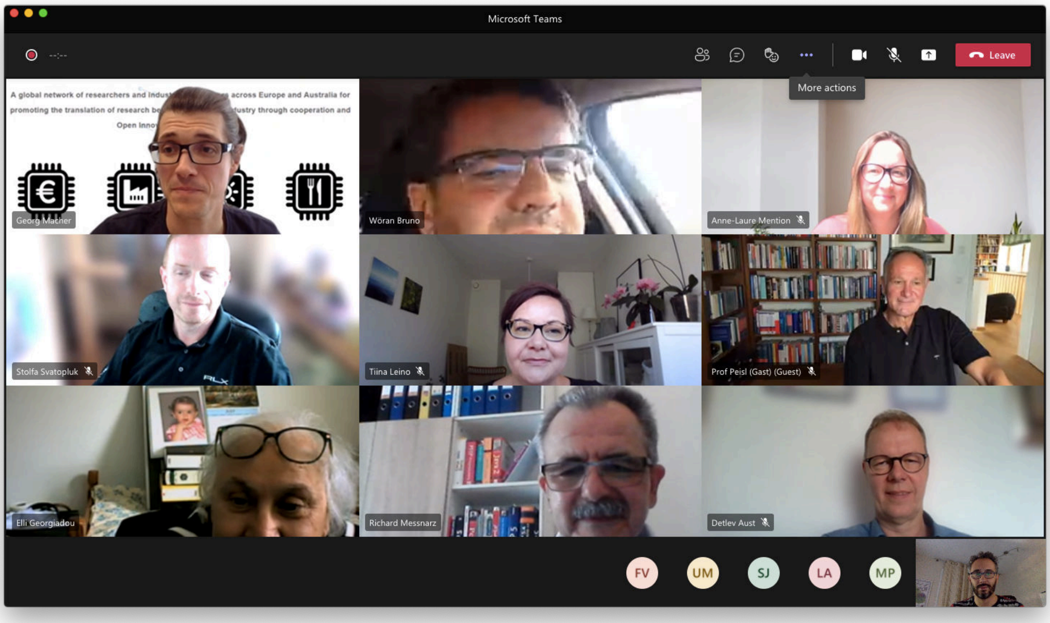


Figure 18 OpenInnoTrain participation at DRIVES Workshop (Online, 02/07/2021)

2.19 Summer Workshop Industrial Research and Innovation in Circularity and Resource Recovery - UPC (RECOPPs) (Online, 14-15/07/2021)

RECOPPs project, funded by EIT Raw Materials celebrated its first Training Course last 14th and 15th of July. An elite panel of researchers and industrial professionals from around Europe gathered in this event to discuss the pioneer implementation of circularity and resource recovery practices in industrial research and innovation. The online event[18] was supported by Barcelona Tech-UPC, OpenInnoTrain and UPC Hub Recircula. With 49 participants during the two-day sessions, the event was considered a success.

[18] https://recopps.com/2021/07/21/circularity-and-more-in-recopps-first-training-course/

3 The first two years and half of OpenInnoTrain

Anne-Laure Mention

This section aims to provide glimpses on the implementation of OpenInnoTrain, and snippets on its achievements. This endeavour is pursued by compiling some artefacts from the project life, such as newsletters and communications.

3 July 2019

We recently had a wonderful first OpenInnoTrain Workshop in Siena[1], led by Dr. Elena Casprini and Prof. Lorenzo Zanni. Keynotes and panellists shared their insights on challenges and opportunities related to university-industry cooperation in the context of FoodTech and CleanTech. We also undertook an amazing eld trip across the beautiful Montepulciano region, where our OpenInnoTrain partner, the Salcheto winery, lavishly treated us with their eco-friendly delightful products!

In the next few months, OpenInnoTrain will also be featured as a caucus at the Academy of Management in Boston, as well as at the upcoming EuroSPI conference in Edinburgh[2], thanks to the amazing work of Rumy Narayan. We also have an upcoming event in Vaasa (led by the University of Vaasa and Merinova), at the intersection of CleanTech and Industry 4.0 early September.

It is also an amazing pleasure to advise that OpenInnoTrain will be featured at the 2019 World Open Innovation Conference in Rome, with a panel session scheduled on Friday 13 December[3]. We will seize the opportunity of this conference to gather the consortium in a partnership meeting, for which more information will be shared as soon as the logistics are sorted out.

Besides events, the 1[rst] secondments have now happened, with some secondees sharing their experience below. OpenInnoTrain's spillovers have also occurred – with some spin of proposals already submitted! Congrats to all proposal leaders and the best of luck in all these endeavours!

During my European tour, I also had the opportunity to meet the Project Officer at the European Commission. Our project is clearly on the spotlight – we are dealing with key economic and societal issues, and as such it has the potential to be a trailblazer in its area.

1 https://www.openinnotrain.eu/events/oi-challenges-foodtech-cleantech-siena-2019/
2 https://2019.eurospi.net/
3 https://www.openinnotrain.eu/events/6th-annual-world-open-innovation-conference/

4 August 2019

We are having our second OpenInnoTrain Workshop on "*Open Innovation for Digitization: Industry 4.0, IoT, Cleantech and Energy Systems*" in Vaasa[4] this week and a session at the upcoming EuroSPI conference mid-September, in Edinburgh, which is the result of Rumy's very successful and productive secondment.

In August, we also had a fruitful caucus at the Academy of Management conference[5], where progress on the project was discussed with participants, as well as opportunities to trigger new cooperation and secondments. The PhD cohort at the University of Copenhagen is now fully informed on those opportunities and is currently processing an expression of interest for secondments within the consortium. Special thanks to Sunny and Gergana (and Marcel as their supervisor) from UCPH for taking the lead on this!

It is also a pleasure to officially welcome on board our new partners – Nofima and Lorit – with the opening of new secondments opportunities in Norway and Scotland respectively. I encourage you to reach out to them for further activities and secondments.

Over the European summer, many new connections have been established and it is particularly rewarding to observe new ties being developed and others being strengthened. For example, Ivana Kovač from UniZAG went to a secondment to Salcheto during this month.

As we are approaching the end of the first year of the project, the mid-term review is currently being organised and is scheduled for March 20, 2020. It will be hosted in Barcelona, and will be organised in conjunction with the first "summer school" (technically Spring school). More details will follow shortly but please do save the date as all partners are expected to attend – this is a critical meeting, with our Project Officer, to assess the progress of the project as well as its long-term viability.

5 January 2020

Every new year brings about new challenges! The key one for us this year is the mid-term review, to be held on Friday 20th March in Barcelona, preceded with a partners-only meeting on Thursday 19th March from 2pm onwards.

2020 promises to be another exciting year for us with several activities foreseen. We start off with a workshop on Wednesday 18th March as part of Vaasa EnergyWeek, to enable partners to meet and discuss Open Innovation, Research

[4] https://www.openinnotrain.eu/events/oi-digitalization-i40-cleantech-vaasa-2019/
[5] https://my.aom.org/program2019/SessionDetails.aspx?sid=16342

Translation and University-Industry Cooperation as means to support the energy transition.

Next, the first OpenInnoTrain Spring School will be held in Zagreb during 24th to 27th March. Right after our Spring School, Zagreb will host the 7th MCAA General Assembly and Annual Conference 2020[6] on 28th and 29th March, where alumni of Marie Skłodowska-Curie actions will meet, with opportunities for international networking for the participants.

In July, OpenInnoTrain will be part of a panel at the Euro Science Open Forum 2020 in Trieste. Together with two other RISE projects, SME 4.0 and MAKERS, this panel under the theme of the *4th Industrial revolution*, is about the knowledge transfer of Industry 4.0 from research to industry[7].

More events are being developed such as the one- day event running consecutively with Open and User Innovation Conference. Led by TUHH, this event focusses on "*Open Innovation and Societal Challenges*" and will take place on Wednesday 8th July at RWTH Aachen[8].

The past year has seen us developed strong ties between our partners as well as external institutions, and we have been busy organising various workshops and events. Recently our consortium meeting took place in Rome, right before the World Open Innovation Conference. We ended the year with our OpenInnoTrain-food oriented session at WOIC where we discussed how in the FoodTech sector, Open Innovation and Research Translation can be facilitated between academia and industry within the University-Industry Cooperation (UIC) framework.

6 April 2020

We find ourselves in unchartered times, with a high degree of complexity and uncertainty, and it has taken its toll on everyone, families and of course, the OpenInnoTrain Project.

In light of the current situation, all OpenInnoTrain events have either been postponed, rescheduled or, at times, cancelled. We are exploring online options for some activities, and will aim to participate to some events held virtually in the next few months. One of them is the upcoming ISPIM conference, which has been shifted to an online event, and where OpenInnoTrain will be represented – more to come on this soon.

---

[6] https://www.mariecuriealumni.eu/mcaa-events/2020-mcaa-general-assembly-annual-conference
[7] https://youtu.be/5wSHMVVdI8Q - https://www.openinnotrain.eu/events/euro-science-open-forum-esof2020/
[8] https://www.openinnotrain.eu/events/open-innovation-and-societal-challenges-oui-2020/

As you already know our mid-term review has been postponed and rescheduled to April 28 – invitations have been sent out, and please keep an eye for further communication, such as the updated agenda. We have done our very best to compact the agenda and restrict everyone's presence to the bare minimum, given the current circumstances and the complexity of handling a conference call with over 25 participants! In view of the mid-term review, may I ask you to review your secondment plan and provide the necessary updates to Massimo, preferably before the Easter long weekend. Secondments until Q4 for 2020 are unlikely to happen, and it is essential that the secondment's reporting - which will be presented to the European Commission during the mid-term review – reflects this reality. Further ways to mitigate the impact on OpenInnoTrain's delivery and delivery timeline are explored, and all suggestions are welcome.

I also would like to introduce Catalina Valencia who is supporting our communication and social media strategy for OpenInnoTrain. Catalina will shortly be in touch to seek stories, initiatives, efforts or news that you would be willing to share with our OpenInnoTrain community and followers. Information sought can be in relation to your research, your secondment or your (and your organisation's) initiatives towards the COVID19 recovery and regrowth. Please give Catalina a warm welcome and watch out for her emails.

7 May 2020

The last few weeks have been quite busy – we held the mid-term review with our Project Officer from the Research Executive Agency as a virtual meeting on April 28. Boaz and Massimo, from RMIT Europe and I presented an overview of progress, mainly covering secondments, scientific progress, and dissemination activities. OpenInnoTrain Work Package leaders (myself for WP1, Tor Helge for WP2, Marina for WP3, Mona for WP4, Nico for WP5, Massimo for WP6 and 7) then briefly updated the Project Officer on progress in each WP, and across WPs. During the last session of the day, we hosted secondees' presentations reflecting on the impact of their secondments, both from an individual and organisation perspective, and concluded with insightful discussions and avenues to move the project forward.

In a nutshell, the *outcome of the review* was mixed: OpenInnoTrain is delivering well in terms of scientific results, yet we are heavily underperforming in terms of secondments, and a catch-up plan needs to be designed and implemented before the next progress report. Failure to deliver will imply a downsizing of the project's budget. On the other hand, if we manage to ramp up on secondment activities, OpenInnoTrain could be featured as a success story and invited to join the Horizon Booster Programme[9]. It is now up to each and all of us to make this happen!

[9] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/d-e-booster

So as Europe slowly – but hopefully steadily – recovers from the pandemic, I would urge you to go back to planning your secondments, and liaise with your colleagues so that we can achieve the 540 person months of secondments, as initially planned.

There have also been exciting developments in some WPs – for example, Nico and Elena have recently launched a special interest group on Food Systems Innovation, which I invite you to join! Kudos to Nico and Elena for this initiative and for creating an environment conducive to sharing ideas and knowledge in your WP, and beyond!

In order to facilitate further interactions within and across work packages, we will also be working closely with WP leaders to set up *WP-centred events* that aim to share and exchange on activities, as well as identify further opportunities for secondments. Stay tuned and watch out for more comms on this from Massimo.

On another note, the Project Officer encouraged us to continue with our dissemination strategy, and our involvement in externally facing events and activities. These events will obviously be organised online for a little while, and we welcome suggestions from all partners for small scale activities. Face-to-face workshops and events will be resumed once international travel restrictions are lifted, and when secondment activities ramp up.

A final note to express my sincere thanks to Bruno Woeran, who is leaving Merinova to take up a new challenge in Austria! It has been wonderful to have you onboard Bruno and I am sure we will find new ways to collaborate. I would also like to seize the opportunity to introduce Prof. Tauno Kekäle, who is stepping up in the role of EU Affairs Manager at Merinova and will be our key contact person for OpenInnoTrain – Welcome onboard Tauno!

8 June 2020

A lot has happened the last few months in our community – we successfully passed the first critical milestone (with the mid-term review) and have been collectively revisiting activities so as to maintain engagement and sustain momentum in our consortium. Living through the imposed and accelerated digital transformation, we are holding our events online and increasingly participating to virtual gatherings. Recently, Tor Helge, Elena, Bruno, Massimo and I hosted a workshop at the 2020 ISPIM Virtual conference around the impact of mobility actions and university-industry cooperation[10]. For those of you who know the atmosphere of the ISPIM community, this virtual event was indeed nowhere close to the real thing, yet it has been an interesting experience, gathering an impressive line-up of thought leaders, all delivering messages in a positive spirit.

---

[10] https://www.openinnotrain.eu/events/xxxi-ispim-innovation-conference-virtual-event/

In the coming weeks, each context-specific Work Package Leader (Tor Helge for FinTech, Marina for Industry 4.0, Mona for CleanTech and Nico for FoodTech) will convene an online workshop aimed at fostering conversations on areas of collaboration, joint research ambitions, and research translation plans.

Those workshops will be a great opportunity to share and exchange information about ongoing activities, as well as launch new initiatives – this is exactly what OpenInnoTrain is for, in that it is meant to provide the framework conditions for your research to be developed and translated with industry partners, and beyond.

Our next big thing will be the update of the secondment plan as borders reopen and travel restrictions are lifted. As you know, the funding from OpenInnoTrain comes exclusively from secondments, so it is critical to resume them as soon as it is feasible and safe to proceed. We also need to put a strong focus on preparing most of the "2-year mark" deliverables, i.e. state of practices executive reports across all WPs - and increasingly start compiling information on our research outputs (e.g. research papers and other contributions which have been developed in the context of secondments) and delivering our impact assessment reports.

9 August 2020

The pandemic continues to provide unforeseen challenges to the smooth running of our project, and there has a been marked interruption in our secondee movements. As some countries in Europe progressively reopen their borders, we expect secondments to resume. However, we must be very aware that the situation is not completely clear in the long run and any secondee who wishes to proceed with their secondment must take all the necessary precautions about travel arrangements and cater for uncertainty, as well as potential disruptions. A certain measure of prudence is required if you are booking flights and accommodation, for example.

While we aim to maintain a strong presence in international events, as well as continue to offer networking opportunities among partners, we also do need to take a conservative approach with regard to travel expenses – the well-known part B budget which is only available when secondments occur and that funds dissemination at project level and research, training and networking costs at partner level. Accordingly, I am convinced you will understand that all 2020 events have been shifted to an online delivery mode, in view of minimising costs while guaranteeing that those will actually happen. We surely do not want last minute cancellations due to travel restrictions.

Our Work Package Leaders have also done a tremendous job in facilitating WP-specific workshops, where partners had to opportunity to share their experience, research and innovation interests, and to virtually mingle. Some highlights are reported below, and I look forward to these events moving to the next level, and more activities being generated.

We are participating in two externally organised events in September with the details below: the Euro Science Open Forum 2020[11] and the EuroSPI Dusseldorf Workshop Series[12]. The University of Zagreb, together with industry partner Koncar, will be hosting a 2-day Autumn school as well as a workshop late September[13].

I am also thrilled to announce the first published papers from this project – see more information on the Publications section of the OpenInnoTrain website[14]. There are also calls for papers that fellow academics could find relevant, see the CfP section[15] for more information.

10 September 2020

As the global crisis continues, its implications are daunting for many of us. Yet, there are plenty of positive signals and things happening and I would like to seize the opportunity of this newsletter to celebrate our successes, big or small.

In Europe, we now seem to be keeping in sync with one of the founding principles of the EU – free movement of people. Something that, personally, I truly feel like celebrating as this form of freedom should – apparently – not be taken for granted. This means that our secondment programme has progressively resumed, and that more secondments are either currently being implemented or will start shortly.

Besides secondments, there is a lot happening in the OpenInnoTrain space! We have been present in two events recently. The EuroScience Open Forum hosted its annual event on 2-6 September. I represented OpenInnoTrain through a presentation on "*Research with Impact in the Tech Economy*"[16]. Moderated by Simona Losmanova of the Research Executive Agency (EU Commission), the main theme of the session was the 4th industrial revolution. Two other H2020 RISE projects revolving on the digital transformation and its implications were presented, as well as industry insights from Siemens. It was a great opportunity to showcase the research we have been conducting but also to connect with researchers, thought leaders and policymakers with a shared interest in shaping the future of open science and supporting the European leadership in this area.

---

[11] https://youtu.be/5wSHMVVdI8Q - https://www.openinnotrain.eu/events/euro-science-open-forum-esof2020/
[12] https://www.openinnotrain.eu/events/eurospi-dusseldorf-workshop-series/
[13] https://www.openinnotrain.eu/events/openinnotrain-2020-phd-workshop-how-to-publish-a-research-paper-successfully/ - https://www.openinnotrain.eu/events/new-date-grand-opportunities-and-challenges-for-industry-4-0-and-foodtech-building-the-bridges-through-open-innovation/
[14] https://www.openinnotrain.eu/publications/
[15] https://www.openinnotrain.eu/call-for-papers/
[16] https://youtu.be/5wSHMVVdI8Q - https://www.openinnotrain.eu/events/euro-science-open-forum-esof2020/

OpenInnoTrain was also present at the EuroSPI Workshop Series where Bruno Woeran, Richard Messnarz, Georg Macher and Massimo Menichinelli participated in two "Recent Innovations" workshops namely "Democratizing Innovation in the Digital Era: Empowering Innovation Agents for Driving the Change" and "OpenInnoTrain - Open Innovation Transfer Opportunities"[17].

We have a few events planned and please see below for more further information. The OpenInnoTrain PhD Workshop (24th September) on "*How to publish a research paper successfully?*"[18] is an activity for doctoral students and early-stage researchers and is a great opportunity to explore new knowledge. On 25th September, the workshop on "*Grand opportunities and challenges for Industry 4.0 and FoodTech – building the bridges through Open Innovation*"[19] is scheduled. We are delighted to announce a masterclass on "*How to analyse Research Translation cases in University-Industry Cooperation*"[20] which is scheduled on 20th and 27th October. All these events are online.

On another positive note, two more papers from this project have been published – see more information on the Publications section of our website.

11 October 2020

It is clear that the global crisis is far from being resolved and there is a second wave of the pandemic being experienced in Europe which will have some impact on our project. Nonetheless, the OpenInnoTrain project has continued its progression with a number of events having taken place and secondments underway. There are more events being planned as well as more secondments in the pipeline.

At the end of the year, we have another major milestone – the submission of the "state of practices" deliverables across WP1-5. Those deliverables are essential to showcase the timely and significant progress of our project, and I would call on all of you to respond to their WP leaders' calls for contribution.

Some highlights of the past events are below. We organised a PhD workshop on "*How to publish a research paper successfully*"[21], which was very successful. There was also the workshop on "*Grand opportunities and challenges for Industry 4.0*"and

[17] https://2020.eurospi.net/index.php/workshop?id=53
[18] https://www.openinnotrain.eu/events/openinnotrain-2020-phd-workshop-how-to-publish-a-research-paper-successfully/
[19] https://www.openinnotrain.eu/events/new-date-grand-opportunities-and-challenges-for-industry-4-0-and-foodtech-building-the-bridges-through-open-innovation/
[20] https://www.openinnotrain.eu/events/masterclass-how-to-analyse-research-translation-cases-in-university-industry-cooperation/
[21] https://www.openinnotrain.eu/events/openinnotrain-2020-phd-workshop-how-to-publish-a-research-paper-successfully/

"*FoodTech – building the bridges through Open Innovation*"[22] which took place on 25th September, masterfully organised by Prof. Marina Dabić and PhD candidate Tena Obradović, for University of Zagreb. Finally, our masterclass (two sessions) on "*How to analyse Research Translation cases in University-Industry Cooperation*"[23] was very well received by the participants, and also gave us an opportunity to deepen cross-fertilisation opportunities across our 4 specific contexts.

We have a few more events planned in the coming weeks. On 6th November, the "*Coopetition workshop: How to collaborate with competitors for innovation?*"[24] is about the challenges and opportunities when collaborating with competitors, led by University of Agder. On 18th November we are running a paper development session for the special issue "*Co-design and collaborative innovation for grand challenges*"[25], for a special issue in IEEE TEMS that I am co-guest editing with Prof. Romme (Eindhoven) and Assoc. Prof. Pierre-Jean Barlatier (EDHEC). Another OpenInnoTrain partner, TUHH is organising a workshop on "*Innovation success in price sensitive markets with frugal solutions*"[26] on 25th November.

OpenInnoTrain partners are involved in several special issues and I would like to bring to your attention the call for papers "*The limits of open innovation: Failures, risks, and costs in open innovation practice and theory*" for a special issue in Technovation.

Finally, I would like to note that we have so far recorded five publications and these can found on the Publications section of our website.

12 December 2020

As we say farewell to 2020, we reflect on what has been a very unusual year, which has brought us the challenges of dealing with the COVID-19 pandemic, but it has also shaped different ways of working and living. In Europe we are seeing a recurrence of the global health crisis and we are now experiencing another lockdown in many parts of the continent. We are again finding ourselves in unchartered times, with a high degree of complexity and uncertainty, and it has taken its toll on everyone, families and of course, the OpenInnoTrain Project.

---

22 https://www.openinnotrain.eu/events/new-date-grand-opportunities-and-challenges-for-industry-4-0-and-foodtech-building-the-bridges-through-open-innovation/
23 https://www.openinnotrain.eu/events/masterclass-how-to-analyse-research-translation-cases-in-university-industry-cooperation/
24 https://www.openinnotrain.eu/events/coopetition-workshop-how-to-collaborate-with-competitors-for-innovation/
25 https://www.openinnotrain.eu/events/paper-development-session-for-the-special-issue-co-design-and-collaborative-innovation-for-grand-challenges/
26 https://www.openinnotrain.eu/events/innovation-success-in-price-sensitive-markets-with-frugal-solutions/

With this in mind, we have secured a suspension of the OpenInnoTrain project. This would allow us to reset for the time being as we in the midst of dealing with the global pandemic but also give us the time to meet our targets with an extension of the project.

Having said this, and however challenging 2020 has been, the OpenInnoTrain project has made a lot of progress with regards to the number of events we organised and participated in as well as the number of secondments having taken place, in spite of the global uncertain territory we find ourselves in.

Throughout the year, together with our partners we organised several events – these were mostly online in view of the global situation, and we also participated in externally organised events such as the Euro Science Open Forum 2020 and the EuroSPI Dusseldorf Workshop Series.

More recently, the University of Agder led a workshop on 6th November, entitled "*Coopetition workshop: How to collaborate with competitors for innovation?*", which was about the challenges and opportunities when collaborating with competitors. On 18th November we ran a paper development session for the special issue "*Co-design and collaborative innovation for grand challenges*", a special issue in IEEE TEMS that I am co-guest editing with Prof. Romme (Eindhoven) and Assoc. Prof. Pierre-Jean Barlatier (EDHEC). Another OpenInnoTrain partner, TUHH organised a workshop on "*Innovation success in price sensitive markets with frugal solutions*" on 25th November. Please see further highlights of some of these events below.

We have also had several journal publications this year, and I am delighted to announce the publication of the book "*Business models, strategies and innovation of companies that apply high technology to cultural goods: first evidence in Italy*" authored by Elena Casprini and Tommaso Pucci[27].

I am sure you will all join me to extend our heartfelt congratulations to Massimo for having defended his dissertation in New Media at Aalto University[28].

13 February 2021

It is clear that we are still facing the consequences of the pandemic and we are far from having completely turned the corner but there are positive news coming from the vaccine rollout.

[27] Casprini, E., Pucci, T., 2020. Business models, strategies and innovation of companies that apply high technology to cultural goods: first evidence in Italy. Declar srl, Pisa. https://doi.org/10.5281/zenodo.4287449
[28] Menichinelli, M., 2020. Open and collaborative design processes - Meta-Design, ontologies and platforms within the Maker Movement, DOCTORAL DISSERTATIONS. Aalto University. http://urn.fi/URN:ISBN:978-952-64-0091-4

With this in mind, we have been very active behind the scenes to set us up for a positive restart of the project once the suspension period is over. I have to say that as a team, we have shown tremendous resilience in the face of the global crisis. We managed to organise many events last year and are now planning many more for the future. We have continued our collaborative work and our publications are increasing. On this note, I would like to thank WP leaders and all the partners who have continued to plan activities, events and secondments. This is an important part of the next few months as we prepare for the restart of our project.

We are delighted in having two more publications:

- "*Open innovation in the manufacturing industry: A review and research agenda*" by Tena Obradović, Božidar Vlačić and Marina Dabić in Technovation[29].
- "*Exploring a new incubation model for FinTechs: Regulatory sandboxes*" by Ahmad Alaassar, Anne-Laure Mention & Tor Helge Aas in Technovation[30].

In December we launched our YouTube channel and please connect with us there too[31].

On a more personal note, I was honoured to have been featured as part of "*International Day of Women and Girls in Science 2021*" by the Marie Skłodowska-Curie Actions[32].

Finally, I am sure you will join me in extending a warm welcome to Pauline Rasera, who is joining us as EU Project Manager and you will be hearing from her more in the coming weeks and months.

14 March 2021

As Europe continues to strive to return to a degree of normality, especially through the vaccine rollout, we would like to make sure that we are ready to resume the main activities of the project, such as secondments, as soon as the suspension period is over. Therefore, we encourage partners to continue to collaborate in

[29] See section 8 - Obradović, T., Vlačić, B., Dabić, M., 2021. Open innovation in the manufacturing industry: A review and research agenda. Technovation 102221. https://doi.org/10.1016/j.technovation.2021.102221
[30] Alaassar, A., Mention, A.-L., Aas, T.H., 2021. Exploring a new incubation model for FinTechs: Regulatory sandboxes. Technovation 102237. https://doi.org/10.1016/j.technovation.2021.102237
[31] https://www.youtube.com/channel/UCvzDl8P1eDGuHfbDO63CxXQ
[32] https://ec.europa.eu/research/mariecurieactions/news/international-day-women-girls-science-2021

preparing events and to create the framework conditions for secondments to restart.

We have recently published our first report "*Executive Report on State of Play in UIC and Research Translation in Europe and Australia*"[33]**,** one of our deliverables. A key takeaway from this report is that **"***The project has found that, for university-industry collaboration to be fully effective and research ideas to transform to useful knowledge, it needs to be matched with appropriate means and modes of research translation*".

I am delighted to share that we will be running our first online Summer School "*Creating Impact Through Research*", scheduled from 17 to 21 May 2021. More details are found below and also on the event page of our website[34].

We will also be taking part at the 2021 IPSIM Innovation Conference, Berlin. We will feature in a panel on "*Industry 5.0 – The Next Frontier*". This panel is tentatively scheduled on 21st June, (08:50- 10:05 CET)[35].

There are numerous news and events that we are sharing with you coming from our partners below. An example is the BEYOND4.0[36] project. There are two interesting events that BEYOND4.0 is organising: "*BEYOND4.0 Summer School*" and "*BEYOND4.0 Scientific Conference*".

15 April 2021

Despite the project suspension, there is still plenty going on among the consortium team as you'll discover further on. Behind the scenes, we continue the planning process to have us ready to welcome secondees to the project again from 2022 – an exciting prospect!

During the project's official pause, the advice of our Project Officer is to keep up our communication and dissemination activities. Based upon this guidance, I urge all OpenInnoTrain consortium members to actively contribute news items to our team at RMIT Europe – whether it be a new paper, a conference you've attended or a new project win.

Furthermore, we're encouraged to keep organising OpenInnoTrain-hosted online events related to our research topics – no matter how big or small. These events

---

[33] See section 0 - Mention, A.-L., Bhimani, H., Menichinelli, M., 2021. D1.1 Executive Report on State of Play in UIC and Research Translation in Europe and Australia (OpenInnoTrain No. D1.1). https://www.openinnotrain.eu/results/d1-1-executive-report-on-state-of-play-in-uic-and-research-translation-in-europe-and-australia/
[34] https://www.openinnotrain.eu/events/summer-school-2021-creating-impact-through-research/
[35] https://www.ispim-innovation-conference.com/
[36] https://beyond4-0.eu/

can take any format and even be co-branded with other projects. Do let the team at RMIT Europe know if you need any support!

In the meantime, we're very excited to be in the final preparation stages for our first Summer School to which we look forward to receiving participation from PhD candidates, postdocs, academics and industry fellows. With registrations open till May 2nd, there's still time to invite people within all of our networks to sign up and learn more about Creating Impact Through Research.

We have recently published the "*Entrepreneurial university: The relationship between smart specialization innovation strategies and university-region collaboration*"[37]. The results of this publication highlight that smart specialisation innovation strategies are enhancing university collaboration regionally. We learn that involvement of universities is an essential ingredient as well.

It's also fantastic to see OpenInnoTrain confirmed in the programme for the ISPIM Innovation Conference in June. In response to the conference theme, innovating our Common Future, several of us are lined up to moderate a panel on Industry 5.0. We'll not only give global perspectives on the current state of play but discuss how Industry 5.0 can contribute to the development of more human centric, resilient and sustainable societies.

At the same conference, there will be another panel hosted under the OpenInnoTrain banner. This session will focus on collaboration for financial services and will involve many from our team and include a presentation by Ahmad Alaassar, our PhD candidate in a cotutelle/joint supervision arrangement between RMIT University and University of Agder. On this note, congratulations to Ahmad who has just been appointed as a research fellow at RMIT Europe!

Finally, a hearty congratulations to our partner RMIT University on their outstanding results in the 2021 Times Higher Education (THE) University Impact Rankings[38]. Ranked number three overall in the world is a huge achievement.

16 June 2021

I'm delighted to deliver this newsletter off the back of our very first OpenInnoTrain Summer School! Over 70 people interested in Creating Impact Through Research registered for the week-long event at the end of May to participate in the interactive programme covering how to plan and achieve effective research impact.

---

[37] Bukhari, E., Dabic, M., Shifrer, D., Daim, T., Meissner, D., 2021. Entrepreneurial university: The relationship between smart specialization innovation strategies and university-region collaboration. Technology in Society 65, 101560. https://doi.org/10.1016/j.techsoc.2021.101560

[38] https://www.rmit.edu.au/news/all-news/2021/apr/rmit-number-three-globally-impact-rankings

I'd like to express my thanks to all of the Summer School's attendees for your contributions and the inspiring discussions. Furthermore, I hope that the knowledge and learnings you have taken from the Summer School will assist you to achieve impact in your own research endeavours!

My gratitude also goes to all those who helped to plan or lead a session in the programme. We have all benefitted from your expertise and I appreciate your time and effort in joining us in this special week. Of course, the Summer School could not have gone ahead without the hard work of our organising committee and I applaud their achievements in organising and delivering this successful and productive event. Well done Ahmad Alaassar, Dr Massimo Menichinelli, Dr Avni Misra and Pauline Rasera!

In more good news, I'm pleased to announce the latest OpenInnoTrain publication, "Ecosystem dynamics: exploring the interplay within fintech entrepreneurial ecosystems", a collaboration between Ahmad Alaassar, Prof. Tor Helge Aas and myself.

In this paper we explore ecosystem dynamics within the FinTech entrepreneurial ecosystem in Singapore and explain how and why opportunity identification and resource exploitation are accelerated or inhibited for FinTech start-ups.

In May we hosted an OpenInnoTrain panel at the IEEE Technology & Engineering Management Conference (Temscon)[39]. Thank you to Petra Berg, Dr. Omar Veledar, Dr. Philipe Reinisch, Bruno Woeran and Georg Macher for a great session on digitalisation and Industry 5.0!

We're now preparing for a busy month with two sessions at the ISPIM Innovation Conference addressing the theme Innovating our Common Future. Join us there for sessions on Industry 5.0 - The Next Frontier and Collaboration for Innovation in Financial Services.

At July's R&D Management Conference OpenInnoTrain will participate in an online session entitled "*Frugal innovation and digitalization: Crossing boundaries and creating impact*"[40]. More details to come!

17 July 2021

A big highlight from the last month was the ISPIM Innovation Conference which took place at the end of June and during which OpenInnoTrain hosted two sessions. I had a terrific time leading the "*Industry 5.0 - The Next Frontier*" panel where I was joined by Assistant Prof. Erwin Rauch, Prof. Marina Dabić, Prof. Steven

[39] https://2021.europe.temscon.org/
[40] https://www.rnd2021.org/Conference-Tracks/id/409

Dhondt, Assistant Prof. Paul Wiegmann, Prof. Stefano Maffei and Assistant Prof. Bozidar Vlacic.

Thank you to Prof. Tor Helge Aas for facilitating the second OpenInnoTrain panel on the topic of "*Collaboration for innovation in financial services*". Tor Helge was joined by Dr. Ahmad Alaassar, Susanne Hannestad, Adjunct Prof. Patrick Schueffel, Marisol Menéndez and Mirèl ter Braak.

Both of our sessions attracted a good attendance and brought about many interesting insights and discussions as you'll discover later in the newsletter. I'd like to thank all of the panellists for your contributions, and look forward to further exploration of these topics and debates in the future!

For me it was also a pleasure to facilitate the "*Communicating your Research: The Beyond Publishing*" panel. This session provided lots of food for thought and initiated a debate on science evaluation and communication models. A particular thank you to Prof. Marina Dabić for sharing your strategies on outreach.

Besides the excitement of ISPIM, it was a thrill to receive the news that the Journal of Innovation Management (JIM)[41], which I co-founded in 2013 with Associate Prof. João José Pinto Ferreira and Prof. Marko Torkkeli, has received the SCOPUS indexing.

This recognition, which cements the journal's reputation for its quality research and multidisciplinary contributions to the area of innovation, could not have been achieved without the support of the extended editorial board and advisory board, or without the authors who believed in the journal from the beginning. If you missed my Ask the Editor session at ISPIM and are interested in publishing in JIM, please get in touch!

We continue to receive some very nice feedback from attendees of our first OpenInnoTrain Summer School, including from Dr. Bamini KPD Balakrishnan from the Universiti Malaysia Sabah who shared her new knowledge on creating impact through research with her colleagues at a recent workshop.

Congratulations to our OpenInnoTrain research fellow, who we can now call 'Dr. Ahmad Alaassar' following his recent graduation! He has received a PhD double degree from the University of Agder and RMIT University[42]. It has been a pleasure for both me and Prof. Tor Helge Aas to supervise you along this journey, Ahmad!

41 http://www.open-jim.org/

42 Alaassar, A., 2021. A Phenomenon-driven Exploration of Regulatory Sandboxes in FinTech Entrepreneurial Ecosystems (PhD Thesis). University of Agder. https://hdl.handle.net/11250/2758259

18 August 2021

Welcome to the August newsletter where we reflect upon recent achievements and look forward to everything coming up in relation to OpenInnoTrain!

As we start to look forward to a return to some degree of normality, with the vaccine rollout in full swing, the OpenInnoTrain project is also starting to prepare for its resumption. Details of this will be communicated very soon. We also note that cross country travel will continue to increase with the rise in uptake of the vaccine across Europe. Therefore, we would like to invite partners to start to consult their internal and national guidelines with regards to travel with the view of having a strong plan for secondments as soon as the OpenInnoTrain project is resumed.

We are currently finalising the first OpenInnoTrain book based on the deliverable 1.1. The book is entitled "*From Research to Innovation: Exploring the Translation Journey with OpenInnoTrain*" and presents highlights from the first 2 years of implementation of the project.

At the same time, we have been very active this summer with OpenInnoTrain represented during 3 events. On 2nd July, at the Innovation Agent workshop organised by EU Blueprint Erasmus+ project DRIVES[43], I presented the OpenInnoTrain project during this workshop. Georg Macher also gave a presentation on open innovation in the automotive domain from an engineer's view.

On 7th July, The Institute for Technology and Innovation Management (TIM) co-organised a special track on "*Frugal Innovation and Digitalization: Crossing Boundaries and Creating Impact*"[44] at R&D Management Conference 2021 ("RADMA"). This track was organised in partnership with OpenInnoTrain. We also supported RECOPPs summer workshop on "Industrial Research and Innovation in Circularity and Resource Recovery"[45]. This online event took place on 14th and 15th July.

The above collaborations are just two examples of our work to create synergies between EU projects. We highly encourage partners involved in other projects to discuss possible cooperation in terms of events, cross-communication, or even research exchanges.

There are a few forthcoming events where OpenInnoTrain will participate. I have been invited as a Keynote speaker at the Copenhagen Fintech Week as part of "*Research Symposium: Making the world a better place with Fintech research*"[46]. Scheduled on 13th of September, my talk is centred around the implications for

---

[43] https://learn.drives-compass.eu/
[44] https://www.rnd2021.org/Conference-Tracks/id/409
[45] https://recopps.com/2021/07/21/circularity-and-more-in-recopps-first-training-course/
[46] https://cphfintechweek.com/cfwprogram/

research, policy and practice in the age of FinTech. We will also have a presence at EuroSPI^2 2021 Conference and ISPIM Connects Valencia Conference 2021.

19 September 2021

As you will recall from the August edition, I mentioned that planning is well underway with the development of a post-suspension strategy for our project. More details will be communicated about the resumption of the project soon. In the meantime, I would highly recommend partners to continue to have discussions within our network to plan for secondments from early 2022.

We have been and continue to add significant value to the project through activities, initiatives and outputs from OpenInnoTrain and/or outputs that have come to fruition as a direct result of the OpenInnoTrain Project. There have been numerous over the last few months of which you would already be aware such as the OpenInnoTrain Summer School, our participation at ISPIM Berlin 2021, and several publications. On this note, we are finalising the publication of first book, entitled "*From Research to Innovation: Exploring the Translation Journey with OpenInnoTrain*". This book is now in the process of final editing and proof printing!

On 13th September, I presented our project at the "*Research Symposium: Making the World a Better Place with FinTech Research*"[47] held during the Copenhagen Fintech Week. My talk was centred around the implications for research, policy, and practice in the age of FinTech. This event was well attended with over 65 attendees. During EuroSPI^2, Georg Macher presented a paper entitled "*Balancing Exploration and Exploitation through Open Innovation in the Automotive Domain – Focus on SMEs*".

There are a few forthcoming events where OpenInnoTrain will participate. I have been invited as a speaker at Barcelona New Economy Week, taking place on 5-8th October. More details are found on their website[48]. OpenInnoTrain will also be involved at ISPIM Valencia 2021[49], to be held on 29th November to 1st December.

Our colleagues at TNO are involved in the organisation of the BEYOND Scientific Conference held on 30th September and 1st October in Sofia, Bulgaria. For more information on this conference, please visit the BEYOND website[50].

As you may be aware, we have been ramping up our social media presence and moving to a more targeted communication strategy. This supports all stakeholders and project partners in having more visibility and increased collaboration between partners but more importantly between stakeholders (external to OpenInnoTrain) within our areas of research and work. Therefore, it is

[47] https://cphfintechweek.com/cfwprogram/
[48] https://www.bnewbarcelona.com/
[49] https://www.ispim-connects.com/
[50] https://beyond4-0.eu/events/scientificconference

crucial that we all take a proactive approach in contributing to this communication strategy. Please see below for more information on how to support this strategy.

Finally, please join me in congratulating Dr Krish Sankaran (Radical Innovations Group AB), winner of Nordic Energy Challenge 2021[51]. Well done Krish!

[51] https://www.youtube.com/watch?v=LlHJkOKGjvI

4 Stories from the Secondees

OpenInnoTrain Secondees

Originally published here: https://www.openinnotrain.eu/researchers/

Sanja Smiljic

UIA → RMIT

10/01/2019 – 20/12/2020

PhD Student

https://www.linkedin.com/in/sanja-smiljic-85713555/

My name is Sanja Smiljic. I am a PhD Research fellow researching collaboration between competing companies (coopetition) as a form of open innovation practices, in mature industries. Based on previously collected data in Norway, I am qualitatively exploring management of the tensions and partner selection in coopetitive open innovation projects.

My PhD is based on a cotutelle agreement between the University of Agder in Norway and Royal Melbourne Institute of Technology, in Australia. In line with that, OpenInnoTrain secondment is a good opportunity to meet and collaborate with colleagues from both universities. Work in international environment is fruitful ground for new ideas, networking and establishment of new pathways for future collaboration.

As a researcher who is originally from Europe, and previously worked in a few different European countries, I consider the time at RMIT as a new experience not only in a professional, but also in a personal sense. It is a meeting point between continents and cultures and the opportunity for all of us to grow and learn from our differences.

Rumy Narayan

UVA → ISCN

30/04/2019 – 31/05/2019

PhD Student

https://www.linkedin.com/in/rumy-narayan-1362513/

I appreciate the freedom to explore and create my own path that the OpenInnoTrain secondment has offered me. This is important as my research involves understanding transition to sustainable energy systems as a process, with a special focus on organisational processes. The nature of the research demands innovative thinking that is able to identify how the current energy paradigm operates and influences distinctive paths and in doing so lay the groundwork for transitioning towards the new sustainable paradigm. In this context, decentralised technologies frequently referred to as blockchain gains relevance.

The secondment allowed me time and space to engage with the latest literature on decentralised technologies, including recent developments in the cryptocurrency space. Based on this material I developed a framework for designing organisational processes through tokenisation. The initial draft was shared with the industry partner and subsequently refined after getting feedback. This framework will be presented at a workshop at EuroSPI on September 19, 2019. This secondment created the opportunity for conducting pure research in addition to leveraging this research to inform businesses about practical transition pathways.

Impact of OpenInnoTrain on my career and organisation

I study transitions to sustainable energy systems. My research interests fall within a framework of innovation possibilities that could potentially address pressing global challenges of our time, while stimulating societal and economic prosperity. This entails activating innovations across sectors, actors, and disciplines, while enabling experimentations, a complex process that needs appropriate tools for coordinating and managing diverse networks.

How has the secondment created new perspectives for applying your knowledge in practical situations?

Transitions research is about changing paradigms that require unique ways of thinking and the consequences of information technology-sustainable energy nexus in this transition process is not very well-understood both within academia as well as industry. It is an opportunity for understanding the underlying structures that enable as well as prevent this process, and the mental models that influence these structures. It might not always translate into results that either academia or industry expects. This has implications on innovation and offers valuable clues into innovation processes – what is their contribution to the transition to a sustainable energy regime.

Transitions in energy systems have deeper implications as it involves questioning our very way of life. It is during such periods that past anomalies can cause tremendous amounts of dissonance. For instance, working with industry revealed some of the flawed knowledge structures that management science is built on and how important it is to challenge these structures in order to offer real solutions to industry.

How has the secondment created new career perspectives for you?

It has provided the opportunity to interact with industry actors and researchers from completely different disciplines and learn from them. With both researchers and industry actors, most often such learning experiences have been enriching and have led to fruitful collaborations.

The secondments have changed perceptions about jobs and careers completely and this change of perception has uncovered the value in developing multi-disciplinary skills and their relevance in the emerging environment.

How has the secondment given you global mobility opportunities?

I have had a global career, so that was not what I was looking for. The secondments have helped me frame a new understanding of career in the emerging information society, which is significantly different from how it is viewed through the lenses of a primarily industrial economy mindset. Learning and mobility is about contextualizing information strategically and that is what the secondments taught me.

The secondments offered opportunities to engage with day-to-day challenges faced by firms and how dominant narratives and prevalent energy configurations encourages path dependencies while impeding innovations that could help them navigate contemporary industrial and societal challenges. Globalisation is no longer about convergence of international markets, it's about diversity of ideas and creating market abundance for value creation and circulation.

How has the secondment given your organisation opportunities?

From the perspective of a doctoral student, one can say that these secondments have fostered valuable networks and links with other researchers and firms.

Zoran Krupka

UniZAG → RMIT_EU

30/07/2019 – 31/08/2019

Professor

https://www.efzg.unizg.hr/zoran-krupka-phd/32291

As part of University of Zagreb's team in "Horizon 2020 project: Open Innovation – Research Translation and Applied Knowledge Exchange in Practice through University-Industry-Cooperation", I have spent one month as a secondee at RMIT Europe in Barcelona. Since I am coming from academic institution, during my stay at RMIT Europe I have experienced a different kind of work focus and dedication.

As an academic, big part of my job is dedicated to students and students' related challenges, while the rest of the time I can invest in research and work related with companies. Here, at RMIT Europe, I have been completely dedicated to research projects which has greatly been influenced by surrounding and atmosphere at RMIT Europe office. During my stay I have finished two papers and submitted them to scientific journals. Also, I started to write research proposal which will be submitted to one of the EU grant competitions.

Finally, this experience has been great in gaining a different view at work that I do every day, in meeting new people with different background exchanging ideas and thoughts with them, as well as warm welcome from all of them making me feel as part of RMIT Europe office.

Tena Obradović

UniZAG → RMIT, 26/06/2019 – 26/08/2019

UniZAG → RMIT Europe, 29/08/2019 – 29/09/2019

PhD Student

https://www.linkedin.com/in/tena-obradovic/

I am a visiting Ph.D. student from University of Zagreb, Faculty of Economics and Business. I stayed at RMIT University, Melbourne for two months. I enjoyed my stay at RMIT University. I got a chance to meet professors and other Ph.D. students who are also working in the area of open innovation.

I participated in a workshop organised by RMIT University called "The beauty of open innovation" and I learned a lot about practices of open innovation from experts working at the university and in the industry. The biggest challenge was the time difference which affected my communication with people working in Europe but it was a good thing that I stayed for two months so I got a chance to completely get used to it.

The best thing about project OpenInnoTrain is that you are surrounded by professionals who are interested in the same field as you. Also, it is a great chance to travel around the world and experience new cultures and traditions. I had the best time and cannot wait for the next adventure!

Impact of OpenInnoTrain on my career and organisation

Tena's field of interest includes the open innovation paradigm, specifically in Industry 4.0. She spent two months at RMIT Melbourne and one month at RMIT Europe, which resulted in personal and professional improvement.

How has the secondment created new perspectives for applying your knowledge in practical situations?

I did a literature review on open innovation in manufacturing and found out that this topic is important for both academia and practice. It is very important for research results to be public and accessible so others can learn and benefit from them. Also, we must not ignore failures because they can also be valuable. During my research I perceived the importance of successful and effective results translation between academia and industry.

I established close cooperation with an experienced researcher from the field of Fab Lab. I got the insight about literature on this topic and already existing surveys and questionaries. During my research, I got the advice on how to improve my questionnaire. I participated in workshops and got the chance to hear about open innovation practices from industry partners. It helped me as a researcher to hear first-hand what do we need to explore more.

How has the secondment created new career perspectives for you?

Since in Croatia, only my mentor, Prof. Dabić is teaching open innovation, it was crucial for me to travel and to meet other experts in this particular field. I got a chance to talk with professors from RMIT Australia researchers from RMIT Europe and to meet other Ph.D. students. I participated in webinars and panel where we exchanged knowledge.

I further improved my English-speaking abilities and learn about other cultures and customs. I also learned how to adapt to working in different time zones and organising online meetings accordingly.

How has the secondment given you global mobility opportunities?

I improved my English, my communication skills, meet a lot of new cultures and friends. I learned how to quickly adapt to new surroundings and establish new productive working environment. I got familiar with different teaching methods. I also improved my skills in working with VOSviewer, and databases such as Scopus and Wos.

How has the secondment given your organisation opportunities?

I learned a lot during my secondments and got the chance to share it with my colleagues in Croatia. During my secondment I participated in a few events organised by RMIT which gave me an insight and guidelines on how to successfully organise our future events. I connected with many project partners who volunteered to be a keynote speaker at our events.

Ebo Kwegyir-afful

UVA → RMIT

18/10/2019 – 30/11/2019

Researcher

https://www.linkedin.com/in/ebo-kwegyir-afful-8181921b/

It was a lengthy journey as I set off from Vaasa on Friday evening and arrived in Melbourne on Sunday morning. Naturally, the 9-hour time difference coupled to the jetlag is tiresome. However, there have been several activities and collaborations with RMIT that make this lengthy journey worthwhile. Some of these benefits are: suggestions and discussions with some senior lecturers on my own research, availability of state-of-the-art equipment for simulations, augmented reality and virtual reality; all of which are related to my research. Particularly, my work at the VX-lab which has all these technologies and equipment is paying off.

Similarly, I also had diverse people and places to work and collaborate with due to the multifaceted study paradigms of RMIT. This opportunity and exposure notwithstanding come with bureaucracies associated to large educational institutions. Secondly, the frequent research seminars and discussions at the Rapid Discovery / Fabrication Team which collaborates with the departments of Manufacturing, Materials and Mechatronics at RMIT that I belong to offers enough teamwork and collaboration that promotes my interests here.

My shock has been the weather: As I experienced all the 4 annual seasons in some days as I was told. Regarding the cost of living which I found to be reasonable, accommodation however is seriously astronomical, and one needs to budget that on the highest side even after researching extensively: Just to live moderately.

Viktoria Drabe

TUHH → RMIT

02/11/2019 – 22/12/2019

02/01/2020 – 18/01/2020

PhD Student

https://www.linkedin.com/in/viktoria-drabe-06775a10a/

My name is Viktoria Drabe and I am a PhD research fellow at the institute for Technology and Innovation Management at Hamburg University of Technology (TUHH). My research focus lies in the area of Circular Economy (CE) and Sustainable Innovation, especially looking at implementation of CE innovations and practices on a firm-level.

After having quantitatively explored organisational enablers and motivational factors for CE implementation, I appreciated the opportunity to meet with researchers at the RMIT to discuss my project and exchange ideas. The variety of research groups and initiatives is very rich, which enabled me to develop new ideas and engage in many interesting discussions. Further, the opportunity to attend various events, for instance in the series of the Global Business Innovation Conversations, was an inspiration for future events that we plan to organize in line with OpenInnoTrain as well.

On a more personal note, the secondment is very valuable as it allows to get to know a new culture, new people and a different academic system. This is always a very enriching experience.

Katja-Maria Prexl

NOFIMA → RMIT Europe

02/11/2019 – 01/12/2019

Post-doctoral Researcher

https://www.linkedin.com/in/dr-katja-maria-prexl/

I am Katja-Maria Prexl, a postdoctoral researcher for the Bionær-funded FoodProFuture project within the Department of Innovation, Consumer and Sensory Sciences at the Norwegian Food Research Institute (NOFIMA). In this role, I research how to match increasing consumer and market needs for plant protein–based foods using foresight and design thinking methodologies. Additionally, I facilitate the implementation of human-centered innovation concepts for the creation of a sustainable food value chain by developing future scenarios, innovation opportunities, and innovation strategies.

With my participation in the OpenInnoTrain project, I aimed to encourage open collaboration between industry and academia through, for example, the co-development of participatory and experimental approaches that involve multiple industry partners and academic disciplines, mainly in food tech.

My secondment with OpenInnoTrain was a valuable opportunity to connect with fellow researchers in this field. During the first month of the secondment, I had the freedom to do market research, exchange knowledge, and collaborate with colleagues at RMIT Europe in Barcelona on a variety of promising projects, with the opportunity to make future contributions through co-publication, citizen involvement in innovation, the creation of different learning platforms to spread various perspectives, and the submission of joint research proposals.

This was my first stay at RMIT Europe and will not be my last, as I have appreciated the opportunity to collaborate and extend my research network in an international environment. Such fruitful and vital exchanges allow researchers to step out of our daily routines. When start-ups and established companies support us in building new collaboration pathways, networks, and friendships, we can better bridge the gap between industry and academia.

My secondment fostered and enabled the sharing not only of knowledge and ideas but also of different perspectives. The more strands you can weave together as a researcher, the more possibilities you can create. We actively hope to translate and transfer knowledge between industries and disciplines, drawing inspiration and making connections to encourage the development of creative solutions. In the context of food, my secondment experience was a bit like umami, the fifth taste: indescribable but incredibly special.

Impact of OpenInnoTrain on my career and organisation

How has the secondment created new perspectives for applying your knowledge in practical situations?

“The more strands you can weave together as a researcher, the more possibilities you can create.” Presentation of own experiences, research projects and recent project in the food tech to exemplify and simplify the transition phase of such collaborative approaches in small, medium-sised and large research projects.

The exchange and continuously meet and wave connections within the RMIT in Barcelona and the direct and indirect environment. By presenting own work, projects and approaches and by discussing and interconnecting around these and coming-up with other or new possibilities to apply in other and new projects or proposals. Fruitful exchange and discussion and at the same time the freedom to read and explore e.g. co-creation, future thinking approaches, more insights on scenarios building for future of food.

How has the secondment created new career perspectives for you?

By just doing and starting the exchange. By being actively involved and having the possibility to do so. By being open and willing to work actively together with the network OpenInnoTrain offers and by building together on joint project, learning from each other, taking chances and curiosity to the next step.

The OpenInnoTrain project with the secondments, the joint activities, actions and tools is what makes this equipment possible. Being part of it, joining it actively and by further developing it as we also learn with each next stay and activity. By taking the opportunity and helping to solve jointly together challenges.

How has the secondment given you global mobility opportunities?

From the pure exchange with RMIT Europe in Barcelona. Starting the secondment also as a role model for others. Examples would be results of trend scouting in BCN itself. Building up of networks with e.g. huge research institutions like EURECAT, or high-impact promising new start-ups like offering the technology for the first 3-D printed plant-based steak, NovaMeat. Another example is the BCN Culinary Institute to bring in different perspectives and possibilities to work in the project and depending on the phase in the project.

Starting to translate these experiences to the OpenInnoTrain environment and in this case to RMIT Europe and in addition collaborating the food tech field in Barcelona and Spain. Starting white papers and planning co-creation publication with other parties at RMIT Europe. Inspiring and transfering knowledge in the network and environment but also at NOFIMA and different industries and disciplines to engage other secondments and promote the possibilities by showing best practice.

How has the secondment given your organisation opportunities?

By fostering a fruitful and vital exchange. By transferring knowledge and insights of co-creation development of participatory and experimental approaches and related methods and tools to other partners and projects involving multi-industry partners and academic disciplines.

By bringing in my own experience and knowledge in research and academia and of my recent focus at NOFIMA on matching consumer and market needs for increased plant protein-based food consumption by using foresight and design and future thinking-based methodologies.

Triinu Varblane

MERINOVA → RMIT

26/10/2019 – 24/12/2019

02/01/2020 – 12/01/2020

International Business Developer

https://www.linkedin.com/in/triinu-varblane/

I am so honoured to be part of the OpenInnoTrain program, hosted here by RMIT University. OpenInnoTrain is a global network of researchers and industry practitioners across Europe and Australia for promoting the translation of research between university-industry through cooperation and staff exchange. Technological innovations and new solutions, through collaboration and education that's how we will make a difference in the future, according to me. This OpenInnoTrain program includes all those important aspects what is important for the better future. I'm also grateful for all new insights and connections I have done, the knowledge sharing, participation in very useful events, all meetings with important organisations, all information you have shared with me, – the learning curve has been huge! One of the very best calibrations I have ever done for my brain. I really looking forward hear the outcomes of OpenInnoTrain during the next 2 years.

Georg Macher

TUG → MERINOVA, 30/08/2019 – 01/02/2020 & 13/09/2019 – 15/02/2020

TUG → LORIT, 15/09/2019– 07/11/2019 & 30/09/2019 & 20/11/2019

Senior Researcher

https://www.linkedin.com/in/georgmacher/

I'm Senior Scientist at Graz University of Technology. At my Institute I'm coordinating the Industrial Informatics research group, one of the research groups, which is geared to tightly collaborate with industry on specific projects. Our research activities focus on safety and cyber-security of embedded systems in industrial context (currently automotive and water power plant).

I'm also active as industry consultant, coach, and trainer, with a special focus on the automotive domain, and involved in some EU funded and national funded project. I'm also very proud to be involved in an EU Blue Print project (DRIVES) for the definition of future job role training in the automotive domain for 2030.

The OpenInnoTrain project was a completely exciting new opportunity for our team. In the research group (I am working with highly committed young experts), we live the motto of challenging the status quo and continuous improvement. To be a role model (team expectations for their coordinator) I stayed as first secondee of TU Graz a secondment at Merinova (Finland) and a second secondment at Lorit (Scotland). Only via these secondments I was offered the chance to get in touch with innovators and novel approaches to sustainable energy systems in the context of the energy cluster in Vaasa.

My second secondment offered me the opportunity to get introduced in the topics of medical device safety. Together with Lorit and the EuroSPI conference, which was held 2019 in Edinburgh, I had the chance to exchange with researcher and cross-fertilize knowhow of the medical device security domain with approaches from the power plant and automotive domain.

Also, in terms of improving my social and cross-domain acumen the secondment increased my knowledge and opened new ways of thinking on decentralised technologies and multi-disciplinary research topics. Hence, the project already broaden my horizon and I appreciate the opportunity to continue and network with the individuals of non-similar professional aspirations to further extend my view.

Impact of OpenInnoTrain on my career and organisation

How has the secondment created new perspectives for applying your knowledge in practical situations?

Through this secondment, I was offered the chance to get in touch with innovators and novel approaches to sustainable energy systems in the context of the energy cluster in Vaasa. The concepts discussed during some of the workshops have broadened my view in terms of circular economy and sustainable/renewable business models, which I would have hardly experienced in the context of the traditional company frameworks I usually cooperate with.

My secondment at Lorit gave me the chance to experience very related topics of safety in the context of the medical domain and provided several personal lessons learned, which I transfer to my research group. Since being positioned as an interlink between my institute and the industry to tighten cooperation and exchange, the OpenInnoTrain project provides me with additional contacts and success stories to assure my position. Further, the option to get secondees from industry at the institute will additionally ensure relevance and actuality of research activities in the individual industry contexts.

How has the secondment created new career perspectives for you?

Both secondments provided enormous chances for networking at events that took place during my stay on side. Furthermore, I also got the opportunity to collaborate with secondees from the University of Vaasa for industrial/scientific paper with them and the hosting organisations in their respective domain. Papers that will be/are submitted to management conferences would not be supported or in the focus of my publication agenda without the OpenInnoTrain project. Networking events and workshops enabled a transfer of best practices from Energy domain trainings (OpenInnoTrain secondment in Vaasa) to a research project for training in the automotive domain (EU Blueprint Project DRIVES).

Having been exposed to work with engineers from other domains and also research fellows from the University of Vaasa management school have broadened my view on the exploitation of technology and the perspective of disruptive business model opportunities. The cooperation with Rumy broadened my intercultural and interdomain experience and taught me life experiences I would never like to miss…

How has the secondment given you global mobility opportunities?

Thanks to the secondment in Edinburgh, I could establish connections with Scottish research fellows in the medical domain. Due to the contact with Merinova Digitalisation Academy, I got in touch with industry experts from the Vaasa region, which would hardly have been in the focus of research of Graz University of Technology.

With the research conducted with Rumy Narayan and Lorit, we could work on societal challenges like safety, security, and privacy needs for medical data. In this context, we worked on Blockchain technology to facilitate the exchange of information while ensuring the privacy needs of patients.

How has the secondment given your organisation opportunities?

A still on-going process which requires some more additional exchange, which is currently in discussion with industry and research colleagues from the Zagreb region as well as continuing with the Vaasa region.

Due to the promotion and marketing of the OpenInnoTrain project, we got in touch with institutes of TU Graz with entirely different research focus but could find communalities and overlaps in the context of Food technologies and Industry 4.0, which we are currently working to exploit and expedite.

Ivana Kovač

UNIZAG → Salcheto

29/07/2019 – 29/08/2019

Professor

https://www.linkedin.com/in/ivana-kova%C4%8D-6bbba615/

I am Assistant Professor at the Faculty of Economics and Business at the University of Zagreb. The fields of my interest are international business, entrepreneurship, international economics, and transfer technologies. I have had very useful and beautiful time during my stay at Montepulciano in Salcheto winery.

I got the chance to meet Mr. Michele Manelli (one of Salcheto owners and its manager) and discussed about position and attitude of the winery regarding open innovation concept, relationship between employee behaviour and innovation in the winery, ways how winery collaborate with university, government, industry (Triple Helix model) and cooperation with different stakeholders regarding fostering and implementing new ideas and innovation especially embedment in local community and local business networks.

More importantly, we conducted situational analysis of open innovation framework used by winery combining with exploring position and management attitude regarding implementing open innovation concept. Furthermore, we assessed open innovation potential for winery strategy development. The key strength is that it opened me up to transdisciplinary research and gave insight to different types of innovation management.

Johan Wasberg

Merinova → INESC TEC

27/05/2019 – 08/06/2019

08/09/2019 – 24/09/2019

Development director

https://www.linkedin.com/in/johan-wasberg-2950452a/

Working as Development Director at Technology Centre Oy Merinova Ab in Vaasa, Finland, the OpenInnoTrain project provided me with an opportunity to visit INESC TEC – the Institute for Systems and Computer Engineering, Technology and Science – located in Porto, Portugal, for a total of one month during the period May – September 2019.

It was especially interesting to learn more about the research and four research clusters of INESC TEC, how they work closely with entrepreneurs and companies, the laboratory facilities, and potential future cooperation areas with the energy technology cluster in Vaasa. Participation in the SEST 2019 2nd Conference on Smart Energy Systems and Technologies provided an excellent opportunity to meet and establish contacts to other European researchers and learn about their latest research results.

In my opinion, the OpenInnoTrain secondments offer a flexible way of establishing new contacts and collaboration between both researchers, companies, and research institutes. Based on my own experience, I highly recommend others to take part in the OpenInnoTrain secondment program.

Bruno Woeran

MERINOVA → RMIT

03/10/2019 – 08/12/2019

EU Affairs Manager

https://www.linkedin.com/in/bwoeran/

As EU – Affairs & International Innovation Networks Manager for Merinova Technology Center Ltd., working with all stakeholders in the Vaasa Area – Companies in the Largest Energy Cluster in the Nordics; Universities, Digital Innovation and Clean-Tech Energy Companies; Regional Agencies and City Developers – I already had the opportunity to be part of the development team setting up the OpenInnoTrain project.

Foreseeing the opportunities in research and company collaborations on an international scale, it was a great experience for my personal development and learning, to experience my own secondment within RMIT in Australia.

Thus, both on the content related side for clean-tech solutions and I4.0 topics setting up future collaborations with Finnish companies as well as the OpenInnoTrain project related management side of things to develop further the execution of goals within the project and its partners.

Furthermore, the many opportunities to connect with interested persons within RMIT and its local environment heightened my learning and communication possibilities. My focus is to work as a catalyst and networker. This was best put to use during my several event participations, such as i.e. the invitation to participate in a Hydrogen Summit which opened links to prospective candidates for secondments with Merinova.

I was also able to further advance my research during the period down under, including study visits to UTS, Advance Queensland, Callaghan Innovation and Victoria Management University. This gave ample food for thought for new collaboration and research projects to be set-up. Hence, OpenInnoTrain already expanded its and my horizon for future collaborations and I foresee the opportunities to come beyond the partner consortium, continuing the networking with individuals, constituents, and stakeholders.

Impact of OpenInnoTrain on my career and organisation

How has the secondment created new perspectives for applying your knowledge in practical situations?

This was a rather managerial secondment visit rather than a research based one. However, we are setting up new pathways for EU/FI energy cluster companies on how to engage locally in the energy transition offered great new collaborations. My initial attendance at local Global Business Innovation Conversations offered great insights and network opportunities, which led to new incoming secondments on pertaining topics – the current crisis pending them naturally. There were also many great discussions and meetings on the whereabouts of future collaborations and also managing the secondments.

There were many great discussions and meetings on the whereabouts of future collaborations and also energy transition related alternative topics; new contacts made in meetings that I got invited to. There are now several new collaborations in the pipeline through coffee talks, which would never have happened without the personal attendance – now they can be taken forward electronically and online.

How has the secondment created new career perspectives for you?

Being able to interact with the project partner in its own environment was an invaluable experience altogether. Having an international career most days of the work life still gives inside views to how other cultures “tick”. One always learns for life, which then turns out to be(come) a career, so this was a greatly appreciated puzzle in this learning curve. Personal encounters always make work, expectations thereof, networking, etc. much easier to organize and work onwards from that common experience. I do hope that I was also able to actively contribute to the overall positive picture for this project‘s outcomes through my many-fold diverse international background in project work. Time well spent in my opinion, although the 2nd shift (5pm-midnight) never really ceased!

How has the secondment given you global mobility opportunities?

Due to current work environment, there is a great deal of transnational learning happening on a daily basis and having the opportunity to spend a longer continuous time frame at another work environment than just the usual conference days, project meeting, workshop or seminar, opened very different viewpoints, from an academic lens as well as a cultural approach on how to handle matters. Transnational learning is continuous and never stops for a European citizen which include getting new insights on global aspects in other local markets. New and different challenges on similar original problems from company and academic backgrounds. Ideas, values and addressing their relevance on a global scheme.

How has the secondment given your organisation opportunities?

Opening up of staff members towards internationalisation of their work aspects. New collaboration opportunities through incoming research secondees and strengthening of ties to consortium partners. New ways in working with cluster companies beyond energy, on Blockchain, IoT, I4.0, Digitalisation topics. Links to new partners for further collaboration in CleanTech Cluster opportunities. Linking incoming secondees with energy cluster company contacts to engage in active research collaboration in the future. New channels for research and innovation matters. Host of 2nd OpenInnoTrain workshop in collaboration with Merinova's 30 year anniversary and presentation of internationalisation strategy to a large stakeholder audience.

Stephan Buse

TUHH → RMIT

20/01/2020 – 20/03/2020

Deputy Head of Department

https://www.linkedin.com/in/stephan-buse-b980a947/

The OpenInnoTrain program offers excellent opportunities to bring together academic and corporate partners across national borders in future-oriented, sustainable joint projects. As deputy director of the Institute for Technology and Innovation Management at the Hamburg University of Technology, it is my task to seek and organize the exchange with practice partners.

OpenInnoTrain offers me a very helpful and therefore valuable platform for this. Within the framework of this program, I have already twice been able to conduct interdisciplinary workshops with university and industry partners as well as NGOs on specific topics of global innovation management within the framework of secondments with colleagues at the Royal Melbourne Institute of Technology.

Further activities of this kind are planned, which is why the importance and benefits of the OpenInnoTrain program cannot be underestimated.

Dr. Krish Sankaran

RIG → TUHH, 01/05/2019 – 31/05/2019
RIG → UPC, 26/01/2020 – 27/02/2020

CEO

https://www.linkedin.com/in/drksankaran/

Dr. Krish Sankaran is the CEO of the Radical Innovations Group Ab. He is a Swiss citizen of Indian origin with 17+ years leadership track record in energy, waste management, and water utilities, metals, infrastructure, manufacturing, and recycling industries. Krish Sankaran brings in solid know-how and proven skills in strategy, organisational leadership, sustainability, business development, global operations, restructuring, joint ventures, operational and strategic risk management. He gained extensive multicultural and international experience running operations in 10 countries and 4 continents. He was named 2020 Mission Innovation Champion[1] by the consortium of 24 countries around the world and the European Commission in recognition of his various contributions in clean energy and circular economy. He is also a visiting industrial faculty in the Swiss Federal Institute of Technology, ETH Zurich, Switzerland. He is trained in engineering science, organisational development and Indian (Advaita) philosophy.

Impact of OpenInnoTrain on my career and organisation

How has the secondment created new perspectives for applying your knowledge in practical situations?

Coming from the industry, we prioritize practical and realistic solutions over academic ones. That being said, we are also keen on developing our new ideas and radical approach with a solid foundation of innovation. In this sense, the possibilities for us to engage with top-notch research groups are of great value. Hence, this secondment allowed us to take this valuable time to engage and discuss with many groups and researchers about our ongoing and future projects and explore ways to engage them in the future.

Secondments are great opportunities for an industrialist like me for two reasons. It allows us to get more focused on the state-of-the-art research in our domain. It gives us perspectives to challenge our limits on an individual level to move to the next stage. On the industry-level, it allows us to focus on the frontiers of science

[1] https://www.michampions.net/meet-the-champions

and technology in my industry, so that we have something new to offer to our clients. On global level, recently I was nominated by the Finnish government for the prestigious Mission Innovation Champion award. Working with top-notch scholars in the domain allows us to challenge our understanding and ability to solve a problem with the best thinking in the world.

How has the secondment created new career perspectives for you?

I had the opportunity to develop new courses for the university using our industrial solutions. I had the opportunity to engage and discuss with 4 important labs and institutions. I was able to network with regional industries and research labs to build our business further in the region.

For sure we had opportunities to learn about the nuances of cross-cultural and multidisciplinary skills, which we actively pursue and promote in our business. This is very important for us as a company to build new collaborations between countries and regions. We are also planning to organize and lead an innovation hackathon in the coming months within the OpenInnoTrain project.

How has the secondment given you global mobility opportunities?

I consider myself as a global citizen. As a Swiss citizen of Indian origin presently working in Finland and who has lived and worked in 10+ countries in 4 continents, I had enough of global mobility in my life. So, it was not the main motivation for me to do the secondment. On the contrary, these secondments allowed me to take time out of my usual industrial routine and learn different perspectives of ongoing work in R&D area in academia. To be a key differentiator for us as a company in these markets, we have to constantly attract motivated and committed people to work on industrial challenges.

The question is rather straightforward for me to answer as we come from the industry. We bring the context of the society and industry we are in, but we are keen on learning the perspectives of new learnings to solve these problems. We had the opportunity to explore these alternative dimensions during these secondment period.

How has the secondment given your organisation opportunities?

One-month period is short to answer this question affirmatively. However, we are looking forward to the next period of the upcoming secondments to test and measure these factors for innovation and impact.

We are exploring new possibilities to develop industry focused projects with the institutions. We can answer this question as and when things move forward in the coming months.

Cornelius Herstatt

TUHH → RMIT

14/01/2020 – 16/02/2020

Head of Department

Professor

https://www.linkedin.com/in/cornelius-herstatt-768bb8/

My approximately five-week stay at RMIT was devoted to two topics in particular: the development of a joint co-operative agreement (co-tutelle) for the promotion of doctoral students at the two universities (TUHH and RMIT) and the preparation of a one-day conference on social innovation, which will be held at the Technical University of Aachen in summer 2020 as part of the OpenInnoTrain project.

I was also able to have first discussions with PhD students and colleagues for the planned co-tutelle and participated in a three-day conference at RMIT in Melbourne. Time passed quickly again, was productive and I am already looking forward to my next stay at RMIT in 2021.

Pauline Reinecke

TUHH → RMIT

15/01/2020 – 15/03/2020

Research Fellow

Doctoral Candidate

https://www.linkedin.com/in/pauline-reinecke-a996a591/

My name is Pauline and I am a PhD student at the Hamburg University of Technology (TUHH), Faculty of Strategic and International Management. With OpenInnoTrain, I had the great opportunity for a two-months-stay at RMIT University, Melbourne. My stay enabled me to present and discuss my dissertation with researchers from the multiple departments at RMIT and receive valuable feedback to advance my research. I participated in the “Engaging For Impact” conference at RMIT which allowed me to mirror my results with attendees of the conference including managers from the field.

I also presented my research at the Global Business Innovation (GBI) Seminar Series at RMIT which is a great program to exchange ideas with other researchers from RMIT.

During my stay I could build up an international network and set up joint research projects which will both serve as a building block for my future career in academia.

Elena Casprini

UNISI → RMIT Europe

23/01/2020 – 15/02/202

19/02/2020 – 23/02/2020

Senior Researcher

https://www.linkedin.com/in/elena-casprini-9836674b/

I am a senior researcher from the Department of Business and Law, University of Siena (Italy). I stayed at RMIT Europe in Barcelona for a month. I enjoyed my first secondment at RMIT Europe where I had the opportunity to meet professors and researchers as well as several businesses.

I think that this experience has helped me in multiple ways. First, it has represented the cornerstone for my next planned secondments: thanks to this first experience, I got several contacts for my future research on open innovation.

Second, I have had the chance to talk to several colleagues who have deepened my expertise on both research methodologies and theories. Furthermore, RMIT Europe is surrounded by a unique environment (in an already extraordinary city such as Barcelona), close to several companies and exposed to several business, academic and cultural events: this allowed me also to appreciate what it means to live and work in a “creative city".

I think that projects such as OpenInnoTrain gives you the chance to grow both professionally and personally: an opportunity that I wish to everyone.

Maria Pajuoja

UVA → RMIT

27/02/2020 – 31/05/2020

PhD student

https://www.linkedin.com/in/maria-pajuoja-9193726/

How do you conduct a research visit during the coronavirus crisis? I arrived in Melbourne for my secondment from the University of Vaasa to RMIT about 2 weeks before the city went into lockdown. All the plans and goals that I had for the 3 months vanished as it started to dawn what the new reality would be.

Things that I had taken for granted (like working on the university premises and meeting people face-to-face) were no longer possible. After the initial shock and disappointment subsided, I re-evaluated my circumstances and found much to like. Firstly, here was an opportunity to fully concentrate on my second article, and I ended up taking it from a vague idea of what it would be about, to data collection and analysis, and a rough first draft, in 3 months.

Secondly, I took full advantage of one of the four acceptable reasons to leave the house: to exercise. Within walking distance, we had beautiful parks and beaches that provided wonderful surroundings for all kinds of exercising, and this daily practice benefitted my work in unexpected ways.

Thirdly, I discovered the strength of my closest relationships; a husband I can rely on for anything, and my kids who didn't for one minute regret not being able to visit the Zoo or the amusement park but who lacked nothing as they learned how to ride a scooter, climb trees, and where the juiciest worms were to be found.

And so, I am immensely grateful for my OpenInnoTrain secondment; just for very different reasons than I expected to be.

Naima Saeed

UIA → RMIT

13/02/2020 – 20/07/2020

Professor

https://www.linkedin.com/in/naima-saeed-phd-5496202/

I work as an Associate Professor of Supply Chain Management at the School of Business and Law at the University of Agder (UiA), Norway. I am a visiting scholar at the Royal Melbourne Institute of Technology (RMIT), Melbourne, Australia, for five months (February 2020-July 2020). My research stay is financed by the European Union project "OpenInnoTrain".

Currently, I am working with colleagues at RIMT on projects related to the sustainability of Australian ports and analysing the global maritime supply chain's restructuring in response to changes in bilateral maritime connectivity and China's belt and road initiative (BRI). On 19th March 2020, I gave a seminar as a part of the 2020 Global Business Innovation (GBI) Seminar Series to the staff members at RMIT.

I presented my current research on a link between maritime connectivity, port competitiveness, and economic growth. Despite some challenges because of the pandemic, I am having a productive time at RMIT. I am grateful to my colleagues at RMIT for all kinds of support during my stay.

Alastair Walker

LORIT → TUG, 25/07/2020 – 30/09/2020

LORIT → TUG, 1/11/2020 – 5/12/2020

CEO

https://www.linkedin.com/in/alastair-walker-410a549/

The secondments give us the chance to share experiences between industry and academia. Often as a consultancy your time is limited due to the commercial pressures, by working with someone in academia they can invest the necessary hours and the reviews together are key to establishing the values of different strategies for risk, software development and cybersecurity in the medical device and automotive worlds.

Being able to present to students at the TU Graz on the challenges of medical device development was also highly rewarding as you have the opportunity to give the students an insight into many of the real-world challenges we face as a consultancy on a daily basis.

We will be working further with OpenInnoTrain on risk analysis techniques for engineering projects, as this sort of collaboration is highly beneficial for both parties.

Part II:
Research Translation

5 State of Play in UIC and Research Translation in Europe and Australia

Anne-Laure Mention, Hardik Bhimani, Massimo Menichinelli

Originally published as: Mention, Anne-Laure, Hardik Bhimani, y Massimo Menichinelli. 2021. «D1.1 Executive Report on State of Play in UIC and Research Translation in Europe and Australia». OpenInnoTrain D1.1. https://www.openinnotrain.eu/results/d1-1-executive-report-on-state-of-play-in-uic-and-research-translation-in-europe-and-australia/.

1 The state of Research Translation in Europe

1.1 A precursor on research translation

The origins and history of Research Translation can be traced to the healthcare sector (Woolf 2008; Searles et al. 2016), more precisely in the concerns about improving the impact of research as the contribution of research activities to achieve desired societal outcomes (Banzi et al. 2011). Considerable resources are usually devoted to health sciences research, but the transfer of research findings into practice is a slow and unclear process (Graham et al. 2006) that cannot keep pace with the rapid advances in healthcare knowledge (Grol and Grimshaw 2003): understanding and reducing this time lag is of critical importance (Morris, Wooding, and Grant 2011). For example, researchers have studied how research can be better accessed and adopted by stakeholders such as a) decisionmakers at all levels, by adopting evidence-based approaches to interventions decisions (Brownson, Fielding, and Maylahn 2009); b) policymakers, by seeking a consistent and systematic translation of public health research into public policies (Brownson et al. 2006); c) citizens, through community-based research initiatives that engage them actively while also directly translating knowledge to them (Israel et al. 1998).

For these reasons, the concepts of "translational research" and "research translation" have emerged in the healthcare sector (medicine; biochemistry, genetics and molecular biology; pharmacology, toxicology and pharmaceutics; neuroscience; immunology and microbiology; psychology; nursing). Both concepts focus on how research can be translated more efficiently into products, services, practices, policies and thus quickly made available to citizens, and their relevance and importance is widely accepted (Woolf 2008). Several interpretations have been elaborated for both terms, roughly referring to translating knowledge from basic research into new approaches for the prevention, diagnosis and treatment of diseases either as new drugs, devices, and treatment options for patients (T1) or into new approaches for improving access, reorganizing and coordinating systems of care (T2) (Woolf 2008). The main difference, also for moving beyond the healthcare sector, is that Translational Research focuses on organizing and managing research processes that enables the movement of knowledge from bench to bedside to community, while Research Translation focuses on bridging the gap between research knowledge and its application in policy and practice (Sydney Health Partners n.d.). That is, Translational Research focuses on the research dimension, while Research Translation focuses on the knowledge transfer dimension; Research Translation has thus a broader focus on the management of the innovation developed through research. Furthermore, Translational Research is based on a linear process constituting of four phases: T1 ("bench to bedside"), T2 ("bedside to practice"), T3 ("dissemination and implementation research"), T4 ("diffusion research") (Zarbin 2020). On the contrary, Research Translation has a more complex approach that focuses on non-linear phases and especially on the innovation ecosystems that support the development and transfer of knowledge: "Research translation is a process of knowledge generation and transfer that enables those utilising the developed knowledge to apply it. This definition acknowledges that, once generated, knowledge flows can be multidirectional and non-sequential" (Searles et al. 2016, 2). Research Translation is therefore an approach that is more focused on the innovation dimension and more flexible in being adopted in other sectors beyond healthcare.

1.2 Interpretation of research translation

This report addresses the need for Europe to increase the return on the considerable investment in funded research, be it through EU-wide initiatives such as the Horizon 2020 program, mission-oriented research programs or University-Industry Cooperation (UIC) projects. Throughout the report, UIC is referred to as an interaction between any level (individual, institutional, community, ecosystem) of university (be public or private) and industry for the purpose of exchanging knowledge and technology (Bekkers and Bodas Freitas 2008). The report asserts that encouraging and supporting the flow of high-quality research is a necessary, but not sufficient condition to achieve impact and benefit societal progress. Constructing effective and efficient pathways or knowledge exchange mechanisms for translation of research into practice are essential. Research translation, in this view, allows for connections and interactions to be formed between researchers, their scientific outputs and those in the position to apply and realise the potential of research, for monetary and non-monetary societal benefits.

The term '**research translation**' is interpreted more broadly in this report and is considered *a process by which scientific theories, investigations and findings are conceptualised, applied and realised to achieve practical outcomes*. It captures the individual, organisational or institutional and regional or ecosystemic engagement in knowledge exchange; and encompasses cooperation and collaboration mechanisms between public and private sector researchers and external parties.

Research Translation is therefore, a pathway to impact consisting of initiatives and specific measures that encourage cooperation among researchers and a large number of external parties – the "users" of the research – that can holistically foster, enhance and sustain over time the application of knowledge-based research (McGagh et al. 2016). Research translation is used in this report in conjunction with other terms such as 'knowledge sourcing' and 'knowledge sharing'. These terms are interpreted at an individual level, where the former refers to searching, recognising and transferring knowledge to inform research or practice and the later involves imparting accumulated knowledge to others. At an organisational level, research translation is addressed in this report with reference to 'knowledge flows' and 'knowledge exchange', where the former reflects movement of knowledge across organisational or institutional boundaries and the later captures the process of bringing researchers, practitioners, members of the society and agencies together for exchange of ideas, insights and evidence.

The term 'engagement' is used in this report with reference to involvement of university and industry parties in research translation activities (e.g. in knowledge exchange, mission-related based research, etc.). In the same vein, 'research cooperation' and 'research collaboration', used interchangeably for the purpose of this report, are interpreted as means or approaches that allow for transfer of scientific knowledge into practical tools, techniques or ways of doing, which through a feedback loop, inform new research agenda, concepts, investigations and theories. 'Research commercialisation' is interpreted as per OECD (2013) – realisation of income from knowledge related research activities through new products or services, achieved through inside-out knowledge transfer mechanisms such as licencing, patenting, spinout and start-up venturing, amongst others. Of note is that the project team conforms to Abreu et al.'s (2013) view and recognises research commercialisation as important, albeit as only one component of the research translation process. Figure illustrates the various forms in which research translation engagement tends to occur between university, industry, government and community partners, at ecosystem, organisational and individual level. What is evident in practice is that various forms of formal and informal, targeted and non-targeted and people-based and community-based interactions tend to take place, of which only a small number are related to revenue generation. Research translation involves sequential and interrelated steps involving - research activities, outputs, translation mechanisms, application, validation and impact creation.

'**Research impact**' is the demonstrable contribution attributable to scientific research activities, which leads to broader economic, societal and environmental benefits beyond the contribution to academia (Bell et al. 2014). Understanding the rationale and mechanisms for high levels of research impact, arising from UIC and public-private cooperation allows for directing knowledge exchange participation and encouraging meaningful outcomes for the economy, society and the environment. Indeed, literature on UIC emerging from EU (Cremades, Balbastre-Benavent, and Domínguez 2015), Australia (Lynch et al. 2018), Canada (Ginsburg et al. 2007) and United States (de Haan, Shwartz, and Gómez-Baquero 2020), amongst others, suggest that there is a prevalent and urgent need to improve translation of research from traditional academic outputs to wider societal benefits.

2 Research Translation: need, motivators and barriers

2.1 Needs, demands and desires for research translation

There is an opportunity for EU to leverage the quality research and knowledge accumulated in universities through formal and informal mechanisms, collaboration and cooperation, between individuals, institutions, communities and industries and the UI ecosystems (McGagh et al. 2016). Global evidence suggests that students and industry do not necessarily see universities as vehicles for social mobility, with some questioning the return on investment (Orazbayeva et al. 2020; OECD 2019a). Teaching focus is shifting towards providing employable skills to suit the digital age. However, applied research and research translation are lagging in providing targeted and problem-based benefits. There is also a doubt whether some universities are prepared and ready to look beyond traditional blue-sky research and focus on delivery current impact on economic and social development. The competition for funding and translational research initiatives (e.g. European Advanced Translational Research Infrastructure) are shifting university priorities towards mission-oriented research, improving access to facilities, technologies, training and support services through exchange of knowledge between university, industry, community and the government agencies. The question remains – how can research translation value to created and captured from UIC and what role do institutions and individual researchers have in the process?

Changes in and access to technologies are forcing, and will continue to shift, universities to reassess their purpose and value to society. This coupled with shifts in public expectations, governmental policies encouraging open and collaborative engagement, global war for talent and Asian economies increasing their investment in universities, will mean university research models will need to radically transform. The change in part is being driven by increasing need for transparency in how public funds are used and the quality and reach of research to inform societal challenges. Increasingly universities in Europe and beyond are positioning themselves as part of an ecosystem and drawing away from the traditional 'hub and spoke' approach. Rossi et al. (2020) conducted interviews with seventy-five participants in UICs and found that driven by their experiences with the knowledge creation within universities and knowledge co-creation through collaboration, collaborators (institutions and individuals) tend to apply a 'bridging' or 'blurring' approach to boundary-spanning practices. The former refers to formal and structured practices and procedures, involving 'designated roles, discrete events and activities to span the boundaries between communities' (Evans and Scarbrough 2014, 119), and the later in contrast refers to less formal and structured practices, characterised by blurred roles, flatter hierarchies, spontaneous and informal interactions and a more 'open-minded' relationship management approach. While there are universities across the EU (e.g. in Finland which has the highest rate of reported UIC) that position as strategic partners in creating and capturing value from collaboration with industry, public and governmental partners, much of the reported interaction has been attributed to ad-hoc or transactional activities with select groups (Georghiou et al. 2018; Bell et al. 2014).

There is a need for universities to confront technological, political and social drivers to establish change towards active research translation from within and across UIC. Just as the analysis at Norwegian University of Science and Technology revealed (Kaloudis et al. 2019), globally there are relatively few research translation instruments designed with the objective to encourage and enhance knowledge creation, transfer and utilisation between universities and partners in their wider ecosystem (Australian Council of Learned Academies, Secretariat 2018). Besides, in terms of collaboration for research and innovation, larger firms are far more likely to collaborate than small to medium-sized firms (SMEs), with Finland, Slovenia and Austria reporting higher levels of UIC than many other countries (OECD 2019b) (Figure). The Global University Network for Innovation (GUNI) (Grau i Vidal et al. 2017) identifies two challenges related to UIC which apply to research translation – contribution towards national, regional and local strategic competitive positioning, and creation and dissemination of useful knowledge towards a sustainable future. On the one hand, to effectively realise their roles as developers of next generation global citizens, universities need to radically change their epistemology – 'what counts for knowledge' (Kecskes et al. 2016). On the other hand, they need to elect to redistribute their power and transform knowledge production by de-centering it from disciplinary silos. In this way, universities can co-produce applied knowledge and communities can leverage useful knowledge to address challenges and grow public good. Saltmarsh (2016) suggests that by taking a transformational view (Figure), universities can deliver on its promise of developing more socially just lifelong learners, in part facilitated by impactful research outcomes.

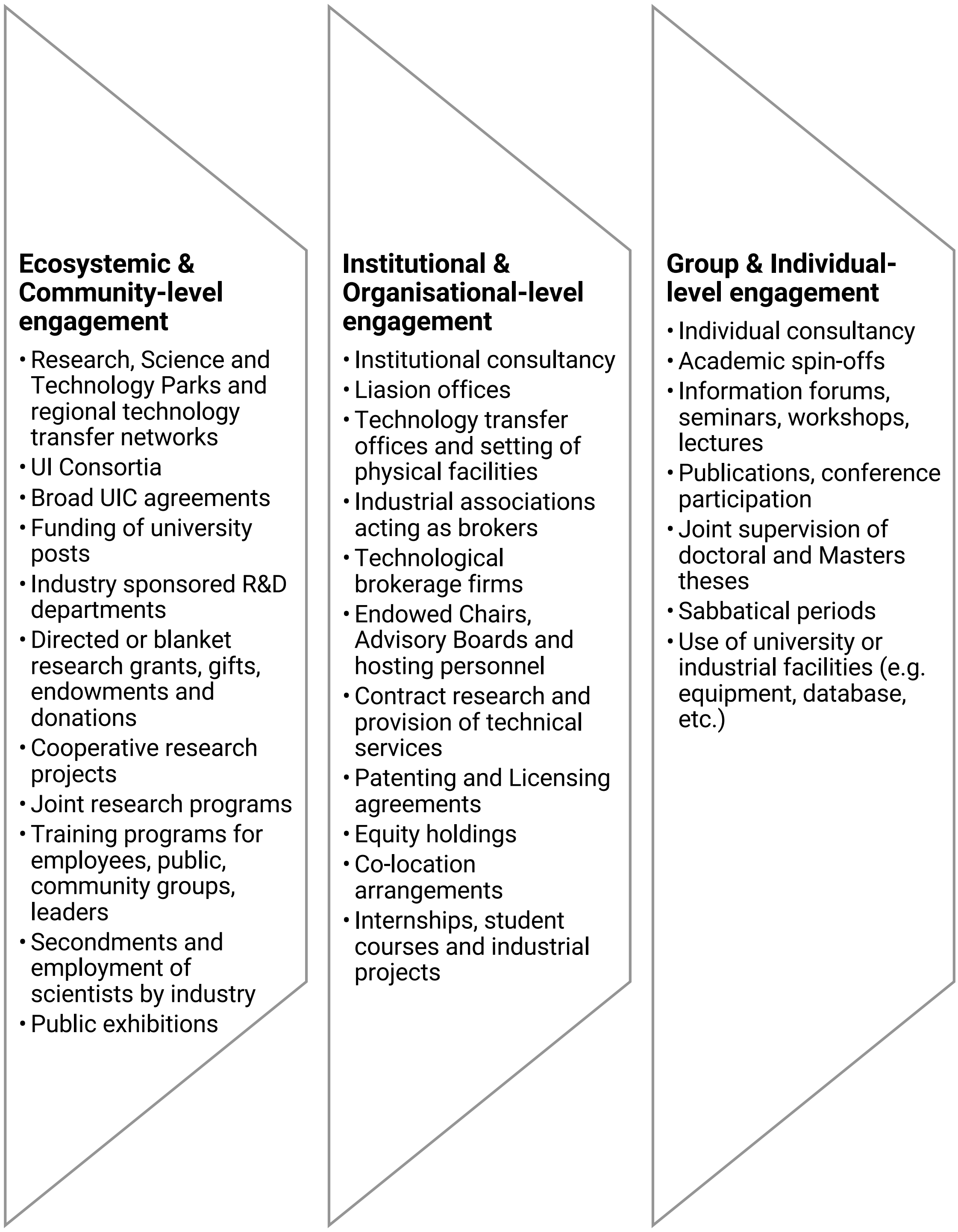


Figure 1 Forms of research translation structures and activities, with reference to UIC. Source: Adapted from Australian Council Of Learned Academies (2018); Ankrah and Al-Tabbaa (2015).

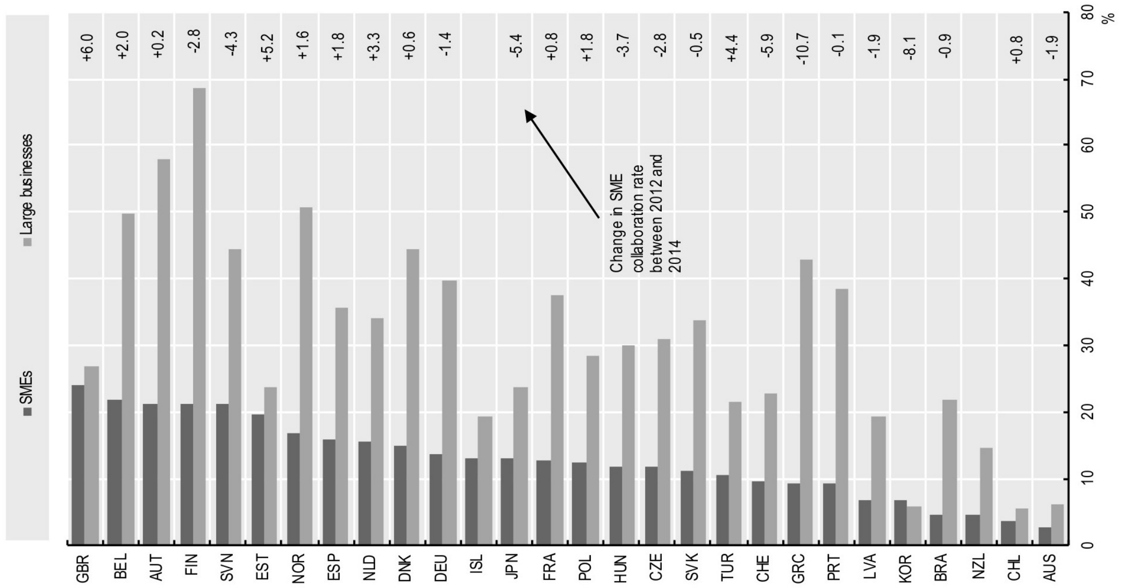


Figure 2 Collaboration between industry and university research centres by country. Source: OECD (2019b), based on the survey of national innovation statistics and the Eurostat, Community Innovation Survey (CIS-2014), http://dx.doi.org/10.1787/888933619068

To engage constructively with society, research translation mechanisms need to address societal challenges, notably identified in the UN's Sustainable Development Goals (SDGs). Such approach can encourage innovative multi-level research translation model that will involve new ways of learning and working with business, government and the society. Governments around the world have invested significant resources in fostering critical UIC partnerships, looking for synergies between education and industry ecosystems. In EU this is demonstrated in the Horizon 2020 programs and other initiatives such as European Commission's Rome Declaration on Responsible Research and Innovation in Europe (Madelin and Ringrose 2016) and a renewed agenda for Higher Education (European Commission 2014). In Australia, the government has invested in responsible research and research translation efforts through National Innovation and Science Agenda. The Linkage Project grants, for instance, in Australia provides universities and researchers with public funding of AUSD 50,000 to AUSD 300,000 for two to five years collaborative projects with industry and government. The Australian Research Council (ARC) Centre of Excellence (CoE) further promote and enhance collaboration across critical areas in Industry 4.0 transformation such as advanced manufacturing, cyber security and Food and Agribusiness among others. The objective of ARC is to encourage collaborative R&D projects between universities and companies outside academia that will solve Industry 4.0 challenge, drive growth, productivity and leverage national and international investments in industry sectors.

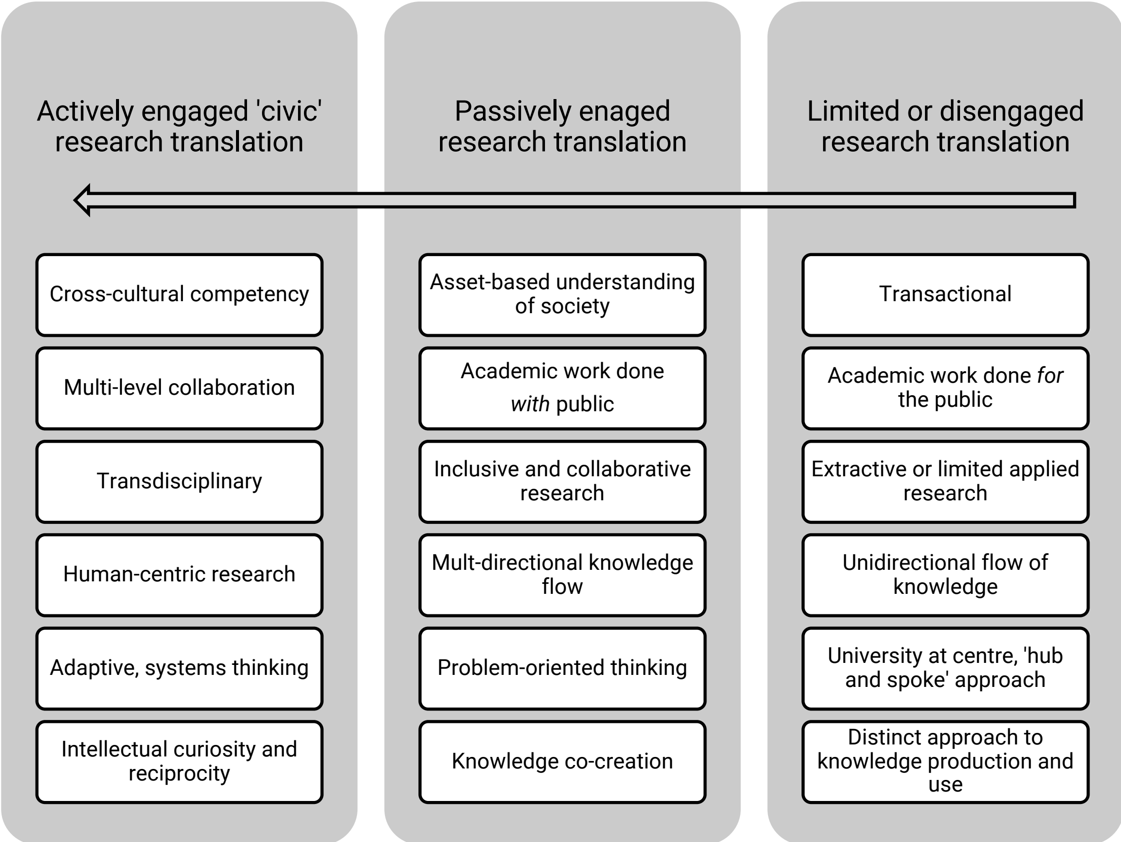


Figure 3 Approaches to Research Translation Source: Adapted from Saltmarsh (2016)

The challenge for universities in pursuits for effective research translation is then to help create change through cutting-edge industry relevant research without becoming victims of transformation priorities. Goddard (2016) identifies such universities as 'civic' institutions. In his view, in a civic university, leadership does not treat engagement with enterprise as a 'third mission' distinct from blue sky research and teaching. In a civic university 'there is no perception of a core or periphery – engagement is seen as embedded and relevant to other areas of the activity' (Goddard et al. 2016, 98). In other words, when teaching and research overlap with intentional activities aimed at attaining societal benefits, research translation extends beyond the hard boundaries into 'real world'. An actively engaged civic research translation is thus, transdisciplinary, human-centric, adaptive and one that is driven by curiosity and reciprocity. This is distinct from traditional blue sky research approach where translation is limited or transactional, where academic work is done by demand or for people rather than being inclusive, where knowledge flow is unidirectional and where university research centres are seen as the hub of a wheel that feeds on other stakeholders (including industry) to meet its research priorities, often with little regard for societal expectations. The path to active engagement will involve some form of passive engagement first as universities learn to adapt, develop structures and strategy for more open and collaborative research and move from research for research's sake approach to problem-solving and knowledge co-creation with public, government and companies.

Those universities that are able to successfully attain active engagement by balancing their roles as civic institutions and marketplace for development of next generation global citizens and learners will be those that truly embrace the essence of research translation and positively contribute to societal progress. In the European context, the European Political Strategy Centre (EPSC) has increasingly voiced the universities need to shift from traditional supply-push models to a more human-centred approach which involves effective transfer of knowledge through all actors, with a focus on people, places and processes (European Commission 2014; Madelin and Ringrose 2016).

2.2 Framing research translation: pathways to impact

Scholarship and blue-sky research are a key feature of universities. However, research translation is the prerequisite for societal impact (OECD 2013). There is no doubt that knowledge production allows for better understanding of the environment, events and possibilities. Yet, when coupled with public-private collaboration mechanisms (e.g. through H2020 programs in EU, ARC programs in Australia, etc.), the benefits tend to be enhanced as research moves beyond mere academic contribution towards addressing societal challenges. For instance, current research conducted at RMIT University (Australia) on the societal issue of financial abuse in collaboration with Victorian Law Foundation and industry partners has been applied to develop new toolkits, programs as well as law and education recommendations, benefiting the economy and society. Such research translation has the potential to provide new products, services and processes and reinforce the ethical, responsible and sustainable practices. Haskel and Wallis (2013) posit that in the UK a robust correlation exists between public-sector funded research engagement at universities and market sector total productivity growth, a notion supported by research in Australia by Elnasri and Fox (2014). Other reports in the same vein (Bell et al. 2014) suggest that knowledge spill-over from university to industry is a consequential and important positive benefit emerging from research translation. As the knowledge economy continues to embrace globalisation, access and application of knowledge emerging from research can enhance innovation activities, at times through adaptive and agile UIC models. As discussed above, a key feature of such models is the role of universities as socially aware, co-creating mission-based civic institutions, with the strength of internal and external connections being the determining factor of knowledge transformation and research translation (Orazbayeva et al. 2020).

Knowledge transformation is thought to happen along two streams (Klevorick et al. 1995) – increasing pools of new knowledge (e.g. through publications, patents, etc) to solve current and emerging problems, and creating new opportunities for inventions and economic returns by connecting real world needs with academic research. The former is university-led, whereas the latter is industry-led. From a research translation perspective, university-led projects are often distinct from industry-led projects. Where the former has a primary objective of directed knowledge acquisition, the later is focused on application of useful knowledge for practical purposes (Ministry of Business Innovation & Employment 2015a). Some degree of overlap is generally expected in either cases. For instance, an industry-led project aimed at creating new market-efficient technology, may carry a prerequisite for discourse-specific knowledge creation, and likewise, exploring human behaviours to create new knowledge on social acceptance of technology may need more context-relevant field research approach. Mission-oriented research in this view captures both university-led and industry-led approaches, aimed at broad-spectrum impact (MBIE 2015b). Comparing timeframe of impact provides further opportunity to understand the disparities. Research impact through research translation can occur over short-term (1 to 3 years), medium term (4 to 7 years) and long term (8 to 10 years) (Ministry of Business Innovation & Employment 2015b). Short term impact tends to focus on awareness of knowledge within the research community, be it about knowledge, attitude or behaviour (e.g. through publications, seminars, workshops, debates and discussions). Medium term impact tends to address knowledge transfer and integration from scientific evidence to practical tools, techniques, processes, products and services. The research translation over medium term is often facilitated by open and collaborative exchange of knowledge over multiple knowledge production cycles (e.g. through scientist mobility, international exchange, secondments, policy briefs and white papers). Long term research impact is ambiguous and hard to measure (ACOLA 2015; OECD 2019) (Bell et al. 2014; OECD 2019a) but reflects broad-spectrum goals such as the SDGs. In this vein, commonly used research translation approach such as patents, licencing and spinout by both university and industry is perhaps only one of the many options in the pathway to research impact (OECD 2013). Interestingly, Haskel et al. (2014) report that UK universities collect less than 5 percent of total income from sale of intellectual property, although OECD (2019b) report suggests that universities tend to be an important source of knowledge for firms, particularly for large firms (see Figure).

As civic institutions, the benefits for university from research translation rest not only in opportunities to generate income, but also interactions, exchanges and active engagement of university researchers with industry in addressing current and practical challenges. These challenges can offer new and interesting research translation opportunities, backed by innovative research designs and methods. A provoking thought shared by the partners of OpenInnoTrain is that perhaps researchers do not need to choose between academic outputs and industry engagement in the pursuit of effective research translation. The two activities of knowledge creation and knowledge transfer in this view are integrated and complement the performance of each other. Indeed, when researchers are more engaged with industry, they also tend to achieve more grants and publications outputs (Hughes 2015; Hughes et al. 2016; Perkmann et al. 2013). As depicted in Figure , there are numerous ways in which individual researchers, universities and research institutions can engage with industry. The era of mere ‘supply push’ may be over and universities need to respond to ‘demand pull’ just as much. The relationships between university and industry can no longer be assumed to be linear, where knowledge creation and knowledge use are distinct sphere, rather knowledge co-creation and multi-linear or collaborative relationships are increasingly becoming the norm.

However, forming research translation driven UIC at any level is complex. It requires reciprocal research translation arrangements, where success needs to be measured in terms of broader research impact, rather than means to achieve grants or support a brand position. Where universities struggle to find a balance between blue sky and applied research, industry struggle to draw up on and enhance their capacity to absorb useful knowledge (i.e. what management researchers call ‘absorptive capacity’ (Cohen and Levinthal 1990). For research ideas to transform to useful knowledge, it needs to be matched with appropriate *means* and *modes* of research translation (Bell et al. 2014). Figure captures the research translation framework adopted in this report. At an individual level, the *means* involve people - university-educated, technically skilled and those with accumulated useful knowledge. At an organisational level, it can involve accumulated collective knowledge be it through organisational processes, routines, systems, structures or culture, and access to technology. At an ecosystem level, research translation can happen by way of licensing, patents, and knowledge co-creation activities (e.g. data sharing).

The *modes* are how research translation can take shape. If means are the ‘what’, then modes are the ‘how’. ACOLA (Bell et al. 2014) identify these modes in terms of access to public spaces for discussion, commercialisation of intellectual property, forming of strategic partnerships, co-creation knowledge to solve grand challenges and collaborative problem-solving. These days open innovation discussions can also happen through social media (Bhimani, Mention, and Barlatier 2019), where social media acts as the driver for knowledge curation and problem identification as well as the enabler for widening engagement and access to otherwise globally distributed knowledge. As discussed elsewhere in this report, traditional modes of research translation through patenting and licensing although still popular (Ankrah and AL-Tabbaa 2015), are limited in their potential value to the extend they are accessible, transferable and exploitable.

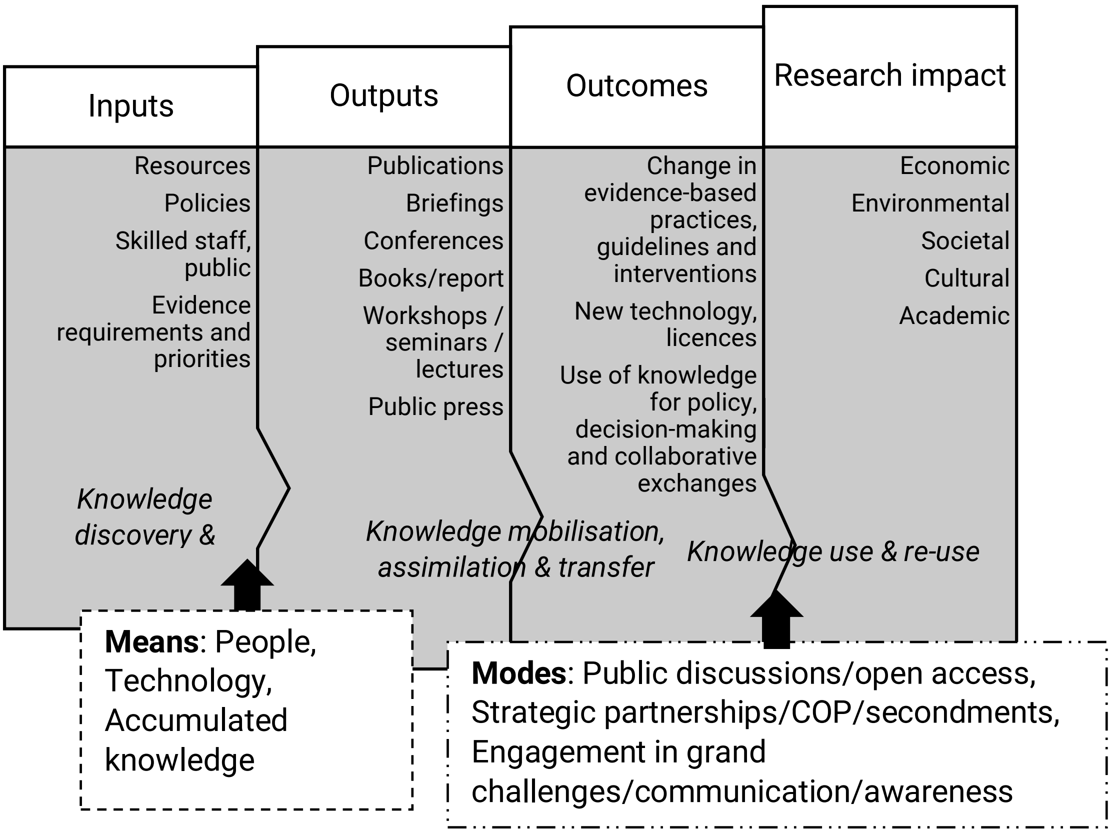


Figure 4 Research Translation framework.(Bell et al. 2014; Ankrah and AL-Tabbaa 2015; Kaloudis et al. 2019)

What seems to be becoming more common is universities and industry coming together to solve grand challenges through hackathons, workshops, and such UIC-themed events. The recent pandemic has further accelerated efforts as evident from numerous treatment interventions, vaccine development and trials as well as those related to. For instance, in response to the greatest challenges voiced by their more than 500 members, University Industry Innovation Network (UIIN) recently launched three new programs aimed at – strategic U-I partnerships, creating transformative universities and pathways to impact. These programs are a response to UIIN community feedback on challenges related to UIC, external relationships and their management and creating a culture to support and measure research impact (UIIN n.d.). Participation and engagement in grand challenges can lead researchers to new domains of enquiry, and thus opportunity for multi-disciplinary thought and outputs. Moreover, research translation activities emerging from grand challenge engagement can help target some of societies pressing challenges, from health, energy, environment to access, accountability and transferability of useful data. Tackling these problems is not a one-time affair and involves ongoing engagement and perhaps even strategic partnerships.

Research translation driven strategic partnerships can involve long-term, deep and rich individual and organisational level engagement, extending beyond joint publications to establishment of Communities of Practice (COPs), secondments, rights to refusal to license and joint development of learning and talent (Bell et al. 2014). Problem-solving in this view is a micro level activity that may start off with individual researchers working with industry over a shorter time frame but can extend to dynamic exchange of ideas and results over a longer time, often with interactions, knowledge and resources flowing in both directions. Figure 4 captures the research translation framework advanced in this report based on above discussions.

In theory and practice, the engagement between university and industry in reference to research translation and innovation through new knowledge can be classified in three paradigms – the science-push or linear model, the ecosystem model and the transformative policy paradigm (Kaloudis et al. 2019). Driven by capacity issues, linear models operate under the assumption that basic research at universities, when propagated through various channels, can gradually enhance applied knowledge and thus lead to commercially and technically useful knowledge. In this model, knowledge creation is within university domain, and hence policies are aimed at enhancing research and researcher capabilities in producing new scientific research. Ecosystemic models which emerged in the late 1990s (Edquist 1997), drew attention to the means and modes of knowledge collaboration across spatially distributed partners. Once it became apparent that not all useful knowledge may be held within the closed boundaries of universities and organisations (Chesbrough 2003), the notion emerged that unless widely distributed knowledge is harnessed by embracing diversity in capabilities and resources, innovation may not happen. Knowledge-push inputs such as people (users, customers, collaborators) and technology are central to the ecosystemic model of research translation. Thus, how people, technology and knowledge connect and create opportunities for new linkages and knowledge is central to policies and mechanism driving the ecosystemic model. This model emphasis open and collaborative innovation system where knowledge partners systematically and purposefully engage in knowledge flows to co-create for the benefit of the society, be it for monetary or non-monetary reasons (Chesbrough 2020). Etzkowitz and Leydesdorff (1998) termed this as the *Triple Helix* – emphasising that it is the structure, quality and strength of the interactions and interconnections between universities, industry and government that determines the success of research translation for useful new knowledge and innovation. Moving beyond Triple Helix, the 21st century thinking calls for UIC that tackles broader challenges – climate change, healthy ageing, responsible finance, digitalisation, sustainable farming and consumption, amongst others. This requires transformative policies and mechanisms that influence the traditional trajectories of evolutionary techno-economic pathways, and interlink people, technologies, organisational models and markets. Such policies and mechanisms prioritise mission-oriented research and its translation through UIC and its various forms (Bekkers and Bodas Freitas 2008; Schot and Steinmueller 2016; Mazzucato 2017).

The cases of research translation mechanisms captured in this report acknowledge the extensive research, policies and investment directed towards creating, capturing and measuring research impact. The objective of this report is not to delve into yet another review of literature on research impact characteristics and evaluation frameworks (Heyeres et al. 2019; Madelin and Ringrose 2016; Ankrah and AL-Tabbaa 2015; Penfield et al. 2014; Sachwald 2015). Rather, this report focuses on key lessons learnt from efforts aimed at research translation, both from a university and industry perspective. Central to these lessons is the agility, connectivity and adaptability of U-I partners to foster long-term active engagement at various levels and broader the context of research and its translation to practice. An underlying objective of many of the initiatives identified in this report is behavioural change – influencing perceptions, motivations, attitudes and culture. This objective is rooted in the logic that by shaping interactions and knowledge exchange mechanisms, people and organisations will become better at identifying, assimilating and transferring useful knowledge for societal impact.

2.2.1 Motivators and facilitators of research translation

Firms' engagement in UIC is an important element in building absorptive capacity of firms (Fontana, Geuna, and Matt 2006; Knudsen and Schleimer 2020). High levels of absorptive capacity can improve a firm's capability to search and engage with universities in knowledge co-creation (Laursen, Reichstein, and Salter 2011). This requires moving towards knowledge co-creation, rather than mere knowledge creation and subsequent knowledge transfer approaches (OECD 2019a). Thus, willing and ability to develop and propagate absorptive capacity within firms can influence UIC, and research translation.

Ankrah and Al-Tabba (2015) classify the motivations for UIC across six categories – 1) necessity - government or strategic institutional policy, 2) reciprocity – access to knowledgeable and skilled people, equipment, resources, 3) efficiency – opportunity to gain economic, technological, business or human capital benefits, grants and incentives, 4) stability – improve access and growth in new knowledge, insights to problems, solutions and risk-sharing, 5) legitimacy – societal pressure, promotion of corporate image, contribution to regional or national economy, recognition, and 6) asymmetry – maintain control over proprietary knowledge and technology. Of these, perhaps necessity and legitimacy are the key motivators for research translation. With government policies directed towards research funding that promote impactful research through UIC. A key feature of these policies is that for universities and industry to benefit, they much collaborate with an aim for economic and social regeneration (Perkmann et al. 2013). This has motivated universities and organisations to tune their attention towards research translation (Perkmann, King, and Pavelin 2011). Various programs such as UK knowledge transfer partnerships and EU's Framework Programmes from Research and Innovation are designed with the clear intent to motivate research translation in Europe, in which people (researchers and practitioners), scientific knowledge and technology circulate freely and openly.

Some scholars have identified that vested interests, competitive dynamics and path-dependencies tend to motivate research translation efforts (Bonaccorsi 2007; Dosi, Llerena, and Labini 2006), whereas others tend to draw attention to geography of innovation (Laursen, Reichstein, and Salter 2011) . Laursen et al. (2011) argued that proximity of firms to top-tier universities tends to increase the intensity of UIC, which can affect research translation outcomes through increased opportunity for informal interactions at university science parks, co-located labs and collaborative spaces (OECD 2019a). Indeed, research suggests that chances for collaboration are improved when university and industry partners are co-located or are within a local region (Mansfield and Lee 1996), with at least one large study suggesting that nearly 35 percent of all industrial inventive activity occurs within 30 kilometres of a university (OECD 2019a). In a study of Norwegian firms, Fitjar and Gjelsvik (2018) found that it does not matter whether the university is top-tier or low-tier, geographical distance between organisation and industry ultimately influences the interactions, with closer the university to organisation, the higher the propensity to collaboration. One underlying motivation behind this could be that collaborating over distance is often complex and costly (D'Este and Iammarino 2010). That and the notion of making contribution to regional economy through long-term connections and interactions could be another motivator for universities and firms to work closely and reap the benefits of localised research translation. EU has particularly emphasised the role of science parks and co-located university-industry research infrastructure through its regional and pan-European policies (European Commission. Directorate-General for Research 2008).

The degree of research translation activities in science parks can vary significantly. Where most science parks are university-led initiatives in countries such as UK (Siegel, Waldman, and Link 2003), other countries such as Australia tend to adopt a mixed approach. Albahari et al. (2017) conducted an extensive study of science parks in Spain and identified four types – Pure science parks with major university shareholder, mixed science parks with university and industry shareholders, technology parks with university presence and pure technology parks with no formal university engagement. They found that knowledge creation and transfer activities (e.g. patenting) were more common in pure science parks while knowledge use to create new products and markets were more common in pure technology parks. Minguillo and Thelwall (2015) found that even in pure science parks, collaboration often extends to off-park partners with universities contributed towards most of the accumulated knowledge. This resonated with the finding of Albahari et al. (2017) that close proximity of university and industry may not mean better research translation, such outcomes may depend on the absorptive capacities of the partners to engage in effective knowledge flows.

At the individual level, direct indicators of research translation (e.g. number of joint academic-industry author publications) or indirect indicators (e.g. funding of cooperative or collaborative government grants) tend to have positive influence on university researcher's engagement with industry (Van Looy et al. 2011). Gulbrandsen et al. (2011) found that individual researcher characteristics and disciplinary affiliations are more important for engagement in impactful research than institutional level characteristics such as focus on applied research or research intensity. From an institutional perspective, research quality has a positive impact on knowledge transfer activities, including R&D cooperation, licensing, patenting and spin-offs (Cassiman, Glenisson, and Van Looy 2007). However, Perkmann et al. (2013) suggests that quality of university department (measured as ability to attract public funding) tends to have a negative influence on the propensity to engage with industry in contractual research, with 'good' individual researchers from lesser ranked universities more likely to engage with industry than their counterparts in higher ranked university. This is motivated by access to resources, equipment, or to pursue interesting real-world research problems. Thus, for research translation to happen in practice, willingness and ability of individual researchers, regardless of the quality of university they work at, is an influencing factor. When research productivity and quality of individual researchers is high, it has a higher (positive) impact on research translation activities (Arnold 2012). Excellent researchers in their fields engage more with research-intensive firms, especially in the presence of certain common disciplines where intermediate knowledge outputs as well as technical and market network relationship are central to their research programs (Arnold 2014).

Research translation is more common in applied sciences (e.g. biotechnology, pharmaceuticals, etc.) owing to stronger need for commercialisation of ideas and inventions, compared to social sciences which tends to produce intangible research outputs. Previous experience in research translation activities, seniority and established contacts facilitate engagement but may not result in research translation (Abramo et al. 2012; Conti and Gaule 2011). However, organisational support for open innovation (Laursen and Salter 2014), have a positive impact on research translation activities such as commercialisation through patents, licencing and spin-offs (Miotti and Sachwald 2003; Bercovitz and Feldman 2006). This suggests that while engagement is an individual-level factor, research translation may be depended on institutional factors. Productive researchers are ones who receive collaborative grants and are more likely to engage with industry, however high impact research is closely connected with institutional knowledge transfer activities, including cooperation, promotion and value appropriation (Belderbos et al. 2014; Faems, Looy, and Debackere 2005). Perhaps, it is the firms that choose to work with excellent researchers. Either way, collaborative research has a positive influence on research translation (Sachwald 2015), with results being of higher quality than research developed in-house (Motohashi and Muramatsu 2012). Thus, from a policy perspective, as much attention is needed to facilitating quality knowledge creation activities as it is to knowledge transfer and use activities.

The number of international partners is also positively associated with firm's capacity for radical innovation (Zucker and Darby 2005). Justified by complementarities, knowledge pools and relevance, international collaborations tend to facilitate research translation activities and innovation outputs. The research translation outcomes in Norwegian cities provide a good case, where cities have benefited from distant knowledge collaboration between local and international firms (Fitjar and Rodríguez-Pose 2011). Search for star scientists often leads firms to look beyond local and regional boundaries. Since technologies that are in early-stage often need to be developed in close connection with the researchers, such that there is interaction between codified and un-codified knowledge, proximity of scientists is an important facilitator for successful research translation (Bonaccorsi et al. 2013; Zucker and Darby 2005). However, when knowledge is codified in publications or hoarded in local scientists, its effect is limited to the local or regional boundaries. It is then through scientist mobility that the spatial range of knowledge can be enhanced. Here again, the capacity and capability of individual scientists to engage in purposeful knowledge flows beyond local boundaries is a key facilitator of research translation and its impact.

Governments have a critical role in formulating, adopting and effectively administering policies that support and promote research translation addressing economic, environmental and societal challenges (OECD 2007). In addition to funding research, policies need to encourage programs and research designs that enhance application of scientific findings and outputs for broader dissemination. These include promoting mechanisms that allow for open innovation through collaborative dialogue, discourse and debate between public and private entities. In Norway for instance, policy instruments are fostering multi-directional knowledge flows and collaboration between industry and universities, through research centres such as Centre for Research-based Innovation (SFIs) and the Centre for Environment-friendly Energy Research (FMEs). These centres act as the catalyst for new knowledge, processes, technologies, products and new skills which ultimately benefit the society. Creating opportunities for collaboration where knowledge can move from discovery to assimilation into existing industry process and its use and re-use to solve applied research problems is a promising avenue where government policies can influence research translation. Moreover, research translation measures that look beyond benefits to academia can aid in seeking and sourcing UIC opportunities. Through value creation pathways that encompass knowledge exchange mechanisms and structures such as capability enablement platforms and practitioner and researcher secondments, among others, can reduce barriers to knowledge exchange and assist in research translation. As such, knowledge spill-over from research translation can have broader, often value enhancing, benefits for the society. For instance, Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia diffused spatial mapping technology and extension programs rather than commercialising which resulted in substantial crop yields and benefits to large number of farmers (Bell et al. 2014). Likewise, New Zealand government has proliferated and promoted the concept of mission-led science with a total investment of approximately $400 million NZD (Ministry of Business Innovation & Employment 2015a). The approach behind this investment is to fund “research, science or technology or related activities directed at achieving a specific outcome” (New Zealand Gazette 2014, 286). The notion resonates with other mission-oriented research policies adopted by governments around the world, including the such long-standing approach in United States (Mazzucato 2016; Boon and Edler 2018).

Proposed as research undertaken towards a particular policy aim or goal of addressing complex, long-term, large-scale challenges, mission-oriented research has been actively promoted in Europe, evident in the recent Economic and Societal Impact of Research and Innovation (ESIR) policy brief provided to (previous) European Commissioner for Research, Science and Innovation, Carlos Moedas (Georghiou et al. 2018). The rationale behind mission-oriented research is to structure research programs around grand challenges and knowledge creation on the one hand, and diffusion and effective utilisation of technology, data and knowledge to build capacity and improve productivity of organisations. In the absence of appropriate government policies and programs that address research translation, universities and research institutes may underinvest in open and collaborative knowledge flows with industry and public sector (Bell et al. 2014). Thus, one aim of government policies aimed at research translation is to ensure accumulated knowledge at universities and research institutes is diffused beyond academia. This has implications for conceptualising research design and measuring research impact (Commonwealth of Australia, Department of Industry and Science 2015).

2.3 Barriers and impediments to research translation

One of the challenges for research translation is finding partners to engage with. Patterns of collaboration between university and business are influenced by their size (see Figure), with larger organisations demonstrating greater tendency to collaborate than small and medium-sized enterprises (Bellucci, Pennacchio, and Zazzaro 2019). According to OECD (2019b) report on Research Excellence and Collaboration, on average only 13 percent of the small to medium-sized enterprises are likely to collaborate with university compared to 31 percent of larger firms. On the other hand, increasing UIC interactions have raised research autonomy and academic freedom concerns, with scholar searching for the evidence of research hampering due to UIC (Banal-Estañol, Jofre-Bonet, and Lawson 2015). Methodological challenges, including factors related to industry and regional contexts, and diversity in impact assessments due to data sources, quality, mission-orientation and research specialisation creates further challenges for effective research translation. There is a need for sharing of interoperable data and an integration of diversity in methodological approaches and data sources for effective research translation (OECD 2019a).

Publicly funded research institutions (PFRIs) and universities employ and educate individuals who can have the skills and capacity to address societal challenges, deliver innovative products and services and engage in enhancement of useful knowledge. However, to attain such a goal, knowledge created and accumulated at universities need to be translated, transferred and utilised. New evidence (OECD 2019a) on UIC suggests that research translation is a complex process since knowledge transfer can happen in many forms (see Figure). Yet, much of the knowledge co-creation and transfer in UIC is still attributable to joint patent filing, with engagement in other research translation mechanisms such as student researcher start-ups and graduate/scientist mobility only recently gaining attention (Cañibano et al. 2020; OECD 2019a). On a promising note, many countries, regions and universities are now developing supporting infrastructures to facilitate non-traditional research translation through more open, collaborative and entrepreneurial co-creation approaches (Etzkowitz 2017; OECD 2019a).

Table 1 Barriers and impediments to research translation Source: Adapted from Ankrah and Al-Tabbaa (2015); Bruneel, D'esteb and Salter (2010); Cricelli and Grimaldi (2010)

Categories	**The Factors**
Individual level	Incentives and access to research funding
	Training and skills in translational research
	Capacity (cognitive, technological and social)
	Awareness of collaborative research capabilities
	Trust, teamwork and adaptability
	Attitude and commitment to U-I engagement activities
	Mobility/movement/exchange
Institutional and organisational level	Access to resources (funding, human, equipment, facilities, etc.)
	Approach towards intellectual property, patents, licencing and construal mechanisms
	Moral and social awareness and actions
	Stability, culture and structure of the institution/organisation
	Absorptive capacity and type of knowledge to be transferred
	Communication and project management efficiencies
	Geographical proximity

	Firm size
Ecosystemic and community level	Capacity constraints (especially in case of SMEs) Inflexible policies for open and collaborative innovations Incentives, grant and funding structures and policies

Ankrah and Al-Tabbaa's (2015) review of UIC literature revealed seven main categories of factors that affect UIC – 1) capacity and resources, 2) legal issues and contractual mechanisms, 3) management and organisational issues, 4) issues related to technology, 5) political issues, 6) social issues and 7)other issues (e.g. risk of research, geographical proximity, disciplinary differences/similarities, awareness, etc.). Siegel, Waldman and Link (2003) suggest that among all other issues, organisational and managerial issues are the most critical factors that can impede UIC, and thus effective research translation. Figure summarises the key barriers and impediments to research translation, adapted from UIC literature. With access to funding and opportunities to generate alternate revenue through patenting, licensing and spin-outs being the primary motivators for universities to engage with industry, Al-Tabbaa, Leach and March (2014) suggest that it is also a notable impediment to UIC, and thus research translation. Drawing on resource dependence theory (Pfeffer and Salancik 2003), they emphasise that chasing economic outcomes puts universities in a vulnerable position. It can create an imbalance in UIC power dynamics, providing opportunities for industry partners to dictate the terms of research and the intensity and direction of knowledge flows, including delivery of research outputs and their subsequent dissemination.

2.4 Mechanisms supporting research translation

As discussed above, research translation involves a complex, multi-directional collaborative process between researchers and industry partners. Collaborative research projects are carried out by researchers based in universities or organisations and are often funded by industry or through public schemes. Where funded collaborative research projects extend over medium (3 years) to long term (10 years), some small-scale projects can also eventuate through individual researcher's engagement with industry partners. Although on a smaller scale and time frame, such projects are often facilitated by contractual agreements or research services arrangements and can involve several individual and institutional stakeholders. Research services, delivered through university research centres or capability development platforms, form part of active research translation mechanisms. They allow for UIC in solving targeted problems or knowledge co-creation, at individual and group-level (Perkmann and Walsh 2007). At times, as in the case of Norway, U-I clusters are established through policy or strategic directives to trigger or enhance collaboration and value creation and value capture that would otherwise be difficult to achieve. In Norway, for instance, three Global Centres of Expertise (GCEs) have been established which delivered 15 NCE projects and 29 ARENA projects. Analysis of these clusters (Røtnes et al. 2017) shows that collaboration increases significantly between cluster firms, including with research institutes and universities. Perkmann and Walsh (2007) suggest that in practice research collaboration and translation is dependent on researcher relationships. They argue that researchers that have the high levels of engagement with industry and relational involvement are the ones more suited to transfer uncodified to codified knowledge. Proximity and face to face contact can facilitate relationship and thus allow researchers to work in collaborative research partnerships leading to mutually beneficial outcomes. Knowledge mobility in this view is related to relational engagement and includes permanent appointment and temporary secondment of researchers in industry organisations. Knowledge is mobilised through secondments and appointments with researchers acting as knowledge brokers or boundary spanners between university research and industry practice (Rosli et al. 2018). The contrasting movement of practitioners to universities is equally important mechanism supporting research translation. In both cases, individuals act as the links or channels for knowledge flows, creating better engagement, interactions and relationships between university and industry partners (Haas and Ham 2015). This happens as relationships are often maintained even after the initial engagement period has passed. Formal collaborations (such as those achieved through secondments) are more important for firms and also tend to capture higher benefits (Monjon and Waelbroeck 2003; Meyer-Krahmer and Schmoch 1998). Highly innovative firms tend to search for relevant and expert partner and would even disregard the benefits of geographical proximity to engage in formal research collaboration with the best foreign universities (Steinmo and Rasmussen 2016). Indeed, several studies have showed that joint R&D contracts, joint publications and researcher/practitioner mobility have a higher and longer-term research impact than mechanisms commonly promoted by policy makers (e.g. Technology Transfer Offices, university patents) (Bekkers and Bodas Freitas 2008). Cohen et al. (2002) found that university research translation and research impact for industry are mostly influenced by informal interactions, publications, conferences and university research services than more formal mechanisms such as patenting and licensing.

At this juncture, it needs to be noted that most of the research translation and UIC literature has been based on patent data or studies involving natural sciences and engineering. The focus on social sciences and the role of individual researchers in economics, sociology, management and law has been limited (Gulbrandsen, Mowery, and Feldman 2011), in part due to the difficulties involved in measuring the research impact of social scientists (Bastow, Dunleavy, and Tinkler 2014). In social sciences, researchers tend to contribute towards research impact through creativity, thought, communication and richer understanding of innovation processes and outcomes. Thus, mobility and relational involvement in collaborative research is more important for social scientists, compared to their counterparts in natural sciences (Bekkers and Bodas Freitas 2008). Perkmann et al. (2013) and Estrada et al. (2016) emphasise that opportunities exist in social sciences for in-depth research in understanding the influence of individual-level characteristics on engagement in research translation activities, both from a university researcher and industry practitioner perspectives.

2.5 OI and UIC activities for Research Translation in industry: the OpenInnoTrain focus

The OpenInnoTrain project focuses on Research Translation in the 4 application settings of FinTech, Industry 4.0, CleanTech and FoodTech. In order to do so, it is structured in this way (Figure 5): WP1 is the core research platform aimed at advancing knowledge at the nexus of Open Innovation, UIC and Research Translation, resulting in more efficient and effective research translational practices capable of enhancing the impact of research outcomes – its results feed into the four work packages of the application settings (WP2 to 5).

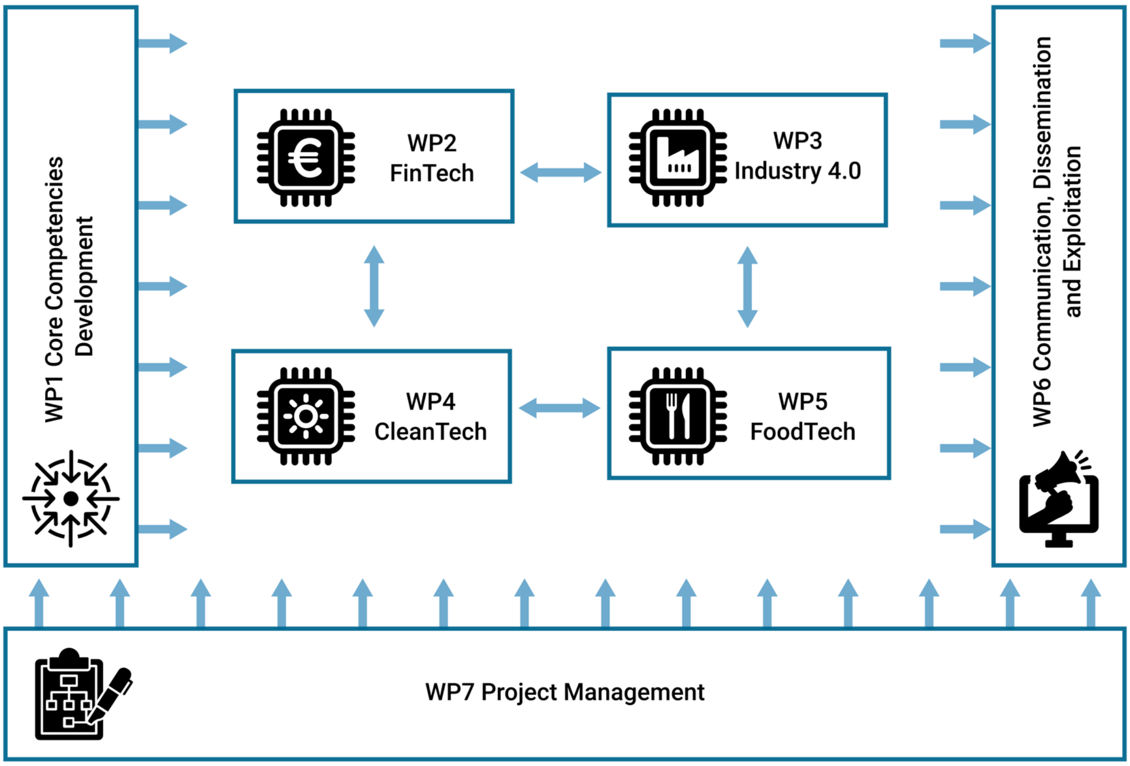


Figure 5 The work package structure of the OpenInnoTrain project

The Fin Tech (Mention 2019; 2020; Lee and Shin 2018) WP targets the issues and challenges that hinder effective Research Translation within the Fin Tech sphere, paying specific attention to the interactions between incumbents, start-ups and university partners, with the objective to neutralize them via the development, implementation and dissemination of suitably conceived and empirically tested

Research Translation tools. The Industry 4.0 (Obradović, Vlačić, and Dabić 2021; Alcácer and Cruz-Machado 2019; Schwab 2017) WP3 targets the issues and challenges that hinder effective Research Translation within the Industry 4.0 application setting. The Clean Tech (Aagaard, Saari, and Mäkinen 2021; Caprotti 2012; Cumming, Henriques, and Sadorsky 2016; Jensen, Lööf, and Stephan 2020) WP4 targets the issues and challenges that hinder effective Research Translation within the Clean Tech sector. The Food Tech (Piatti, Graeff-Hönninger, and Khajehei 2019; Renda 2019; D'Antino et al. 2020) WP5 targets the issues and challenges that hinder effective Research Translation within the Food Tech sector. Finally, WP6 focuses on the communication, dissemination and exploitation activities, and WP7 focuses on the management of the project.

The research translation journey is not a linear process – every stage, from idea and discovery to knowledge use and re-use can inform each other. In structuring the OpenInnoTrain objectives of research translation, the investigators and partners followed the approach depicted in Figure 6 adapted from Knowledge Translation Australia (2018).

Project Partners (Means)	**Message**	**Audience**	**Messenger**	**Form (Modes of engageme nt)**	**Fit**	**Evaluation**
Who can help create impact? When will they be engaged? What will they bring to the project?	Research goals and objectives	Who will be impacted? When? What's in it for them?	Who is best placed to deliver the message (the influencer) ?	*How*? Access? Medium of knowledge exchange?	Context? Common language? Purpose?	Research impact metrics - measures of success

Figure 6 Critical considerations for research translation. Source: Adapted from Knowledge Translation Australia (2018)

In the context of OpenInnoTrain, Research Translation contributes to partner organisations and seconded staff at least in terms of 1) transfer, dissemination, diffusion and acceptance of technologies; 2) stakeholder engagement and acceptance of technologies; 3) research impact assessment and improvement. In the first direction, Research Translation provides approaches for improving the adoption by individuals, assimilation by the system, diffusion and dissemination of innovations (Greenhalgh et al. 2004; Dorizzi 2007). As the 4 application settings of OpenInnoTrain represent emerging technologies, researchers benefit from understanding how such novelties can be diffused and accepted. In the second direction, Research Translation provides contributes for stakeholder engagement and acceptance of research results and technologies, with a specific focus on decisionmakers at all levels (Brownson, Fielding, and Maylahn 2009), policymakers (Brownson et al. 2006), citizens, through community-based research initiatives (Israel et al. 1998). Engaging stakeholders at all levels can support researchers in developing innovations that are both more directly connected with the market and society and also improve their diffusion and acceptance. Following with the third direction, Research Translation increases the impact of research and its assessment (Lavis et al. 2003; Banzi et al. 2011; Glasgow, Vogt, and Boles 1999; Searles et al. 2016) by consciously and directly empowering researchers in understanding and improving the innovation ecosystems and processes behind their work.

3 A vision for Research Translation in Europe

Starting from 2021 and ending in 2027, Horizon Europe will be the current research and innovation framework programme of the European Union (European Commission. Directorate General for Research and Innovation. 2020a). Among the several important elements, it should be noted the acknowledgment that "The EU has consolidated its global position in basic science, including in fields critical to the future economy. However, Europe is significantly falling behind its global competitors in terms of transferring research excellence into innovative products and services" (European Commission 2019). Transferring or translating research into products and services seems to be one of the elements of the European Innovation Council: "According to the draft, a new type of Transition grant will support projects translating research to market, while the three EIC funding programmes will each set out targeted calls in strategic areas, alongside open bottom-up calls." (Naujokaitytė 2021). Inspired by the role of the European Research Council (ERC)[1] in supporting research in Europe through competitive funding and to support investigator-driven frontier research, the European Innovation Council (EIC)[2] aspires to become the hallmark of excellence for impact-oriented innovators (European Commission. Directorate General for Research and Innovation. 2020b) . After a pilot phases, the EIC will become a new funding agency with the goal of facilitating the transfer of inventions and research by supporting the development of ideas that have commercial potential, the transition of promising results to market and an accelerator support (grants, loans, coaching services) (Schiermeier 2021).

The EIC will support high-risk, high-impact ideas, research translation and accelerating the scale-up of innovations in order to "generate impacts from other programmes, such as the European Research Council, the European Institute of

[1] https://erc.europa.eu/
[2] https://ec.europa.eu/research/eic/index.cfm

Innovation and Technology and its Knowledge and Innovation Communities (KICs), other parts of Horizon Europe, as well as from national and regional programmes. The outputs from these programmes are usually not mature enough to attract private investors and need the transition funding provided by the EIC. Joint or complementary activities between them and the EIC will further increase the level of impact" (European Commission. Directorate General for Research and Innovation. 2020b, 5). Furthermore, its programmes "should not be seen as a rigid linear pathway from deep research to market, but rather as elements of a more dynamic process that provides multiple entry points to the market" (European Commission. Directorate General for Research and Innovation. 2020b, 11). In this view, firms in the knowledge economy already invest widely in knowledge intensive activities, creating and using broad range of intangible assets. However, new knowledge, especially in social sciences, is often situated in the minds of individuals tasked to bring universities closer to industry. That and the increasing focus on digital transformation, need for new and firm-specific skills and government interventions in R&D activities, means universities need to deliver more, better and enhanced outcomes on research translation – contributing to the knowledge-based societal capital and addressing the demand to innovate for economic and social change. The proverbial question remains - how exactly can European universities embrace research translation?

Research translation and impact measurement is difficult because connections within UIC and consequential knowledge spill-over effects are not one-to-one. The World Economic Forum Council on the Economics of Innovation relates this difficulty to bias towards technology-intensive sectors, poor granularity and poor predictive power of research impact. Sachwald's (2015) report which voices the Commission's advisers' opinion, recommends an overhaul of current research translation measures and indicators, providing for a careful use of research translation indicators to draw considered policy conclusions. Before developing objective measures of impact from research translation, we propose that the first step is to acknowledge that Europe needs a distinct Research Translation Mission, distinct from, but not substituting its research and innovation agenda. The Research Translation Mission can succeed if it instils four characteristics:

- Broad university, research centre and societal ownership of research missions, aimed and designed to deliver improvements or enhancements in productivity, growth, social inclusion and sustainability.
- Orchestrated cooperation and collaboration between universities, research centres, industry and public, with mutual accountability, rather than a research theatre of well-meaning discourse followed by weak, slow and variable creation, transfer and use of knowledge to industry and society.
- A foundation of priority investment in core research translation mechanisms, tools and assets: individual researchers, local centres of research excellence, European industry associations and public administration.

- Enhanced focus on cross-continental collaboration and knowledge exchange, including scientist mobility, where research aims and design are rooted in local strengths, needs and granular development plans.

To conclude, today's university is not a mere centre for teaching and investigation, rather it is a beacon for regional and local knowledge, innovation and success. As the OECD's Europe's Mission to Innovate reports, "The transformation needed here is lateral and disruptive. A move beyond the generation, dissemination and curation of knowledge to the civic and entrepreneurial university: a place that is good for society and innovation as well as good at research and teaching" (Madelin and Ringrose 2016, 35). This is a vision that is consistent with fully open and collaborative innovation model. Thus, in summarising this report, we advance our foreword on research translation in Europe and hope it provides a blueprint for meaningful actions:

- As research excellence centres, universities should move intentionally to recruit for, reward and incentivise researchers for research translation endeavours. Such an effort can bring universities closer to industry and civic society.
- Students and PhD candidates need help to successfully engage, design and deliver impactful research that benefits the society; they need research translation role models; they need to be taught on how to build digital data skills and how to conceptualise, design, develop and deliver research that addresses industry and societal challenges; they need access to industry and follow-on financial support, so that they can go from desk research to applied research to prototyping and even spinning-out their ideas without leaving academia.
- Universities need to think beyond science and technology parks, but integrate cross-disciplinary academic discourses, places and meeting places, where not only researchers but also industry and civic partners are encouraged to interact, share ideas and knowledge and actively engage in co-creation of useful knowledge. In such an environment open innovation can flourish, where students, researchers, professors and industry partners can come together to address real-world challenges and deliver research that suits real-world context.
- Universities need to match research translation endeavours with appropriate strategy and governance mechanisms, establishing university-industry engagement and capability development platforms to consolidate commitment towards research translation and provide a lean structure to emphasise UIC rather than academic politicising or polarisation of research agendas.

References

Aagaard, Annabeth, Ulla A. Saari, and Saku J. Mäkinen. 2021. "Mapping the Types of Business Experimentation in Creating Sustainable Value: A Case Study of Cleantech Start-Ups." *Journal of Cleaner Production* 279 (January): 123182. https://doi.org/10.1016/j.jclepro.2020.123182.

Abreu, Mônica Cavalcanti Sá, Maria Cristiane Cunha, and Silvia Maria Pedro Rebouças. 2013. "Effects of Personal Characteristics on Organizational Commitment: Evidence from Brazil's Oil and Gas Industry." *The International Journal of Human Resource Management* 24 (20): 3831–52. https://doi.org/10.1080/09585192.2013.781527.

Alcácer, V., and V. Cruz-Machado. 2019. "Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems." *Engineering Science and Technology, an International Journal*, January. https://doi.org/10.1016/j.jestch.2019.01.006.

Australian Council of Learned Academies, Secretariat. 2018. "Annual Report 2018." Melbourne: Australian Council of Learned Academies (ACOLA). https://acola.org/2018-acola-annual-report/.

Banzi, Rita, Lorenzo Moja, Vanna Pistotti, Andrea Facchini, and Alessandro Liberati. 2011. "Conceptual Frameworks and Empirical Approaches Used to Assess the Impact of Health Research: An Overview of Reviews." *Health Research Policy and Systems* 9 (1): 26. https://doi.org/10.1186/1478-4505-9-26.

Bekkers, Rudi, and Isabel Maria Bodas Freitas. 2008. "Analysing Knowledge Transfer Channels between Universities and Industry: To What Degree Do Sectors Also Matter?" *Research Policy*, Special Section Knowledge Dynamics out of Balance: Knowledge Biased, Skewed and Unmatched, 37 (10): 1837–53. https://doi.org/10.1016/j.respol.2008.07.007.

Bell, John, Bob Frater, Leslie Butterfield, Stuart Cunningham, Mark Dodgson, Kevin Fox, Tom Spurling, and Elizabeth Webster. 2014. *The Role of Science, Research and Technology in Lifting Australian Productivity*. Report for the Australian Council of Learned Academies. Melbourne: Australian Council of Learned Academies (ACOLA). https://acola.org/role-science-research-tech-lifting-aust-saf04/.

Brownson, Ross C., Jonathan E. Fielding, and Christopher M. Maylahn. 2009. "Evidence-Based Public Health: A Fundamental Concept for Public Health Practice." *Annual Review of Public Health* 30 (1): 175–201. https://doi.org/10.1146/annurev.publhealth.031308.100134.

Brownson, Ross C., Charles Royer, Reid Ewing, and Timothy D. McBride. 2006. "Researchers and Policymakers: Travelers in Parallel Universes." *American Journal of Preventive Medicine* 30 (2): 164–72. https://doi.org/10.1016/j.amepre.2005.10.004.

Caprotti, Federico. 2012. "The Cultural Economy of Cleantech: Environmental Discourse and the Emergence of a New Technology Sector: The Cultural Economy of Cleantech." *Transactions of the Institute of British Geographers* 37 (3): 370–85. https://doi.org/10.1111/j.1475-5661.2011.00485.x.

Cremades, Enrique, Francisco Balbastre-Benavent, and Elena Sanandrés Domínguez. 2015. "Managerial Practices Driving Knowledge Creation, Learning and Transfer in Translational Research: An Exploratory Case Study." *R&D Management* 45 (4): 361–85. https://doi.org/10.1111/radm.12081.

Cumming, Douglas, Irene Henriques, and Perry Sadorsky. 2016. "'Cleantech' Venture Capital around the World." *International Review of Financial Analysis* 44 (March): 86–97. https://doi.org/10.1016/j.irfa.2016.01.015.

D'Antino, Alessio, Max Leveau, Amy Dingemans, Berkok Yuksel, and Mathilde Redshaw. 2020. "The State of Global Foodtech Report 2020." Talent Garden / Forward Fooding. https://foodtech-report.talentgarden.org/.

Dorizzi, Romolo M. 2007. "The Diffusion of Innovations Theory Could Help Laboratorians in Research Translation." *Clinical Chemistry and Laboratory Medicine* 45 (4): 553–54. https://doi.org/10.1515/CCLM.2007.101.

Elnasri, Amani, and Kevin J. Fox. 2014. "The Contribution of Research and Innovation to Productivity and Economic Growth." Discussion Papers 2014–08. School of Economics, The University of New South Wales. https://ideas.repec.org/p/swe/wpaper/2014-08.html.

European Commission. 2014. "Rome Declaration on Responsible Research and Innovation in Europe." https://ec.europa.eu/digital-single-market/en/news/rome-declaration-responsible-research-and-innovation-europe.

———. 2019. "The European Innovation Council (EIC)." https://ec.europa.eu/info/files/european-innovation-council-eic_en.

European Commission. Directorate General for Research and Innovation. 2020a. *Horizon Europe*. Brussels: European Commission. https://data.europa.eu/doi/10.2777/340354.

———. 2020b. *The European Innovation Council: A Vision and Roadmap for Impact : EIC Pilot Advisory Board*. Brussels: European Commission. https://data.europa.eu/doi/10.2777/836599.

Evans, Sarah, and Harry Scarbrough. 2014. "Supporting Knowledge Translation through Collaborative Translational Research Initiatives: 'Bridging' versus 'Blurring' Boundary-Spanning Approaches in the UK CLAHRC Initiative." *Social Science & Medicine* 106 (April): 119–27. https://doi.org/10.1016/j.socscimed.2014.01.025.

Georghiou, Luke, Daria Tataj, Julio Celio, Stefania Giannini, Dainius Pavalkis, Roberto Verganti, and Adnrea Renda. 2018. *Mission-Oriented Research and Innovation Policy: A RISE Perspective.* Brussels: Europea Commission. https://data.europa.eu/doi/10.2777/426921.

Ginsburg, Liane R., Steven Lewis, Lisa Zackheim, and Ann Casebeer. 2007. "Revisiting Interaction in Knowledge Translation." *Implementation Science* 2: 34. https://doi.org/10.1186/1748-5908-2-34.

Glasgow, R. E., T. M. Vogt, and S. M. Boles. 1999. "Evaluating the Public Health Impact of Health Promotion Interventions: The RE-AIM Framework." *American Journal of Public Health* 89 (9): 1322–27. https://doi.org/10.2105/ajph.89.9.1322.

Goddard, John, Ellen Hazelkorn, Louise Kempton, and Paul Vallance. 2016. *The Civic University: The Policy and Leadership Challenges*. Cheltenham, UK: Edward Elgar Pub.

Graham, Ian D., Jo Logan, Margaret B. Harrison, Sharon E. Straus, Jacqueline Tetroe, Wenda Caswell, and Nicole Robinson. 2006. "Lost in Knowledge Translation: Time for a Map?" *Journal of Continuing Education in the Health Professions* 26 (1): 13–24. https://doi.org/10.1002/chp.47.

Grau i Vidal, Francesc Xavier, J. B Goddard, Budd L Hall, Ellen Hazelkorn, Rajesh Tandon, and Global University Network for Innovation. 2017. *Towards a Socially Responsible University: Balancing the Global with the Local*. Girona: Global University Network for Innovation (GUNi). http://www.guninetwork.org/files/download_full_report.pdf.

Greenhalgh, Trisha, Glenn Robert, Fraser Macfarlane, Paul Bate, and Olivia Kyriakidou. 2004. "Diffusion of Innovations in Service Organizations: Systematic Review and Recommendations." *The Milbank Quarterly* 82 (4): 581–629. https://doi.org/10.1111/j.0887-378X.2004.00325.x.

Grol, Richard, and Jeremy Grimshaw. 2003. "From Best Evidence to Best Practice: Effective Implementation of Change in Patients' Care." *The Lancet* 362 (9391): 1225–30. https://doi.org/10.1016/S0140-6736(03)14546-1.

Haan, Uzi de, Shuli C. Shwartz, and Fernando Gómez-Baquero. 2020. "A Startup Postdoc Program as a Channel for University Technology Transfer: The Case of the Runway Startup Postdoc Program at the Jacobs Technion–Cornell Institute at

Cornell Tech." *The Journal of Technology Transfer* 45 (6): 1611–33. https://doi.org/10.1007/s10961-019-09764-7.

Haskel, Jonathan, and Gavin Wallis. 2013. "Public Support for Innovation, Intangible Investment and Productivity Growth in the UK Market Sector." *Economics Letters* 119 (2): 195–98. https://doi.org/10.1016/j.econlet.2013.02.011.

Israel, Barbara A., Amy J. Schulz, Edith A. Parker, and Adam B. Becker. 1998. "REVIEW OF COMMUNITY-BASED RESEARCH: Assessing Partnership Approaches to Improve Public Health." *Annual Review of Public Health* 19 (1): 173–202. https://doi.org/10.1146/annurev.publhealth.19.1.173.

Jensen, Febi, Hans Lööf, and Andreas Stephan. 2020. "New Ventures in Cleantech: Opportunities, Capabilities and Innovation Outcomes." *Business Strategy and the Environment* 29 (3): 902–17. https://doi.org/10.1002/bse.2406.

Kaloudis, Aris, Arild Aspelund, Per M. Koch, Thomas A. Lauvås, Marius Tuft Mathisen, Øivind Strand, Roger Sørheim, and Torgeir Aadland. 2019. "How Universities Contribute to Innovation: A Literature Review-Based Analysis." NTNU. https://www.ntnu.edu/documents/1272711283/1276140112/Rapport_How+universities+contribute+to+innovation_web.pdf.

Kecskes, Kevin, Rita Sumner, Erin Elliott, and Adriane Ackerman. 2016. "A Year-Long Journey in the Orchard : Growing Community amid the Brambles." In *University—Community Partnerships*, edited by B.D. Wortham-Galvin, Jennifer H. Allen, and Jacob D.B Sherman, 11–34. Routledge. https://doi.org/10.4324/9781351283564-2.

Klevorick, Alvin K., Richard C. Levin, Richard R. Nelson, and Sidney G. Winter. 1995. "On the Sources and Significance of Interindustry Differences in Technological Opportunities." *Research Policy* 24 (2): 185–205. https://doi.org/10.1016/0048-7333(93)00762-I.

Lavis, John, Suzanne Ross, Christopher McLeod, and Alina Gildiner. 2003. "Measuring the Impact of Health Research." *Journal of Health Services Research & Policy* 8 (3): 165–70.

Lee, In, and Yong Jae Shin. 2018. "Fintech: Ecosystem, Business Models, Investment Decisions, and Challenges." *Business Horizons* 61 (1): 35–46. https://doi.org/10.1016/j.bushor.2017.09.003.

Lynch, Elizabeth A., Shanthi A. Ramanathan, Sandy Middleton, Julie Bernhardt, Michael Nilsson, and Dominique A. Cadilhac. 2018. "A Mixed-Methods Study to Explore Opinions of Research Translation Held by Researchers Working in a Centre of Research Excellence in Australia." *Bmj Open* 8 (9): e022357. https://doi.org/10.1136/bmjopen-2018-022357.

Madelin, Robert, and David Ringrose. 2016. *Opportunity Now: Europe's Mission to Innovate*. Brussels: The Publications Office of the European Union. https://data.europa.eu/doi/10.2759/928766.

Mazzucato, Mariana. 2017. "Mission-Oriented Innovation Policy: Challenges and Opportunities." IIPP WP 2017-01. UCL Institute for Innovation and Public Purpose (IIPP) Working Paper Series. UCL. https://www.ucl.ac.uk/bartlett/public-purpose/publications/2017/sep/mission-oriented-innovation-policy-challenges-and-opportunities.

McGagh, John, Helene Marsh, Mark Western, Peter Thomas, Andrew Hastings, Milla Mihailova, Matt Wenham, and Australian Council of Learned Academies (ACOLA). 2016. *Review of Australia's research training system*. Report for the Australian Council of Learned Academies. Melbourne: Australian Council of Learned Academies (ACOLA). https://acola.org/research-training-system-review-saf13/.

Mention, Anne-Laure. 2019. "The Future of Fintech." *Research-Technology Management* 62 (4): 59–63. https://doi.org/10.1080/08956308.2019.1613123.

———. 2020. "The Age of FinTech: Implications for Research, Policy and Practice." *The Journal of FinTech*, June, 2050002. https://doi.org/10.1142/S2705109920500029.

Ministry of Business Innovation & Employment, New Zealand. 2015a. *National Statement of Science Investment, 2015-2025.* Ministry of Business, Innovation & Employment - New Zealand Government. http://natlib-primo.hosted.exlibrisgroup.com/NLNZ:NLNZ:NLNZ_ALMA11312471270002836.

———. 2015b. "National Science Challenges Performance Framework. Guidance Document (1)." Ministry of Business, Innovation & Employment - New Zealand Government. https://www.mbie.govt.nz/assets/21ad1b6da3/nsc-performance-framework-guidance-document.pdf.

Morris, Zoe Slote, Steven Wooding, and Jonathan Grant. 2011. "The Answer Is 17 Years, What Is the Question: Understanding Time Lags in Translational Research." *Journal of the Royal Society of Medicine* 104 (12): 510–20. https://doi.org/10.1258/jrsm.2011.110180.

Naujokaitytė, Goda. 2021. "Taking Wing: New Features of Fully-Fledged EIC Revealed in Leaked Draft." Science|Business. February 2, 2021. https://sciencebusiness.net/news/taking-wing-new-features-fully-fledged-eic-revealed-leaked-draft.

Obradović, Tena, Božidar Vlačić, and Marina Dabić. 2021. "Open Innovation in the Manufacturing Industry: A Review and Research Agenda." *Technovation*, January, 102221. https://doi.org/10.1016/j.technovation.2021.102221.

OECD. 2013. "Firms Collaborating on Innovation with Higher Education or Public Research Institutions, by Firm Size, 2008-10: As a Percentage of Product and/or Process Innovative Firms in Each Size Category." OECD Publishing. https://doi.org/10.1787/sti_scoreboard-2013-graph110-en.

———. 2019a. *Digital Innovation: Seizing Policy Opportunities*. Paris: OECD Publishing. https://doi.org/10.1787/a298dc87-en.

———. 2019b. *University-Industry Collaboration: New Evidence and Policy Options*. Paris: OECD Publishing. https://doi.org/10.1787/e9c1e648-en.

Orazbayeva, Balzhan, Todd Davey, Carolin Plewa, and Victoria Galán-Muros. 2020. "Engagement of Academics in Education-Driven University-Business Cooperation: A Motivation-Based Perspective." *Studies in Higher Education* 45 (8): 1723–36. https://doi.org/10.1080/03075079.2019.1582013.

Piatti, Cinzia, Simone Graeff-Hönninger, and Forough Khajehei, eds. 2019. *Food Tech Transitions: Reconnecting Agri-Food, Technology and Society*. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-21059-5.

Renda, Andrea. 2019. "The Age of Foodtech: Optimizing the Agri-Food Chain with Digital Technologies." In *Achieving the Sustainable Development Goals Through Sustainable Food Systems*, edited by Riccardo Valentini, John L. Sievenpiper, Marta Antonelli, and Katarzyna Dembska, 171–87. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-23969-5_10.

Rossi, Federica, Muthu De Silva, Ning Baines, and Ainurul Rosli. 2020. "Long-Term Innovation Outcomes of University–Industry Collaborations: The Role of 'Bridging' vs 'Blurring' Boundary-Spanning Practices." *British Journal of Management*, November, 1467-8551.12449. https://doi.org/10.1111/1467-8551.12449.

Saltmarsh, J. 2016. "Higher Education's Accountability for the Public Good." Presented at the Keynote address delivered to the Academic Resource Conference, Western Association of Schools and Colleges.

Schiermeier, Quirin. 2021. "How Europe's €100 Billion Science Fund Will Shape 7 Years of Research." *Nature*, February. https://doi.org/10.1038/d41586-021-00496-z.

Schot, Johan, and W. Edward Steinmueller. 2016. "Framing Innovation Policy for Transformative Change: Innovation Policy 3.0." DRAFT – Version 2. Brighton, UK: SPRU Science Policy Research Unit, University of Sussex. http://tipconsortium.net/wp-content/uploads/2018/03/SchotSteinmueller_FramingsWorkingPaperVersionUpdated2018.10.16-New-copy.pdf.

Schwab, Klaus. 2017. *The Fourth Industrial Revolution*. Illustrated edition. New York: Currency.

Searles, Andrew, Chris Doran, John Attia, Darryl Knight, John Wiggers, Simon Deeming, Joerg Mattes, et al. 2016. "An Approach to Measuring and Encouraging Research Translation and Research Impact." *Health Research Policy and Systems* 14 (1): 60. https://doi.org/10.1186/s12961-016-0131-2.

Woolf, Steven H. 2008. "The Meaning of Translational Research and Why It Matters." *JAMA* 299 (2): 211–13. https://doi.org/10.1001/jama.2007.26.

Zarbin, Marco. 2020. "What Constitutes Translational Research? Implications for the Scope of Translational Vision Science and Technology." *Translational Vision Science & Technology* 9 (8). https://doi.org/10.1167/tvst.9.8.22.

6 A research template for understanding Research Translation cases

Massimo Menichinelli, Elena Casprini

1 Introduction

There is an increasing concern about making sure that the results of research activities achieve the desired societal outcomes (Banzi et al., 2011); how to speed up the transfer of research findings into practice (Graham et al., 2006); how to make sure it keeps pace with the rapid advances in knowledge (Grol and Grimshaw, 2003); how to make sure research is better accessed and adopted by stakeholders and decision-makers (Brownson et al., 2009), policymakers (Brownson et al., 2006), citizens (Israel et al., 1998).

These have been particularly a concern in the healthcare sector where the origins and history of Research Translation can be traced to (Mention et al., 2021). As defined by Searles et al., "*Research translation is a process of knowledge generation and transfer that enables those utilising the developed knowledge to apply it. This definition acknowledges that, once generated, knowledge flows can be multidirectional and non-sequential*" (2016, p. 2). Research Translation is thus a multidirectional and non-sequential process of knowledge generation and transfer that enables its application in practice through the engagement of the actors of an innovation ecosystem. Research Translation is done by moving back and forward from basic sciences and labs to practical implementation, between University and Industry.

Research Translation is an emerging topic still to be studied, especially in other sectors than the healthcare one. The Horizon 2020 MSCA-RISE OpenInnoTrain project aims at studying Research Translation in Open Innovation within the University-Industry Cooperation (UIC) framework in the 4 sectors of FinTech (Lee and Shin, 2018; Mention, 2020, 2019), Industry 4.0 (Alcácer and Cruz-Machado, 2019; Ibarra et al., 2018; Obradović et al., 2021; Schwab, 2017), CleanTech (Aagaard et al., 2021; Caprotti, 2012; Cumming et al., 2016; Jensen et al., 2020) and FoodTech (D'Antino et al., 2020; Piatti et al., 2019; Renda, 2019).

Among the many activities of the OpenInnoTrain project, during October 20th and 27th 2020, a Masterclass explored how to identify and analyse Open Innovation cases developed between universities and industries within the emerging approach of Research Translation, in the sector of FinTech, Industry 4.0, CleanTech and FoodTech. The goal of this masterclass was to share and learn new approaches for understanding cases of Open Innovation between University and Industry through Research Translation. During the masterclass, the authors presented a proposal of an analytical framework for understanding Research Translation case studies: this contribution documents such a framework and details its theoretical background and adoption. Our working definition of Research Translation for this framework is a process-oriented Open Innovation initiative taking place within University-Industry Cooperation through multiple knowledge transfers in a network of interactions that are part of an innovation ecosystem.

How can we analyse Research Translation case studies? After this Introduction (1), the following section (2) provides a literature review of the background concepts behind Research Translation and the analysis of its case studies. The next section (3) details the proposal of a template for research protocols for analysing case studies of Research Translation, starting from goals and research questions through presenting the workflow and the structure of the interview protocol. Finally, conclusions (4) detail the overview of this contribution, its limitations and potential future development and applications.

2 Theoretical Models behind the concept of Research Translation

Understanding Research Translation requires embracing the multidirectional knowledge flows happening among parties (Searles et al., 2016). This leads us to consider at least three streams of research when approaching the phenomenon. First, the *what*: this has to do with *research* and, consequently, with the broader concepts of *knowledge* and *innovation*. Then, the *how* and the *who*: these have to do with what we mean with *translation* and the process that is involved with making research understandable and usable and the narrow set of *actors*, with particular reference to universities and industries (Bercovitz and Feldman, 2006), involved in these processes. Finally, the *where*, and therefore the context where research translation happens, with particular reference to the whole *innovation ecosystem*.

2.1 The “What”: from knowledge to innovation

Knowledge is a core concept for science advancement; in this chapter we follow this definition: “*Knowledge is information possessed in the mind of individuals: it is personalized information (which may not be new, unique, useful or accurate) related to facts, procedures, concepts, interpretations, ideas, observations, and judgements*” (Alavi and Leidner, 2001, p. 109). Knowledge derives from information, and information from data (Alavi and Leidner, 2001). In a context such as the current one, with the increased amount of data due to technologies and the wider diffusion of information, knowledge even more represents a key resource to be managed. In a very simplified scheme, knowledge, in fact, is conducive, throughout research and development, to innovation.

We suggest that, in approaching research translation cases, scholars would ask themselves "*what is the innovation of this research translation case?*". In order to identify innovation, we would like to distinguish among three different ways of approaching innovation (Kahn, 2018): innovation as an outcome (e.g., product, process, marketing, business model etc.), innovation as a process (how the output becomes usable) and innovation as a mindset (i.e. the internalisation of innovation in the culture). Once defined the focus on innovation (outcome, process or mindset), our framework moves a step ahead considering the "how" and the "who".

2.2 The "How" and the "Who": Knowledge Flows and Actors Interactions

The "how" innovation is translated is clearly related to the processes by which an innovation is implemented and diffused and who the involved actors are. Traditionally, scholars have advanced the innovation funnel, where product innovation (as a product launch in the market) results from several steps starting from idea generation, for example in the steps described in the stage-gate model (Cooper, 1990). However, such types of models focus on the company as the main actor involved in the innovation process. Here, the employees - mainly employees working in the R&D department - are the key actors dealing with the whole process. As we know, in the last two decades the innovation-related literature has been shaped by the concept of Open Innovation that has instead broadened the set of actors and the ways that are involved in innovation.

Open innovation is defined as "*the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively*" (Chesbrough, 2006, p. 1). Literature on Open Innovation has distinguished among multiple types of actors that could help companies in developing innovation such as market actors (e.g. customers, suppliers, competitors) and institutional actors (e.g. universities, government research organisations) (Laursen and Salter, 2006). The impact that these actors may have on the innovation outcome varies according to the focal actor's characteristics. Just as examples, we could cite the peculiarities of open innovation in small- and medium-sized companies (e.g. see the book by Frattini et al., 2018), the capabilities that family firms may leverage upon when executing open innovation (Casprini et al., 2017), but also the structural positioning within a network (Huggins et al., 2020).

We also might consider the different types of relationships linking actors that could shape how innovation is developed. For example, Bercovitz and Feldman (2006), in analysing the university-industry relationships, propose a conceptual model encapsulating economic, social and political influences that could impact how universities may develop knowledge. We think that Bercovitz's and Feldman's paper (2006) is particularly useful since it provides five mechanisms of how university transfers knowledge namely sponsored research, licenses, recruitment of students, spin-offs and serendipity.

Furthermore, there are different ways for pursuing Open Innovation, for example with pecuniary (e.g., via licensing) and non-pecuniary (e.g., by revealing means) strategies (Dahlander and Gann, 2010). In such a context, scholars have also considered how companies may use different tools, such as social media (Mount and Martinez, 2014) and digital technologies (Urbinati et al., 2020), in involving several actors that could contribute at different levels of the innovation funnel (from idea generation to product launch, but also its end of life).

More recently, Bogers et al. (2018) argue that "*at the core of open innovation is the ability to create an ecosystem where people, organizations, and sectors can foster co-creation. It involves business models - the logic of creating and capturing value - that dynamically transcend organizational boundaries within that innovation ecosystem*" (p. 10).

2.3 The "Where": Ecosystems

Literature on ecosystems has bloomed in the last decades, with several definitions (Aarikka-Stenroos and Ritala, 2017; Adner, 2017; Bogers et al., 2019) and frameworks proposed. According to Adner (2017), the concept of ecosystem is different from others (that focus on) such as platforms (technology) and multi sided markets (transactions), networks (patterns of connectivity) and alliances (connectivity at firm level), business model (focal firm and firm strategy), project management (coordination of multiple activities towards a goal), supply chain (there is a critical path and the focus is on make or buy decisions), among others. Furthermore, there are also start-up ecosystems and service ecosystems (Aarikka-Stenroos and Ritala, 2017).

Defining an ecosystem has been at the core of some recent papers. Adner (2017) distinguishes between two main approaches in studying ecosystems. The first, that he is advancing, is the "*ecosystem-as-structure*" (focus on activity) according to which ecosystem is "*the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*" (p. 40). The second one, that has dominated the field and traces its roots back to biology, is the "*ecosystems-as-affiliation*" (focus on actors) where there are several actors who are loosely interconnected and whose survival depends on each other. These two approaches, which change in terms of focus (value proposition vs actor), present the same constituting elements, i.e. activities, actors, positions and links. Jacobides et al. (2018) identify three streams of research about ecosystems namely related to business (firm-environment), innovation (innovation/value proposition and the related actors) and platform (i.e. "*how actors organize around a platform*", p. 2257). Bogers et al. (2019) define an ecosystem as "*an interdependent network of self-interested actors jointly creating value*" (p. 2), thus identifying four components (i.e. interdependence, network, self-interested actors, creating value).

As a consequence of these perspectives, scholars have advanced some tools/principles to help managers in designing ecosystems. For example, Talmar et al. (2018) propose an *ecosystem pie model* that distinguishes between ecosystem level constructs (i.e. the ecosystem's value proposition, the target user segments, the interdependent actors) and the actor level constructs (resources, activities, value addition, value capture, dependence and risk). Peppard and Rylander (2006) introduce the *Network Value Analysis* as a way to analyse competitive ecosystems and apply it to the mobile operators. Konietzko et al., (2020) advance a set of principles for the circular ecosystem innovation.

3 A proposal of a research template for analysing Research Translation case studies

3.1 A perspective on Research Translation

Considering the main concepts emerging from the literature review of the previous section, we propose here a framework for analysing Research Translation case studies. More than a prescriptive framework, this proposal should rather be considered as a template for preparing interview protocols and for studying the resulting data of Research Translation cases. The next sections detail the research questions, workflow and set of questions of such a framework; this section details the perspective that informs the framework. We propose a framework with a systemic and network perspective based on four main elements: Innovation, Process, Networks, Ecosystem. We consider this approach relevant as "*networks are becoming the paradigm to uncover the hidden architecture of complexity*" (Caldarelli and Catanzaro, 2012, p. 6). Such a systemic approach goes beyond the traditional view of studying only the innovation as a case study with a product, process or service as the unit of analysis a with clearly defined and limited boundaries of the context (Figure 1).

In this framework, innovation (as a product and/or service, and as a process) is not seen as a single entity to be studied alone but instead as an entity developed through processes which should be considered together with it (Figure 2). More specifically, going deeper in the understanding of such processes, which should be considered as networks of interactions (collaborations) and flows (of ideas, projects, artifacts, material and financial resources and so on) within an innovation ecosystem (Figure 3).

Figure 1 Analytical Framework: Innovation as the traditional focus of case studies

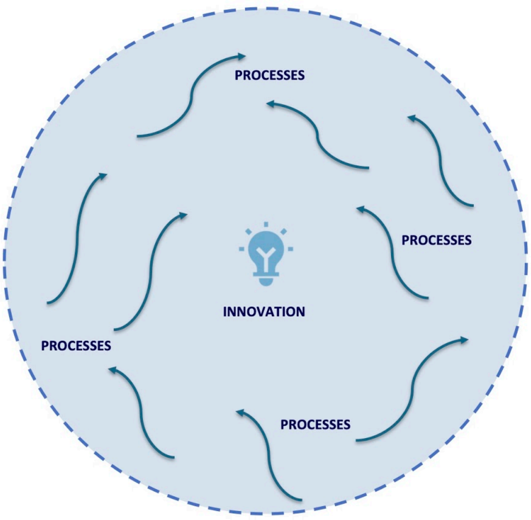


Figure 2 Analytical Framework: Innovation emerging from a set of processes

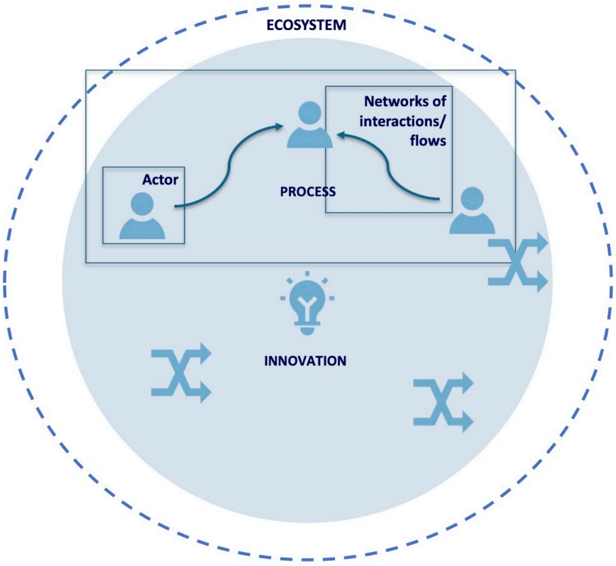


Figure 3 Analytical Framework: Unit of Analysis: Innovation emerging from networks of interactions among actors within an Innovation Ecosystem

Our working definition of Research Translation for this framework is: *Research Translation can be understood as a process-oriented Open Innovation initiative taking place within University-Industry Cooperation through multiple knowledge transfers in a network of interactions part of an innovation ecosystem*. The main features of Research Translation therefore are:

1) a process-oriented initiative
2) with an Open Innovation approach
3) taking place within University-Industry Cooperation
    a) through multiple knowledge transfers
    b) in a network of interactions
    c) in an innovation ecosystem.

3.2 Research Questions

The overall objective of this analytical framework is to provide the foundation for analysing Research Translation cases studies with a systemic perspective, and in general, a way for studying such an emergent innovation phenomenon and framework. Starting from a first and main research question RQ0, the starting point for thinking about a Research Translation case study would be this:

- RQ0. How does Research Translation take place in this case study?

Which can be refined and developed into a more structured RQ0 with these main elements:

- RQ0. How is this Research Translation case study:
  - organised? and
  - how was it developed (and then organised)? and
  - how could it be replicated?

And summarised in this longer research question RQ0:

- RQ0. How was this Research Translation case study developed and organised and how could this shed light on its replicability?

As this is still a broad research question, a set of three sub-research questions (RQ1-2-3) can be added in order to unpack several dimensions of RQ0, and that will ultimately contribute to it (Figure 4). It shall be noted how RQ2 works at two levels: at individual actor's level and at collective actors' level (the innovation ecosystem):

1. RQ1. What is the innovation of the RT case?
2. RQ2. Who are the actors involved in the innovation ecosystem of the RT case?
3. RQ3. How have actors interacted within the RT case?

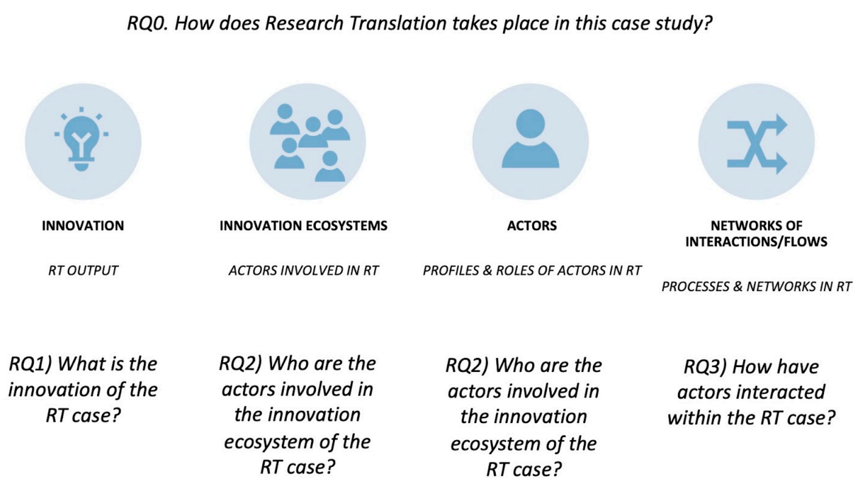


Figure 4 Analytical Framework: Framework, Research Questions Unit of Analysis and sub-Units of Analysis

3.3 Workflow

We suggest this workflow for analysing Research Translation case studies, by starting from an innovation and moving then to the organisations behind it:

1. STEP 01: Identify an innovation developed with Research Translation.
2. STEP 02: Contact and interview the identified organisations behind the innovation.
3. STEP 03: Repeat STEP 02 for the other relevant organisations identified during the interviews of STEP 02.
4. STEP 04: Data analysis.
5. STEP 05: Elaborate findings: from descriptive case study (organising the collected material) towards an exploratory case study with theoretical lenses.

This workflow informs the questions of the interview detailed in the following sections. There are several possible workflows for studying a case study, and consequently different entry points: one could start from an organisation, then identify its Research Translation processes and later only identify innovations, and so on. In case of a different workflow and entry point, the following questions should be reorganised.

3.4 Interview

3.4.1 Introduction

Introduction of the interviewers and of the scope of the interview:

1. Introduction of the interviewers.
2. Purpose of the interview.
3. Definitions of concepts of Research Translation, Innovation Ecosystem, University-Industry Cooperation.
4. Overview of the whole interview.
5. Informed consent for the participation of the interviewee.

3.4.2 Interview – Organisation (RQ2)

Questions about the profile of the organisation (an individual actor):

1. How was the organisation founded? (by whom, how the idea was developed, ...)
2. What are the key activities of the organisation?
3. Why is the organisation unique in respect to its main competitors?

3.4.3 Interview – Innovation (RQ1)

Questions about the innovation at the centre of the Research Translation:

1. How has the organisation developed the innovation?
2. How was the idea generation phase?
3. What is the Problem that this innovation has addressed both in terms of research and practice?
4. What is the Goal of this innovation?
5. What are your main Findings gathered working on the innovation?
6. Who might benefit from this?
7. How could this innovation be replicated by others?

3.4.4 Interview – Innovation Ecosystem (RQ2)

Questions about the actors of the innovation ecosystem behind the Research Translation (all the actors):

1. How would you define the innovation ecosystem behind this innovation?
2. What has been the role of university, business, government and other types of actors?
3. Who are the actors who have been involved in the innovation ecosystem? List and describe 10 other actors in the innovation ecosystem your organisation has interacted with during the life cycle of the innovation. In the next questions, we will ask you about the interactions with them from your organisation's focal point of view:

Table 1. List of the 10 actors the interviewed actor has interacted the most in the development of this Research Translation initiative

Actors	Actors' descriptions
Actor 1	...
Actor 2	...
Actor 3	...
Actor 4	...
Actor 5	...
Actor 6	...
Actor 7	...
Actor 8	...
Actor 9	...
Actor 10	...

3.4.5 Interview – Interactions / Flows of research activities (RQ3)

Please rate the interactions between your organisation and the other actors of the innovation ecosystem in terms of **research activities**.

How often (from 1 "very rarely", to 5 "very frequently") has your organisation interacted with each of them in each phase?

Table 2. Likert scale for frequency of interactions in research activities

1	**2**	**3**	**4**	**5**
Very rarely	Rarely	Occasionally	Frequently	Very frequently

Table 3. Frequency of interactions in research activities between the interviewed actor and all actors along all the phases

	Idea generation & collection	**Scoping (idea selection)**	**Build business case**	**Development**	**Testing & validation**	**Launch**
Actor 1	1		2			
Actor 2		3				3
Actor 3				4		
Actor 4						5
Actor 5		1	1	2		
Actor 6					2	
Actor 7			1			
Actor 8				2		
Actor 9	1					
Actor 10		2		2		

Overall, in all the phases, how positive or negative have your interactions with each of them been?

Table 4. Likert scale for quality of interactions in research activities

-2	-1	0	1	2
Very negative	Negative	Moderate	Positive	Very positive

Table 5. Overall quality of interactions in research activities between the interviewed actor and all actors in all the phases

Actors	Quality of interactions in all phases with each actor
Actor 1	-1
Actor 2	0
Actor 3	2
Actor 4	1
Actor 5	2
Actor 6	-1
Actor 7	1
Actor 8	0
Actor 9	2
Actor 10	-2

3.4.6 Interview – Interactions / Flows of business & implementation activities (RQ3)

Please rate the interactions between your organisation and the other actors of the innovation ecosystem in terms of **business & implementation activities**.

How often (from 1 “very rarely”, to 5 “very frequently”) has your organisation interacted with each of them in each phase?

Table 6. Likert scale for frequency of interactions in business & implementation activities

1	2	3	4	5
Very rarely	Rarely	Occasionally	Frequently	Very frequently

Table 7. Frequency of interactions in business & implementation activities between the interviewed actor and all actors along all the phases

	Idea generation & collection	**Scoping (idea selection)**	**Build business case**	**Development**	**Testing & validation**	**Launch**
Actor 1	1		2			
Actor 2		3				3
Actor 3				4		
Actor 4						5
Actor 5		1	1	2		
Actor 6					2	
Actor 7			1			
Actor 8				2		
Actor 9	1					
Actor 10		2		2		

Overall, in all the phases, how positive or negative have your interactions with each of them been?

Table 8. Likert scale for quality of interactions in business & implementation activities

-2	**-1**	**0**	**1**	**2**
Very negative	Negative	Moderate	Positive	Very positive

Table 9. Overall quality of interactions in business & implementation activities between the interviewed actor and all actors in all the phases

Actors	**Quality of interactions in all phases with each actor**
Actor 1	-1
Actor 2	0
Actor 3	2

Actor 4	1
Actor 5	2
Actor 6	-1
Actor 7	1
Actor 8	0
Actor 9	2
Actor 10	-2

3.4.7 Interview – Interactions / Flows of partnership & collaboration activities (RQ3)

Please rate the interactions between your organisation and the other actors of the innovation ecosystem in terms of partnership management & other collaboration activities.

How often (from 1 "very rarely", to 5 "very frequently") has your organisation interacted with each of them in each phase?

Table 10. Likert scale for frequency of interactions in partnership management & other collaboration activities

1	**2**	**3**	**4**	**5**
Very rarely	Rarely	Occasionally	Frequently	Very frequently

Table 11. Frequency of interactions in partnership management & other collaboration activities between the interviewed actor and all actors along all the phases

	Idea generation & collection	**Scoping (idea selection)**	**Build business case**	**Development**	**Testing & validation**	**Launch**
Actor 1	1		2			
Actor 2		3				3
Actor 3				4		
Actor 4						5

Actor 5		1	1	2		
Actor 6					2	
Actor 7			1			
Actor 8				2		
Actor 9	1					
Actor 10		2		2		

Overall, in all the phases, how positive or negative have your interactions with each of them been?

Table 12. Likert scale for quality of interactions in partnership management & other collaboration activities

-2	**-1**	**0**	**1**	**2**
Very negative	Negative	Moderate	Positive	Very positive

Table 13. Overall quality of interactions in partnership management & other collaboration activities between the interviewed actor and all actors in all the phases

Actors	**Quality of interactions in all phases with each actor**
Actor 1	-1
Actor 2	0
Actor 3	2
Actor 4	1
Actor 5	2
Actor 6	-1
Actor 7	1
Actor 8	0
Actor 9	2
Actor 10	-2

3.4.8 Interview – Impact

What is the impact of the innovation? Think at local, regional, national and international level, and at the organisational level.

Table 14. Overall quality of interactions in partnership management & other collaboration activities between the interviewed actor and all actors in all the phases

		Economic	**Environmental**	**Social**	**On your organisation**
Existing	So far				
Expected	Short term (<12 months)				
	Medium term (1-3 years)				
	Long term (> 3 years)				

4 Conclusions

Research Translation is an emerging approach for understanding and managing knowledge transfer within an innovation ecosystem. Our working definition of Research Translation is that it can be understood as a process-oriented Open Innovation initiative taking place through multiple knowledge transfers in a network of interactions part of an innovation ecosystem, between University and Industry. Considering the main concepts emerging from the literature review, we propose here a framework for analysing Research Translation case studies based on four main elements: Innovation, Process, Networks, Ecosystem. This framework is a template for preparing interview protocols and for studying the resulting data of Research Translation cases.

As this chapter is a first proposal of a template for interview protocols for studying Research Translation case studies, it still lacks a proper application and testing with case studies. The next steps for this line of research should be on developing full interview protocols and analyses for case studies. The testing on such cases should be documented both in terms of processes, protocols and tools, for example by sharing protocols with other researchers with an Open Science approach or by exploring the adoption of new interactive tools such as Network Canvas (Birkett et al., 2021). Beside testing and improving the protocol itself, further research should align its development to research about Research Translation and ideally contribute to it by producing insights from case studies towards the founding concepts of Research Translation, validating thus the conceptual framework at the foundation of this template.

Acknowledgments

Icons: Light Bulb, Crossed Arrows Photo Frame by Vectors Market from the Noun Project. https://thenounproject.com/vectorsmarket/

References

Aagaard, A., Saari, U.A., Mäkinen, S.J., 2021. Mapping the types of business experimentation in creating sustainable value: A case study of cleantech start-ups. J. Clean. Prod. 279, 123182. https://doi.org/10.1016/j.jclepro.2020.123182

Aarikka-Stenroos, L., Ritala, P., 2017. Network management in the era of ecosystems: Systematic review and management framework. Industrial Marketing Management 67, 23–36. https://doi.org/10.1016/j.indmarman.2017.08.010

Adner, R., 2017. Ecosystem as Structure: An Actionable Construct for Strategy. Journal of Management 43, 39–58. https://doi.org/10.1177/0149206316678451

Alavi, M., Leidner, D.E., 2001. Review: Knowledge management and knowledge management systems: conceptual foundations and research issues. MIS Q. 25, 107–136. https://doi.org/10.2307/3250961

Alcácer, V., Cruz-Machado, V., 2019. Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems. Eng. Sci. Technol. Int. J. https://doi.org/10.1016/j.jestch.2019.01.006

Banzi, R., Moja, L., Pistotti, V., Facchini, A., Liberati, A., 2011. Conceptual frameworks and empirical approaches used to assess the impact of health research: an overview of reviews. Health Res. Policy Syst. 9, 26. https://doi.org/10.1186/1478-4505-9-26

Bercovitz, J., Feldman, M., 2006. Entpreprenerial Universities and Technology Transfer: A Conceptual Framework for Understanding Knowledge-Based Economic Development. J. Technol. Transf. 31, 175–188. https://doi.org/10.1007/s10961-005-5029-z

Birkett, M., Melville, J., Janulis, P., Phillips, G., Contractor, N., Hogan, B., 2021. Network Canvas: Key decisions in the design of an interviewer-assisted network data collection software suite. Soc. Netw. 66, 114–124. https://doi.org/10.1016/j.socnet.2021.02.003

Bogers, M., Chesbrough, H., Moedas, C., 2018. Open Innovation: research, practices, and policies. California Management Review 60, 5–16.

Bogers, M., Sims, J., West, J., 2019. What Is an Ecosystem? Incorporating 25 Years of Ecosystem Research. Proceedings 2019, 11080. https://doi.org/10.5465/AMBPP.2019.11080abstract

Brownson, R.C., Fielding, J.E., Maylahn, C.M., 2009. Evidence-Based Public Health: A Fundamental Concept for Public Health Practice. Annu. Rev. Public Health 30, 175–201. https://doi.org/10.1146/annurev.publhealth.031308.100134
Brownson, R.C., Royer, C., Ewing, R., McBride, T.D., 2006. Researchers and Policymakers: Travelers in Parallel Universes. Am. J. Prev. Med. 30, 164–172. https://doi.org/10.1016/j.amepre.2005.10.004
Caldarelli, G., Catanzaro, M., 2012. Networks: a very short introduction, 1st ed. ed, Very short introductions. Oxford University Press, Oxford.
Caprotti, F., 2012. The cultural economy of cleantech: environmental discourse and the emergence of a new technology sector: The cultural economy of cleantech. Trans. Inst. Br. Geogr. 37, 370–385. https://doi.org/10.1111/j.1475-5661.2011.00485.x
Casprini, E., De Massis, A., Di Minin, A., Frattini, F., Piccaluga, A., 2017. How family firms execute open innovation strategies: the Loccioni case. J of Knowledge Management 21, 1459–1485. https://doi.org/10.1108/JKM-11-2016-0515
Chesbrough, H., Vanhaverbeke, W., West, J. 2006. Open Innovation: Researching a new paradigm, Oxford University Press
Cooper, R.G., 1990. Stage-gate systems: A new tool for managing new products. Business Horizons 33, 44–54. https://doi.org/10.1016/0007-6813(90)90040-I
Cumming, D., Henriques, I., Sadorsky, P., 2016. 'Cleantech' venture capital around the world. Int. Rev. Financ. Anal. 44, 86–97. https://doi.org/10.1016/j.irfa.2016.01.015
Dahlander, L., Gann, D.M., 2010. How open is innovation? Res. Policy 39, 699–709. https://doi.org/10.1016/j.respol.2010.01.013
D'Antino, A., Leveau, M., Dingemans, A., Yuksel, B., Redshaw, M., 2020. The state of global Foodtech report 2020. Talent Garden / Forward Fooding.
Frattini, F., Usman, M., Roijakkers, N., Vanhaverbeke, W., 2018. Researching open innovation in SMEs, Researching Open Innovation In SMEs. World Scientific Pub Co Inc.
Graham, I.D., Logan, J., Harrison, M.B., Straus, S.E., Tetroe, J., Caswell, W., Robinson, N., 2006. Lost in knowledge translation: Time for a map? J. Contin. Educ. Health Prof. 26, 13–24. https://doi.org/10.1002/chp.47
Grol, R., Grimshaw, J., 2003. From best evidence to best practice: effective implementation of change in patients' care. The Lancet 362, 1225–1230. https://doi.org/10.1016/S0140-6736(03)14546-1
Huggins, R., Prokop, D., Thompson, P., 2020. Universities and open innovation: the determinants of network centrality. J Technol Transf 45, 718–757. https://doi.org/10.1007/s10961-019-09720-5
Ibarra, D., Ganzarain, J., Igartua, J.I., 2018. Business model innovation through Industry 4.0: A review. Procedia Manuf. 22, 4–10. https://doi.org/10.1016/j.promfg.2018.03.002
Israel, B.A., Schulz, A.J., Parker, E.A., Becker, A.B., 1998. REVIEW OF COMMUNITY-BASED RESEARCH: Assessing Partnership Approaches to Improve Public Health. Annu. Rev. Public Health 19, 173–202. https://doi.org/10.1146/annurev.publhealth.19.1.173
Jacobides, M.G., Cennamo, C., Gawer, A., 2018. Towards a theory of ecosystems. Strat Mgmt J 39, 2255–2276. https://doi.org/10.1002/smj.2904
Jensen, F., Lööf, H., Stephan, A., 2020. New ventures in Cleantech: Opportunities, capabilities and innovation outcomes. Bus. Strategy Environ. 29, 902–917. https://doi.org/10.1002/bse.2406
Kahn, K.B., 2018. Understanding innovation. Business Horizons 61, 453–460. https://doi.org/10.1016/j.bushor.2018.01.011
Konietzko, J., Bocken, N., Hultink, E.J., 2020. Circular ecosystem innovation: An initial set of principles. Journal of Cleaner Production 253, 119942. https://doi.org/10.1016/j.jclepro.2019.119942
Laursen, K., Salter, A., 2006. Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. Strat. Mgmt. J. 27, 131–150. https://doi.org/10.1002/smj.507

Lee, I., Shin, Y.J., 2018. Fintech: Ecosystem, business models, investment decisions, and challenges. Bus. Horiz. 61, 35–46. https://doi.org/10.1016/j.bushor.2017.09.003
Mention, A.-L., 2020. The Age of FinTech: Implications for Research, Policy and Practice. J. FinTech 2050002. https://doi.org/10.1142/S2705109920500029
Mention, A.-L., 2019. The Future of Fintech. Res.-Technol. Manag. 62, 59–63. https://doi.org/10.1080/08956308.2019.1613123
Mention, A.-L., Bhimani, H., Menichinelli, M., 2021. D1.1 Executive Report on State of Play in UIC and Research Translation in Europe and Australia (OpenInnoTrain No. D1.1).
Mount, M., Martinez, M.G., 2014. Social Media: A Tool for Open Innovation. California Management Review 56, 124–143. https://doi.org/10.1525/cmr.2014.56.4.124
Obradović, T., Vlačić, B., Dabić, M., 2021. Open innovation in the manufacturing industry: A review and research agenda. Technovation 102221. https://doi.org/10.1016/j.technovation.2021.102221
Peppard, J., Rylander, A., 2006. From Value Chain to Value Network: Insights for mobile operators. European Management Journal 24, 128–141. https://doi.org/10.1016/j.emj.2006.03.003
Piatti, C., Graeff-Hönninger, S., Khajehei, F. (Eds.), 2019. Food Tech Transitions: Reconnecting Agri-Food, Technology and Society. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-21059-5
Renda, A., 2019. The Age of Foodtech: Optimizing the Agri-Food Chain with Digital Technologies, in: Valentini, R., Sievenpiper, J.L., Antonelli, M., Dembska, K. (Eds.), Achieving the Sustainable Development Goals Through Sustainable Food Systems. Springer International Publishing, Cham, pp. 171–187. https://doi.org/10.1007/978-3-030-23969-5_10
Schwab, K., 2017. The Fourth Industrial Revolution, Illustrated edition. ed. Currency, New York.
Searles, A., Doran, C., Attia, J., Knight, D., Wiggers, J., Deeming, S., Mattes, J., Webb, B., Hannan, S., Ling, R., Edmunds, K., Reeves, P., Nilsson, M., 2016. An approach to measuring and encouraging research translation and research impact. Health Res. Policy Syst. 14, 60. https://doi.org/10.1186/s12961-016-0131-2
Talmar, M., Walrave, B., Podoynitsyna, K.S., Holmström, J., Romme, A.G.L., 2018. Mapping, analyzing and designing innovation ecosystems: The Ecosystem Pie Model. Long Range Plann. https://doi.org/10.1016/j.lrp.2018.09.002
Urbinati, A., Chiaroni, D., Chiesa, V., Frattini, F., 2020. The role of digital technologies in open innovation processes: an exploratory multiple case study analysis. R and D Management 50, 136–160. https://doi.org/10.1111/radm.12313

Part III:
The four OpenInnoTrain sectors

7 The Age of FinTech: Implications for Research, Policy and Practice

Anne-Laure Mention

Originally published by World Scientific Publishing Company as Open Access under a Creative Commons BY 4.0 license[1] as: Mention, A.-L., 2020. The Age of FinTech: Implications for Research, Policy and Practice. J. FinTech 2050002. https://doi.org/10.1142/S2705109920500029. No changes were made.

Published 30 June 2020

FinTech is inducing changes in how financial services (FS) are perceived, developed, promoted, delivered and consumed. Future of FinTech, however, is rooted in deliberate integrated actions to improve framework conditions related to consumer trust, regulation and scalability. Building on limited scholarship, this paper identifies the building blocks for the future of FinTech and provides prescriptive areas of focus to guide research, policy and practice. In sum, the purpose of the paper is to serve as a catalyst and a call for an integrative approach in developing a common understanding and interpretation of FinTech as a socially-constructed phenomenon at the intersection of research and technology management.

Keywords: FinTech; research; technology management; policy; framework.

1 Introduction

Financial services (FS) industry is undergoing accelerated change in parallel to technological affordances of the industry transformation. *FinTech*, an umbrella term used to describe innovative technology-enabled FS business models is inducing paradigmatic shift in how financial service firms deliver pecuniary and non-pecuniary benefits to interacting parties (Schueffel, 2016; Zavolokina et al., 2016). The US Financial Stability Board defines FinTech as “technologically enabled financial innovation that could result in new business models, applications, processes or products with an associated material effect on financial markets and institutions and the provision of financial services." Driven by digitization and digitalization (for discussion on interpretations see, Gobble, 2018), the promise of FinTech is now a feature of global discussions (Bofondi and Gobbi, 2017; Carney, 2017).

On the one hand, FinTech is forcing legacy financial institutions to clarify their strategies, develop new capabilities and transform their cultures (Buchak et al., 2018; Leong and Sung, 2018; Nonninger and Tesfaye, 2018). On the other hand, FinTech start-ups stand to benefit from technology-enabled capabilities, characterized by higher knowledge intensity and lower internal resource dependency (Mention and Torkkeli, 2012; Dapp, 2014; Philippon, 2016). There exists little doubt that FinTech is revolutionizing how FS are developed, promoted, delivered and consumed (Dapp, 2014). However, the jury is still out on the future of FinTech. The renewed momentum is delivering double-edged consequences – modernizing financial architecture and catalyzing behavioral change on one end and, disrupting incumbent employers, service models and regulations on the other end.

The research on this multifaceted socially constructed FinTech phenomenon is still in its infancy, but growing steadily (for recent reviews see, Gomber et al., 2017; Zavolokina et al., 2016). Zavolokina et al. (2016) position the first debate on the concept and definition of FinTech. Drawing on use of FinTech term in popular media, they conceptualized FinTech as a digital innovation focused on creating, changing, improving and disrupting information technology applications in finance and create competition in the sector, achieved through new services, products, processes or business models. More recently, Gomber et al. (2017) in adopting the digital innovation in finance premise reviewed the current state of research in digital finance from a business innovation perspective. They revealed the digital finance cube and argued that future research direction on the topic rests at the intersection of business functions, technologies and technological concepts, and types of institutions involved in the FinTech. Collectively, these reviews showcase the peculiarities of how FinTech is conceived in academia and practice. Other sets of studies have explored the FinTech universe, for instance, its applications across domains of banking functions (e.g., Gomber et al., 2018; Schwab and Guibaud, 2016; Stoeckli et al., 2018) and types of customer-centric and value-creating digitalization transformations brought about by FinTechs to retail banking (e.g., Davies et al., 2016; Dhar and Stein, 2017; Gozman et al., 2018; Marjanovic and Murthy, 2016; Shim and Shin, 2016).

However, to the best of our knowledge, there exists limited synthesis and insights on the building blocks of FinTech, conceptualizing aspects which may guide discussions on the future-oriented implications for FinTech research, policy and practice. This paper thus advances the argument that for an industry that is rapidly shaping the way we live; it seems necessary to identify its building blocks and guide future actions. Moving beyond the promise of FinTech, its definitions and domains of application, our belief (and hope) is that a coherent understanding of the future-oriented challenges and opportunities can shape deliberate actions today. In believing so, we acknowledge that FinTech is not confined to start-up ventures and is increasingly adopted by incumbents for its competitiveness and scalable applications (Alt and Puschmann, 2016; Schwab and Guibaud, 2016). Despite the variations in functional FinTech perspectives such as those related to compliance and regulatory issues i.e., "RegTech" (Gomber et al., 2018), insurance business, i.e., InsurTech (Stoeckli et al., 2018), retail banking (Schwab and Guibaud, 2016), and similarly, the building blocks for the future of FinTech reflect common considerations for how finance technology can be made possible to serve societal needs and demands. Interactions among main subjects and topics related to FinTech in literature are indeed focused on challenges related to awareness and adoption (Schulte and Liu, 2018), regulatory and privacy concerns (Ducas and Wilner, 2017; Traynor et al., 2017) and inhibitors of new products and services related to business models (Chen, 2016) and innovation collaboration or implementation (Au and Kauffman, 2008; Saksonova and Kuzmina-Merlino, 2017). Therefore, to synthesize a framework for future of FinTech, we set the following research questions which will guide the reader through the paper: (1) *what are the future-oriented challenges and opportunities of FinTech?* and (2) *what are the building blocks and implications for future research, policy and practice in the context of FinTech?*

The rest of this paper is organized as follows. In the *FinTech: the end of a beginning*, current framework perspectives are identified, which will serve as the basis for future-oriented discussion. To do that, this paper provides a glimpse of the rapidly growing global FinTech phenomenon, leading to our practice-oriented framework building approach. Subsequently, in *future of FinTech: an introduction*, challenges and opportunities are outlined, situating the discussions on open innovation and interoperability of framework conditions for growth and scalability across borders. For illustrative purposes, the paper relies on the European Union's (EU) FinTech conditions, in part due to the presence of rich regional and EU-wide policy, academic and popular press publications. Our *concept map for the future of FinTech* reflects three components building blocks for the future of FinTech, action lines and areas of potential impact. Thereafter, a summary is included in *conclusion, limitations and future directions*. Here, the paper identifies potential implications for research, policy and practice of FinTech and how the adopted approach builds on the existing promise of FinTech. Collectively, the aim of this paper is to inspire new ways to explore and explain the socially-constructed multifaceted FinTech phenomenon.

2 FinTech: The End of a Beginning

Technological affordances, coupled with the proliferation of open innovation business models (Brunswicker and Chesbrough, 2018) are promoting early internationalization and higher knowledge intensity (Autio et al., 2000). For instance, the set of products that traditionally have been within the exclusive remit of licensed credit institutions – payment services and loans – are now the most prominent FS provided by non-traditional technology-enabled financial firms representing a wide array of customer-centric value propositions and business models (EBA, 2016). FinTech firms are developing new ways for accessing, delivering, experiencing and co-creating FS (personalized solutions and mass customization). Diversity through portability of digital financial products, hybrid and cross-industry business models in new markets are the underlying premise of FinTech with benefits promoted as greater transparency and improved risk management with instant evaluation of feedback and adjustment of service in real-time.

For policy making, the FinTech market is quickly becoming too large to ignore. Industry reports on FinTech investments (see, e.g., Accenture, 2016; Cortina and Schmukler, 2018; Demirguc-Kunt et al., 2018; World Economic Forum, 2015) provide an appreciation for the state-of-the-art. About five years ago, an Accenture (2016) report noted that FinTech investments rose dramatically between 2013 and 2014, from US$4.05 billion in 2013 to US$12.2 billion in 2014. Although such reports on FinTech are limited in scope (i.e., often based on regional data) and uncoordinated, in 2015 there were at least 4,000 FinTech firms with more than a dozen identified as "unicorns" (valued over US$1 billion) (The Economist, 2015). The global investment in FinTech was US$22.3 billion in 2015, 12 times more than five years prior in 2010 (Accenture, 2016). Since then, KPMG (2018) reported that global investment in FinTech reached US$24.7 billion across 1,076 deals in 2016. More recent CBInsights (2018) reports identified the top 250 FinTech firms which collectively raised over US$31.85 billion in 2018. KPMG's (2018) FinTech Pulse report stated that global FinTech investment increased from US$50.8 billion in 2017 to US$111.8 billion in 2018, more than double due to unprecedented number of deals through multiple channels.

Not surprisingly, the FinTech investment and growth trends are also attracting scholarly attention, evident from special academic journal issues like *Journal of Management Information Systems*' "Special Issue: Financial Information Systems and the FinTech Revolution" (Gomber et al., 2018), *International Journal of Entrepreneurship and Management*'s "Innovation for Financial Services" (Mention et al., 2012) and "Towards a Philosophy of Financial Technologies" in *Philosophy and Technology* (Coeckelbergh et al., 2018). Amongst these, some scholars have argued that the concept of FinTech is not new, dating back nearly 150 years of technology-led shifts in perceptions, processes and practices related to FS (Arner et al., 2016a). Alt and Puschmann (2016) categorized these technological shifts into five phases lasting 20 years each, both pre- and post-1960. Building on this typology, Puschmann (2017) categorized future directions for FinTech research across three dimensions: innovation degree (disruptive, incremental), innovation object (business model, product/service, organization, process, system) and innovation scope (inter- and intra-organizational). More recently, Gai et al. (2018) provided a framework with five FinTech dimensions – privacy and security, data techniques, hardware and infrastructure, applications and management and service models. Likewise, Gozman et al. (2018) in reviewing the FinTech startups that participated in SWIFT's Innotribe competition, proposed a conceptual framework for FinTech innovation. Their FinTech ecosystem model for competition and cooperation identified three constructs – services, business infrastructure and technical components to capture different FinTech innovation types. They referred to FinTech components as granular technologies adopted by both startups and incumbents (e.g., Big data, artificial intelligence) which form the building blocks of FinTech. A parallel stream of FinTech research has focused on the tensions between financial market stability and regulation (Arner et al., 2017; Buchak et al., 2018; Magnuson, 2018). Scholars in this stream have situated discussions on capabilities afforded by FinTech. The central message being that future of FinTech is rooted in directing digital capabilities to reduce compliance costs, manage risks and enhance trust in the financial system (Bofondi and Gobbi, 2017; Boot, 2017).

Some scholars, however, have focused on reaching a consensual definition of FinTech by drawing attention to categories of its applications. For instance, Leong and Sung (2018) summarized FinTech across four applications (payments, advisory, financing, compliance) and defined FinTech as “a cross-disciplinary subject that combines finance, technology management and innovation management” (p. 75), a purview adopted for the purpose of this paper. Likewise, Zavolokina et al. (2016) reviewed how popular press perceives FinTech and summarized the definitions across three dimensions – input (combination of technology, organization and money flow), mechanism (create or improve change, disrupt, apply IT to finance, create competition) and output (new products, services or business models). The debate on what is FinTech is still ongoing (Leong and Sung, 2018).

The lack of this consensus has also shifted focus away from FinTech as a research object toward FinTech as a context. Studies at the periphery have discussed the use of FinTech as a tool for financial inclusion and poverty reduction (see, e.g., Jones, 2018). Others such as Lee and Kim (2015) focused on the application of FinTech (i.e., crowdfunding), while Arner et al. (2015) and Jagtiani and John (2018) focused on consumer protection and behavior to attract attention toward regulatory challenges. More recently, Gozman et al. (2018) analyzed 403 FinTech start-ups that participated in SWIFT's Innotribe competition to create a foundational understanding of the global FinTech landscape. They clustered FinTech firms based on core markets, business infrastructures and underlying technologies. Their conclusion resonates with our premise that FinTech firms leverage diverse and varied range of innovation strategies for value creation through coopetitive and competitive mechanisms, which calls for a foundational perspective for future research.

3 Future of FinTech: An Introduction

3.1 Opportunity affordances for the future of FinTech

The increased recognition of the role of FinTech in FS markets is bringing a “start-up-like” mentality to corporate organizations. Incumbent financial institutions are beginning to embrace the concept of “FinTech intrapreneurship”, an inward-looking approach to innovation, where teams and individuals are developing and driving new venture initiatives within large FS organization (Nicoletti, 2017). This approach allows for inbound and outbound knowledge and capabilities exchange, related and unrelated diversification strategies deployment and the creation on an open, collaborative and co-creative environment, conducive to FinTech and financial innovation (Martovoy et al., 2015). Emerging open innovation practices within FS, thus, encourage and promote FinTech intrapreneurial activities that can cut through corporate layers, sourcing lean, agile, experimentation strategies, along with bringing new vision, energy, direction and purpose to incumbent financial institutions (Bogusz et al., 2018).

This new regime is expected to increase competition, co-opetition, customer centricity and cross-sectoral collaboration (account aggregation) in the banking industry. Access to customer banking data, conditional to customer consent, will enable FinTech firms and incumbent banks to provide tailored, innovative and wide-ranging payment products and services. Customers stand to benefit from competitive pricing through mobilization of secure Application Programming Interfaces (APIs), enabling easier comparison of banking choices. Based on open banking principles, access to banking data will also enable consumers to access innovative services to assist them to analyze their expenditure and better manage their finances. Thus, new regulatory regimes associated with open banking are shaping the future of FinTech by establishing banking-as-a-platform and marketplace banking.

3.2 Challenges for the future of FinTech

FinTech start-ups are faced with numerous challenges during early stages of their product/service development. FinTech start-ups are faced with difficulties in terms of portraying a hyper-clear value proposition of intangible/service-based FinTech offerings and understanding both users and product/ service market fit (Altenhain and Heinemann, 2018). In principle, venture capitalists (VCs) and angel investors' valuations can make funding difficult in terms of leveraging lean business models and scalable platforms (Bömer and Schwienbacher, 2018; Cumming and Schwienbacher, 2018). Furthermore, VCs are looking for unique, new and differentiated offerings and demonstration of scalability and mitigation of risk.

FinTech start-ups experience hurdles in terms of securing operating leverage, especially due to significant upfront investment requirements for building intellectual property (Lee and Shin, 2018). Therefore, for FinTech start-ups acquiring early-stage funding, proof of concept development is an onerous barrier due to an inability to showcase a proven business model, find the right market and determine the customer/user demographics. As Still et al. (2019) identified FinTech start-ups need to develop competencies in relation to understanding innovation relationships. To gain competitive edge, FinTech firms need to leverage emerging technologies, awareness and realization of which calls for dynamic capabilities related to screening, auditing, roadmapping and forecasting. Yet for incumbents, key technological trends manifested in FinTech product/service offerings requires adopting efficient technological methods against legacy systems, leading to barriers toward new technology integration (Moshirian et al., 2019). Furthermore, from the human side, FinTech start-ups are faced with talent shortage challenges. Against the backdrop of skills development, talent attraction and diversified agile teams realizing the human to digital customer interaction shift is a significant FinTech challenge (Dove, 2018; Mei et al., 2018; Wang and Huang, 2018).

Finally, customer and institutional trust results in lower customer adoption. FinTech start-ups find it very hard to reach customers who are used to traditional FS (Claessens et al., 2018). Above all, FinTech start-ups need to battle with misconceptions and concerns with regards to security and reliability of data inertia over innovation – a challenge that requires building relational and behavioral trust (Salampasis et al., 2014). FinTech has brought to light foundational questions with regards to regulatory interventions calling for a new dialogue on the “if, when, what and how” aspects of regulation and compliance in the context of responsible (ethical) innovation (Magnuson, 2018). Disruptive forces coupled with evolved need for multi-disciplinary talent pose challenges for FinTech firms and regulators alike, in terms of gaining consumer trust, developing supportive regulatory infrastructure and enhancing FinTech's ability to scale-up and deploy solutions across borders.

4 Concept Map for the Future of FinTech

A concept map is captured in Fig. 1. Concept maps are widely used in the literature and practice to express connections between knowledge domains and constructs (Cañas and Novak, 2008). A concept map generally includes a graphical representation of a set of concepts depicted in geometric shapes, where relationships are shown via connecting lines with linking words or phrases to specify the relationship. Thus, concept maps through graphical structure and content form the basis for the development of a conceptual framework (Daley, 2004).

In the rest of this section, the five building blocks and its implications for research, policy and practice of FinTech are discussed. Collectively, our aim is to guide coherent efforts to shape the future of FinTech. FinTech, as “a new financial industry that applies technology to improve financial activities” (Schueffel, 2016, p. 32) is built upon distributed business models of value creation and value capture from customer-centric innovations (Gozman et al., 2018). Gozman et al. (2018) proposed that a key challenge of the future of FinTech is for policy makers to find a balance between protecting consumers and fostering innovations such that it draws upon existing regional capabilities and leads to further business and employment opportunities. In the same vein, Gozman et al. (2018) posited that future implications for FinTech research and practice rest in understanding how large and start-up firms can come together for value-creating FinTech applications designed for diverse stakeholder groups, including characterizing forces that influence globalization, integrated standards of operation and cooperation amongst firms.

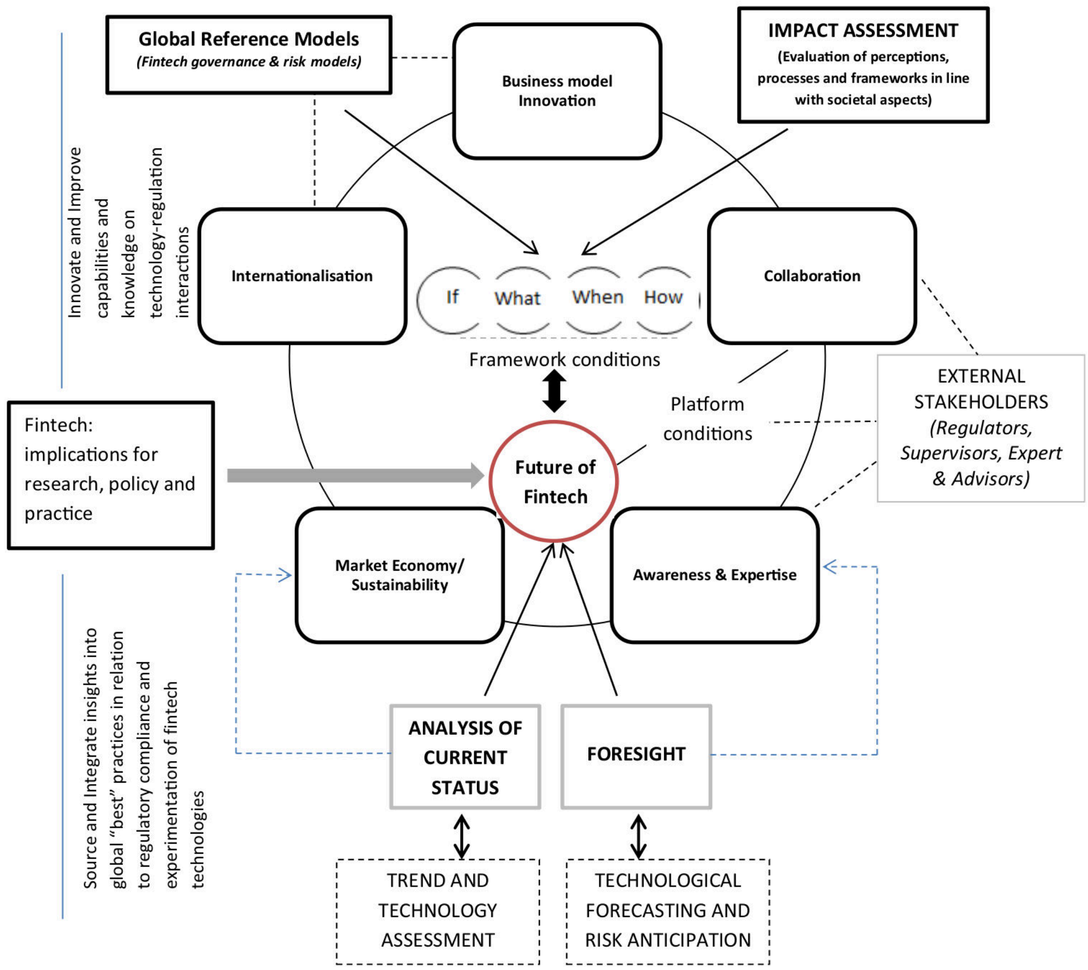


Figure 1. Concept map for future of FinTech.

Indeed, proliferation of FinTech innovations precipitates in the shifting paradigms of innovation adaptability within the wider FS industry and as such calls for a continuous adaptation and evaluation of aggregate value across stakeholder groups. Taking a broad perspective of FinTech innovations, the purpose of the concept map is to attract attention to increase the integration of the building blocks to transactions and transformations in the primary finance market (e.g., payment and cashflow solutions) alongside adaptations in the secondary markets (e.g., supply chain service models such as straight through processing within sharing economy). The building blocks in this view relate to incumbents and start-ups alike and highlight the role of intermediaries in shaping the increasingly porous boundaries between traditional and new business model systems. While incumbents need to generate and implement scalable innovations to remain relevant through their satellite start-ups and FinTech innovation labs; the FinTech start-ups also need to maintain progress toward scalable and integrated solutions. The holistic purview thus calls for an interconnected view of the building blocks for the future of FinTech.

4.1 Collaboration

Collaboration is a critical building block for the future of FinTech, particularly since most FinTech start-ups are likely to fail if they do not build partnerships (Capgemini, 2018). It is thus not surprising that FinTech businesses are seeking out opportunities to network with specialized external partners to leverage on resources and generate profits from otherwise increasingly lower margins (Davies et al., 2016; Shim and Shin, 2016; Gimpel et al., 2018). There is a need to coordinate research, policy and practice on regulation in FS at a global level to enable FinTech to grow, scale-up and internationalize (Gozman et al., 2018). While not every FinTech start-up has the potential to scale, those performing with excellence in their core businesses may benefit from strategic collaboration within and across international borders to address traditional incumbent customers' pain points for scale and distribution (Verhage, 2018). Collaboration between various stakeholder groups (e.g., incumbents, central banks, regulators, start-ups, consumers and ancillary supply chain providers) plays a formative role in facilitating value-creating and market-enhancing innovations. Given the applied and often disruptive nature of FinTech, implications of FinTech solutions can only be realized if researchers, policy makers and practitioners have access to suitable trend and technology assessment tools which facilitate transparent and real-time information processing of large amounts of diverse sets of data. Besides, FinTech research so far has adopted a narrow domain and problem-based approach to target isolated diffusion challenges or application opportunities afforded by technological advances (Gomber et al., 2018; Milian et al., 2019). Moreover, dissimilar FinTech appraisal and evaluation methods and differences in market contexts have further limited the value of current FinTech research toward policy making and multi-market growth strategies in practice. Consumer viewpoints in FinTech research have also been fragmented and often focused on functional technology-push perspectives found in practice (see, Arwas and Soleil, 2016; Derks et al., 2018). Pousttchi and Dehnert (2018), for instance, focused on the impact of digitalization on retail banking, attracting attention to how technologies are shaping consumer behavior toward search, purchase and use of FS. Yet, a systematic, cohesive and joint research agenda informed by stakeholder's views and roles in conceptualizing, developing and delivering technologies has the potential to shape future awareness, regulation and growth of FinTech firms through deeper understanding of design, manipulation and impact of market exchanges (Ellig and Fike, 2016; Gomber et al., 2018).

One plausible exploratory method at this formative stage would be to conduct in-depth interviews with key stakeholders and market players to delineate perceptions, processes and practices in the context of FinTech. The key stakeholders and market players related to FinTech may come from various subsegments, from FS institutions, industry associations, representations such as the banking federations, regulators and supervisors, policy making organizations, and entrepreneurship and venturing catalysts (such as accelerators, incubators, landing pads, and regulatory sandboxes). A coherent discussion in such studies should aim to (a) discuss evolution of FinTech trends, challenges as well as current products and services, (b) analyze the changes in supply and value chains, with a focus on intermediation-disintermediation-re-intermediation and (c) assess impact of national regulatory processes on FinTech investment and innovation performance.

4.2 Awareness and expertise

The FinTech landscape now includes not only start-ups but also incumbents who are able to leverage distinctive innovation capabilities (Davies et al., 2016). Thus, coupled with up-skilling of FinTech, research and policy efforts are needed toward development of compliance toolkits, enabling diverse types of FinTech firms and/or initiatives to meet regulatory requirements (for a typology of FinTech firms and initiatives see, Eickhoff et al., 2017; Milian et al., 2019). Moreover, for regulators, awareness is essential for rapidly emerging technologies and the consequences they bring to market integrity, stability and sustainability (Buchak et al., 2018; Magnuson, 2018). FinTech start-ups are generally more “in touch” with the public and thus cross-sectoral knowledge sharing between regulators and FinTech to enhance awareness of consumer habits and behavior can contribute positively toward building consumer trust and loyalty for digital platforms (Arner et al., 2016b). While tools and practices have been developed to envisage likely evolutions of trends, FinTech researchers need to leverage the synergies between strategic planning and strategic design processes in creation of future value.

The design for behavior change which draws from research in psychology and other disciplines is one approach that can inform decision and strategies for a desired FinTech future (see, e.g., Fogg, 2003; Lockton et al., 2010). Evidence also suggests that firms that apply foresight are indeed those which achieve a sustainable competitive advantage (Grant, 2010). Figuratively speaking, in foresight, the focus is directed on “…the world as it could be, through the imagination and realization of possible futures…” (Grand and Wiedmer, 2010, p. 2). Specifically, strategic design-foresight methods in the emerging field of FinTech can generate a range of possible future and strategic options, providing an enhanced understanding of possible challenges and strategic risks and best practices for alternative futures (Heger and Rohrbeck, 2012). Collectively, application of these methods in a practice-oriented research design can serve as behavioral intervention for building capacity toward future thinking and cognitive adaptability (Vecchiato and Roveda, 2010). Analysis, interpretation and protection of practices for responsible FinTech innovation are a part of the foresight process that can inform strategic thinking and strategy formulation. In a further step, foresight exercise can help policy makers investigate upcoming technologies and their potential usage for FinTech entrepreneurship (Wonglimpiyarat, 2017; see also Ernst and Young, 2015).

In this sense, future of FinTech is rooted in behavioral intervention methodologies that foster regulatory compliance and enable FinTech scale-up based on creative interpretations derived from Socio-cultural, Technological, Economic, and Political (STEP) drivers of change (Nicoletti, 2017). Specifically, employing a design-inspired foresight research approach, can help gaining deeper insights through Delphi-like techniques, thus, moving away from the traditional management practices of predicting the future based on current knowledge. The Delphi technique is among the more established foresight methods, first introduced by the RAND Corporation in the 1950s (Linstone and Turoff, 1975). Adopted for practice-oriented research, it can allow groups of regulators, supervisors, advisors, entrepreneurs and experts to consider and reflect upon interpretations of opportunities, obstacles and risks related to FinTech from early stage design and piloting to internationalization. A further strength of the Delphi method is that it allows experts to be geographically dispersed, which means that participants can interact around the FinTech topic and receive sequential feedback without the need for constant physical proximity (Lee and Shin, 2018).

4.3 Market economy and sustainability

FinTech venture challenges discussed above include those arising from multiple and cross-country regulatory authorities/jurisdictions. Under open and collaborative environment, trust plays a central role in efforts toward harmonizing compliance frameworks for human-centric financial innovations (Salampasis et al., 2014). Friction between incumbents and early-stage start-ups needs development of relational and behavioral trust, bifurcating misconceptions and concerns for cyber security and reliability of data inertia over innovation (Stewart and Jürjens, 2018). From a regional policy perspective, regulatory measures related to equity requirements, “safe” experimentation of new technologies and less cumbersome supervisory arrangements are needed alongside tighter rules and higher supervision at an international level (Arner et al., 2017; Baxter, 2016). These are particularly important as FinTech solutions continue to shift financial infrastructure away from traditional centralized networks toward digitalized operations through networked domain-specific ecosystemic partners, and even incorporate decentralized solutions (e.g., use of blockchain technology) (Alt and Puschmann, 2016; Pousttchi and Dehnert, 2018).

Sustainable development of the FinTech thus calls for a focus on responsible innovations considering the tenets of embedded trust – demographic diversity, knowledge sharing attitude, ambidextrous thinking, collaborative culture, customer adoption of FinTech innovations and efficient use of resources (e.g., lower acquisition and operational costs) (Salampasis et al., 2014; Haddad and Hornuf, 2016). Du et al. (2018) through a study on blockchain identify supportive culture as an important element of FinTech actualization. Gold and Kursh (2017) concentrated on robo-advisors and how this technology is perceived and responded to by decision-makers in traditional asset management firms. The expansive review of FinTech literature by Milian et al. (2019) highlighted the gap (and hence the need) for research at the intersection of financial technologies and its adoption, with reference to building capabilities in dealing with externalities such as legal and compliance issues. Accordingly, behavioral research aimed at building regulatory capabilities for FinTech entrepreneurs through specialized knowledge transfer training programs can nurture an emerging FinTech entrepreneurship landscape.

4.4 Internationalization

As it stands, 95% of FinTech firms fail when they reach the scale-up phase (Pai, 2017). The primary reason is that FinTech often fail to integrate and deploy solutions beyond regional and national regulatory boundaries and fail to target customers at infection points (Strange and Rampell, 2016). Yet, examples abound of FinTech firms that have experienced accelerated growth, with studies pointing to China as one of the main centers for digital finance innovations (see, Milian et al., 2019; Stern et al., 2017). For instance, Yu'E Bao, a Chinese internet money market fund owned by Ant Financial (an a±liate of Alibaba) took advantage of the opportunity to generate business from excess cash transactions from digital wallet transactions and went from no assets to US$90 billion in 10 months. However, Yu'E Bao became “too big to fail” in under a year. For Arner et al. (2016a), the FinTech challenge is rooted in managing the tension between futuristic FinTech innovation frameworks and trust in the market. A broad range of challenges exist in cross-border regulation of FinTech, including those related to commerce of services, operational controls for regulatory risk and money laundering, privacy and security of consumers and assets, structural validation of data storage and disclosure, and collaboration on nationally sensitive and non-sensitive information, amongst others (Arner et al., 2017; Kopp et al., 2017). Regulators in such cases face the issue of knowing *if* they should regulate, *what* to regulate, *when* to regulate and *how* to regulate in a rapidly emerging FinTech space (Arner et al., 2017; Gomber et al., 2018). Implications for research include a need to build repository of FinTech best practices, regulations and experimentations frameworks, aimed at mapping existing worldwide intelligence. These maps could then be funneled into customized tools and processes for enabling and improving internationalization initiatives. A behavioral research approach could be aimed at the cognition-context spectrum (Clark, 2010), taking an agentic lens to examine the impact of “think local” and “think global” mindsets and encourage responsible choices and actions (Niedderer, 2007, 2014).

4.5 Business model innovation

Untangling tension between regulatory requirements and acceptance of consumer-focused innovations in an otherwise conservative regulatory bias for new and emerging technologies calls for a focus on business model innovation. FinTech firms have a need to test, configure and design several applications integrating different and usually heterogeneous technologies.

Testing through live simulations and realistic operating conditions is a vital part within the development process, especially within a lean/agile venturing environment (Arner et al., 2016a). An experimentation test-bed is a platform (usually cloud-based) grounded in the exploration–exploitation conundrum, allowing users to create their own experiments for rigorous and replicable testing over the web using state-of-the-art technologies at a rapid pace. As a tool that has already gained a lot of traction and attention (Balan et al., 2014), allows users to acquire experimental validation within a laboratory-based, open, dynamic, stable and secure environment. This validation allows for faster deployment of early prototypes in the real word. In principle, the key objectives of a FinTech experimentation testbed are (a) technical analysis and assessment of a FinTech solution under real conditions, (b) evaluation of customer adoption of a FinTech solution, (c) magnitude of service usability, potential, efficiency and effectiveness with users in the development process and (d) testing of technical stability (see, e.g., Patel et al., 2017). In this context, a FinTech experimentation testbed aims at removing barriers to entry for FinTech innovators and entrepreneurs by providing a degree of experimentation realism (Sanchez et al., 2014) and driving FinTech innovative technological advancement and breakthroughs.

Like-wise "test-and-learn" or "regulatory sandbox", is a dynamic and flexible regulatory framework, aimed at providing a temporary, safe and under specific pre-determined conditions relaxation of certain flexible and lenient regulatory requirements and obligations (Dostov et al., 2017; Thomadakis, 2017). This safe environment allows early-stage start-ups to conduct real-world market reach and market reaction testing on their products/services, fine-tune their business models, and design the unique value proposition of their offerings without the obligation to obtain a full license and clear regulatory hurdles, reducing the barriers to entry and regulatory costs.

Regulatory sandboxes serve as a "diagnostic tool" to help FinTech entrepreneurs determine their innovation capacity, validate their technological concept and end-customer market adoption, while planning strategically toward scale, growth and impact. Moreover, regulatory sandboxes help early-stage FinTech ventures build long-term experimentation capabilities (cyclical process of testing validated learning pivoting) that are essential to FinTech innovation, allowing for validated learning through brief looped iterations with customers/users. They provide the opportunity for customer feedback and development of mutual value propositions, on the premise of minimizing potential systemic risk and protecting consumer interest (Tsai and Peng, 2017). It is believed that regulatory sandboxes have the potential to provide a harmonized strategy for governing financial innovation (Iris, 2017) within a "smart regulation" paradigm shift (Zetzsche et al., 2017). The underlying reasoning behind regulatory sandboxes is to provide foundations for sound competition within the financial industry (Noh, 2017). Despite lack of harmonized framework conditions (see, Sajtos and Tőrös, 2018), regulatory sandboxes can foster cooperative forces between incumbent financial institutions and FinTech firms by limiting wasteful efforts and expenditure on resources for understanding and safely testing technological innovations (Arner et al., 2015). However, their net positive or negative impact to FinTech scalability and growth is yet to be empirically and systematically examined (Bromberg et al., 2017). Accordingly, from a research implication purview, it is important to explore and explain how exactly regulatory sandboxes helps in creating a cross-sectoral, start-up friendly, use-case tailored global reach ecosystem.

5 Conclusion, Limitations and Future Directions

This paper addresses the following questions: (1) *what are the future-oriented challenges and opportunities of FinTech?* and (2) *what are the building blocks and implications for future research, policy and practice in the context of FinTech?* Discussions are situated on the current framework conditions and limited scholarship on the topic to identify the five building blocks for the future of FinTech. This section provides some reflection on these discussions to identify its limitations and future directions for research in the field.

The rapidly growing importance of FinTech on a global scale is firstly acknowledged. FinTech, as an industry, is now "too big to fail", a perspective that departs from the "too small to care" and "too big to ignore" continuum. In other words, without appropriate regulatory attention, the future of FinTech may be bleak, with gaps in market risk management filled by third-party speculators and analysts which may not benefit the end consumers (see, Mugerman et al., 2019). The disruptive forces and their implications for FinTech, regulators and wider financial markets were then discussed, leading to the identification of limited literature on FinTech frameworks and the observation that studies found no coherent understanding of FinTech and its implications (e.g., Arner et al., 2015; Gomber et al., 2017; Zavolokina et al., 2016). This ignited the interest for this paper and shaped its objective of unveiling a formative concept map. It is hoped that, collectively, these efforts will serve as the basis to understand perceptions, processes and practices of socially-constructed phenomenon of FinTech from a multi-faceted perspective. Moreover, this paper draws on the future-oriented challenges and opportunities related to FinTech growth and scalability across borders. This brings value to those researchers who are searching for the problem in practice to advance research on FinTech. This paper also presents a problem-driven framework building approach which may be used to explore new and emerging fields related to innovation and technology management. The adopted approach is particularly beneficial when the objective is to build a practice-oriented framework for a phenomenon from limited scholarship. Overall, this paper contributes to the wider research on technology man- agement, digital finance, and digital innovation by drawing attention to the cross-sector implications of rapidly growing and pervasive FinTech market.

This study has several limitations which are noteworthy to understand opportunities for future research. First, its approach is based on nuances found in practice, policy actions and widely dispersed literature on FinTech. A systematic review of literature is not suitable at this stage since the field is still in its infancy, however such an approach could be beneficial to establish clear research propositions in the future. The aim of this paper was not to evaluate current methodologies and actions applied to shape the future of FinTech. This approach was purposefully adopted as nearly all the large-scale efforts (e.g., the EU H2020 actions identified above) have been made in the last four years and their impact is yet to be realized. In the future, a benchmarking or time series analysis method coupled with trend extrapolation and impact analysis could inform how investments in FinTech actions plans are benefiting consumers, FinTech entrepreneurs and financial markets. A notable feature of the references we relied on is that they are regionalized with no clear framework for comparative analysis. In this view, the proposed concept map for the future of FinTech provides the building blocks for analyses across regional and international borders and has limited value in understanding the specific role and responsibilities of various stakeholders in shaping the future of FinTech. Future studies could complement this concept map through empirical work that delves deeper as data build around globalized FinTech markets. Perhaps, the recent work by Milian et al. (2019) which explored how FinTech literature has evolved over time can complement this work and help researchers and policy makers in developing novel research designs and understanding domain agnostic building blocks for the future of FinTech, respectively.

In considering the economic, governance and behavioral topics related to FinTech, it is noted that opportunities abound for technology and innovation scholars to take the position as lead contributors to the future of FinTech, at the intersection of regulatory frameworks, emerging financial technologies and the entrepreneurial environments. Researchers should accordingly be encouraged to adopt multi-disciplinary approaches to extend the concept map and bring meaningful results to shape regulatory forces, technological innovations and behavioral strategies of FinTech.

Acknowledgments

This research has received funding from the Horizon 2020 Programme of the European Union within the OpenInnoTrain project under grant agreement no. 823971. The content of this publication does not reflect the official opinion of the

European Union. Responsibility for the information and views expressed in the publication lies entirely with the author.

References

Accenture, 2016, Fintech and the Evolving Landscape: Landing Points for the Industry, *Accenture*, available at: https://www.accenture.com/t20161011 T031409Zw/plen/acnmedia/PDF-15/Accenture-Fintech-Evolving-Landscape.pdf (accessed March 16, 2019).

Alt, R., and T. Puschmann, 2016, *Digitalization of the Financial Industry: Fundamentals of Fintech Evolution*, Springer, Berlin, Heidelberg.

Altenhain, T., and C. Heinemann, 2018, Fintech Hypes, but Wealthy Internet Savvy Investors Prefer to Stay Hybrid, In *Digital Marketplaces Unleashed*, Springer, Berlin, Heidelberg, pp. 343–357.

Arner, D. W., J. N. Barberis, and R. P. Buckley, 2015, The Evolution of Fintech: A New Post-Crisis Paradigm?, University of Hong Kong Faculty of Law Research Paper No. 2015/047; UNSW Law Research Paper No. 2016-62, available at SSRN: https://ssrn.com/abstract=2676553.

Arner, D. W., J. N. Barberis, and R. P. Buckley, 2016a, 150 Years of Fintech: An Evolutionary Analysis, *Jassa*, 3(22), 22–29.

Arner, D. W., J. N. Barberis, and R. P. Buckley, 2016b, The Emergence of Regtech 2.0: From Know Your Customer to Know Your Data, *Journal of Financial Transformation*, 44(79), 79–86.

Arner, D. W., J. N. Barberis, and R. P. Buckley, 2017, Fintech and Regtech in a Nutshell, and the Future in a Sandbox, *Research Foundation Briefs*, 3(4), 1–20.

Arwas, A., and K. Soleil, 2016, Robo-Advice 2.0: The Next Generation, *Journal of Financial Transformation*, 43, 30–36.

Au, Y. A., and R. J. Kauffman, 2008, The Economics of Mobile Payments: Understanding Stakeholder Issues for an Emerging Financial Technology Application, *Electronic Commerce Research and Applications*, 7(2), 141–164.

Autio, E., H. J. Sapienza, and J. G. Almeida, 2000, Effects of Age at Entry, Knowledge Intensity, and Imitability on International Growth, *Academy of Management Journal*, 43(5), 909–924.

Balan, R. K., A. Misra, and Y. Lee, 2014, Livelabs: Building an In-Situ Real-Time Mobile Experimentation Testbed, in *Proc. 15th Workshop on Mobile Computing Systems and Applications*, ACM, February.

Baxter, L. G., 2016. Adaptive Financial Regulation and Regtech: A Concept Article on Realistic Protection for Victims of Bank Failures, *Duke LJ*, 66, 567.

Bofondi, M., and G. Gobbi, 2017, The Big Promise of Fintech, *European Economy*, 2, 107–119.

Bogusz, C. I., A. M. Puertas, A. Larsson, S. Siri, and R. Teigland, 2018, Introduction: FinTech and Shifting Financial System Institutions, in R. Teigland, S. Siri, A. Larsson, A. M. Puertas, and C. I. Bogusz (editors), *The Rise and Development of FinTech*, Routledge, Sweden, pp. 1–18.

Bömer, M., and A. Schwienbacher, 2018, Resource-Based Perspective of VC Investments in FinTech, available at SSRN 3312793, doi: 10.2139/ssrn.3312793. Boot, A. W., 2017, The Future of Banking: From Scale & Scope Economies to Fintech, *European Economy*, 2, 77–95.

Bromberg, L., A. Godwin and I. Ramsay, I, 2017, Fintech Sandboxes: Achieving a Balance between Regulation and Innovation, *Journal of Banking and Finance Law and Practice*, 28(4), 314–336.

Brunswicker, S., and H. Chesbrough, 2018, The Adoption of Open Innovation in Large Firms: Practices, Measures, and Risks – A Survey of Large Firms Examines How Firms Approach Open Innovation Strategically and Manage Knowledge Flows at the Project Level, *Research-Technology Management*, 61(1), 35–45.
Buchak, G., G. Matvos, T. Piskorski, and A. Seru, 2018, Fintech, Regulatory Arbitrage, and the Rise of Shadow Banks, *Journal of Financial Economics*, 130(3), 453–483.
Capgemini, 2018, *World Fintech Report*, https://www.capgemini.com/news/ capgeminis-world-Fintech-report-2018-highlights-symbiotic-collaboration-as-key-to-future-financial-services-success/ (accessed on May 15, 2019).
Cañas, A. J., and J. D. Novak, 2008, Concept Mapping Using Cmaptools to Enhance Meaningful Learning, in A. Osaka, S. B. Shum, and T. Sherborne (editors), *Knowledge Cartography, Advanced Information and Knowledge Processing*, Springer Verlag, pp. 25–46.
Carney, M., 2017, The Promise of Fintech–Something New Under the Sun, in Speech at Deutsche Bundesbank G20 Conference, by Bank of England Governor Mark Carney, January 25.
CBInsights, 2018, *The Fintech 250: The Fintech Startups of 2018*, https://www.cbinsights.com/research/Fintech-250-startups-most-promising/ (accessed on May 15, 2019).
Chen, L., 2016, From Fintech to Finlife: The Case of Fintech Development in China, *China Economic Journal*, 9(3), 225–239, doi:10.1080/17538963.2016.1215057.
Cortina, J. J., and S. L. Schmukler, 2018, The Fintech Revolution: A Threat to Global Banking? *Research and Policy Briefs*, The World Bank, https://ideas.repec.org/p/wbk/wbkrpb/125038.html (accessed on May 15, 2019).
Claessens, S., J. Frost, G. Turner, and F. Zhu, 2018, Fintech Credit Markets Around the World: Size, Drivers and Policy Issues, *BIS Quarterly Review*, September, https://ssrn.com/abstract=3288096 (accessed on March 6, 2019).
Clark, G. L., 2010, Human Nature, the Environment, and Behaviour: Explaining the Scope and Geographical Scale of Financial Decision-Making, *Geografiska Annaler: Series B, Human Geography*, 92(2), 159–173.
Coeckelbergh, M., Q. DuPont, and W. Reijers, 2018, Towards a Philosophy of Financial Technologies, *Philosophy & Technology*, 31(1), 9–14.
Cumming, D. J., and A. Schwienbacher, 2018, Fintech Venture Capital, *Corporate Governance: An International Review*, 26(5), 374–389.
Daley, B. J., 2004, Using Concept Maps in Qualitative Research, Concept Maps: Theory, Methodology, Technology, in *Proceedings of the First International Conference on Concept Mapping*, A. J. Cañas, J. D. Novak, and F. M. González (editors), Pamplona, Spain.
Dapp, T. F., 2014, Fintech – The Digital (R)Evolution in the Financial Sector: Algorithm-Based Banking with the Human Touch, *Current Issues: Digital Economy and Structural Change*, Deutsche Bank Research, accessed on May 15, 2019, https://www.dbresearch.com/PROD/RPS_EN-PROD/PROD0000000000451941/Fintech_%E2%80%93_The_digital_%28r%29evolution_in_the_financia.PDF.
Davies, S., Jackett, D., Kashyap, M., Nicolacakis, D., Qureshi, M., and Shipman, J., 2016, Customers in the spotlight: How FinTech is reshaping banking – Global FinTech Survey 2016, PricewaterhouseCoopers, viewed 1 March 2020, https://www.pwc.com/il/he/bankim/assets/fin-tech-banking.pdf.
Demirguc-Kunt, A., L. Klapper, D. Singer, S. Ansar, and J. Hess, 2018, The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. World Bank Group, accessed on March 16, 2019, http://documents.worldbank.org/curated/en/332881525873182837/pdf/126033-PUB-PUBLIC-pubdate-4-19-2018.pdf.

Derks, J., Gordijn, J., and Siegmann, A., 2018, From Chaining Blocks to Breaking Even: A Study on the Profitability of Bitcoin Mining from 2012 to 2016, *Electronic Markets*, 28(3), 321–338.
Dhar, V., and R. M. Stein, 2017, FinTech Platforms and Strategy, *Communications of the ACM*, 60(10), 32–35.
Dove, T., 2018, Career Outlook: It's Not Rocket Science, It's Fintech, *Hispanic Engineer and Information Technology*, 33(1), 39–43.
Dostov, V., P. Shoust, and E. Ryabkova, 2017, Regulatory Sandboxes as a Support Tool for Financial Innovations, *Journal of Digital Banking*, 2(2), 179–188.
Du, W. D., S. L. Pan, D. E. Leidner, and W. Ying, 2018, Affordances, Experimentation and Actualization of Fintech: A Blockchain Implementation Study, *The Journal of Strategic Information Systems*, 28(1), 50–65, doi: 10.1016/j. jsis.2018.10.002.
Ducas, E., and A. Wilner, 2017, The Security and Financial Implications of Blockchain Technologies: Regulating Emerging Technologies in Canada, *International Journal*, 72(4), 538–562.
EBA, 2016, Discussion Paper on The EBA's Approach to Financial Technology (Fintech), European Banking Authority, accessed on May 15, 2019, https://www.eba.europa.eu/documents/10180/1919160/EBA+Discussion+Paper +on +Fintech+%28EBA-DP-2017-02%29.pdf.
Eickhoff, M., J. Muntermann, and T. Weinrich, 2017, What Do FinTechs Actually Do? A Taxonomy of FinTech Business Models, in *ICIS 2017 Proc.* 22. viewed on March 1, 2020, http://aisel.aisnet.org/icis2017/EBusiness/Presentations/22.
Ellig, J., and R. Fike, 2016, Regulatory Process, Regulatory Reform, and the Quality of Regulatory Impact Analysis 1, *Journal of Benefit-Cost Analysis*, 7(3), 523–559.
Ernst and Young, 2015, High-Growth Organizations Combining Innovative Business Models and Technology to Enable, Enhance and Disrupt Financial Services, in *Fintech on the Cutting Edge: An Evaluation of the International Fintech Sector*, Ernst and Young, UK, accessed May 15, 2019, http://www.ey.com/Publication/vwLUAssets/EY-UK-FinTech-On-the-cutting-edge/%24FILE/EY-UK-FinTech-On-the-cutting-edge.pdf.
Fogg, B. J., 2003, *Persuasive Technology*, Morgan Kaufmann Publishers, Amsterdam.
Gai, K., M. Qiu, and X. Sun, 2018, A Survey on FinTech, *Journal of Network and Computer Applications*, 103, 262–273.
Gimpel, H., D. Rau, and M. Röglinger, 2018, Understanding FinTech Start-Ups – A Taxonomy of Consumer-Oriented Service Offerings, *Electronic Markets*, 28(3), 245–264.
Gobble, M. M., 2018, Digitalization, Digitization, and Innovation, *Research-Technology Management*, 61(4), 56–59.
Gold, N. A., and S. R. Kursh, 2017, Counterrevolutionaries in the Financial Services Industry: Teaching Disruption – A Case Study of Roboadvisors and Incumbent Responses, *Business Education Innovation Journal*, 9, 139–146.
Gomber, P., R. J. Kauffman, C. Parker, and B. W. Weber, 2018, On the Fintech Revolution: Interpreting the Forces of Innovation, Disruption, and Transformation in Financial Services, *Journal of Management Information Systems*, 35(1), 220–265.
Gomber, P., J. A. Koch, and M. Siering, 2017, Digital Finance and FinTech: Current Research and Future Research Directions, *Journal of Business Economics*, 87(5), 537–580.
Gozman, D., J. Liebenau, and J. Mangan, 2018, The Innovation Mechanisms of Fintech Start-Ups: Insights from SWIFT's Innotribe Competition, *Journal of Management Information Systems*, 35(1), 145–179.
Grant, R., 2010, *Contemporary Strategy Analysis*, Blackwell Publishing, Oxford. Grand, S., and M. Wiedmer, 2010, Design Fiction: A Method Toolbox for Design Research in a Complex World, in *Proceedings of the DRS 2010 Conference: Design and Complexity*, Montreal.
Haddad, C., and L. Hornuf, 2016, The Emergence of the Global Fintech Market: Economic and Technological Determinants, *Small Business Economics*, 1, 25.

Heger, T., and R. Rohrbeck, 2012, Strategic Foresight for Collaborative Exploration of New Business Fields, *Technological Forecasting and Social Change*, 79(5), 819–831.

Iris, H. Y., 2017, A Rational Regulatory Strategy for Governing Financial Innovation, *European Journal of Risk Regulation*, 1–23.

Jagtiani, J., and K. John, 2018, Fintech: The Impact on Consumers and Regulatory Responses, *Journal of Economics and Business*, 100, 1–6, doi: 10.1016/j.jeconbus.2018.11.002.

Jones, L., 2018, Guest Editorial: Poverty Reduction in the Fintech Age, *Enterprise Development and Microfinance*, 29(2), 99–102.

Kopp, E., L. Kaffenberger, and N. Jenkinson, 2017, *Cyber Risk, Market Failures, and Financial Stability*, International Monetary Fund.

KPMG, 2018, The Pulse of Fintech: Global Report on Fintech Investment Trends. KPMG, accessed May 14, 2019, https://home.kpmg/au/en/home/insights/2017/04/pulse-of-Fintech.html.

Lee, I., and Y. J. Shin, 2018, Fintech: Ecosystem, Business Models, Investment Decisions, and Challenges, *Business Horizons*, 61(1), 35–46.

Lee, T. H., and H. W. Kim, 2015, An Exploratory Study on Fintech Industry in Korea: Crowdfunding Case, in *2nd International Conference on Innovative Engineering Technologies (ICIET'2015)*, August, Bangkok.

Leong, K., and A. Sung, 2018, Fintech (Financial Technology): What is it and How to Use Technologies to Create Business Value in Fintech Way? *International Journal of Innovation, Management and Technology*, 9(2), 74–78.

Linstone, H., and M. Turoff, 1975, *The Delphi Method: Techniques and Applications*, Addison-Wesley, Boston.

Lockton, D., D. Harrison, and N. A. Stanton, 2010, The Design with Intent Method: A Design Tool for Influencing User Behaviour, *Applied Ergonomics*, 41(3), 382– 392.

Magnuson, W., 2018, Regulating Fintech, *Vanderbilt Law Review*, 71, 1167.

Marjanovic, O., and V. Murthy, 2016, From Product-Centric to Customer-Centric Services in a Financial Institution–Exploring the Organizational Challenges of the Transition Process, *Information Systems Frontiers*, 18(3), 479–497.

Martovoy, A., A. L. Mention, and M. Torkkeli, 2015, Inbound Open Innovation in Financial Services, *Journal of Technology Management & Innovation*, 10(1), 117–131.

Mei, S., L. Peiguang, and N. Xiushan, 2018, Research on Fintech Industry Development and Talent Training Status, in *2018 13th International Conference on Computer Science & Education (ICCSE)*, IEEE, August.

Mention, A. L., and M. Torkkeli, 2012, Drivers, Processes and Consequences of Financial Innovation: A Research Agenda, *International Journal of Entrepreneurship and Innovation Management*, 16(1–2), 5–29.

Mention, A. L., M. Torkkeli, and E. Huizingh, 2012, Guest Editorial of the Special Issue Innovation for Financial Services, *International Journal of Entrepreneurship and Innovation Management*, 16(1/2).

Milian, E. Z., M. D. M. Spinola, and M. M. de Carvalho, 2019, Fintechs: A Literature Review and Research Agenda, *Electronic Commerce Research and Applications*, 34, 100833.

Moshirian, F., B. Susantono, and R. Yu, 2019, Challenges and Opportunities Associated with Financial Technology in the 21st Century, *SSRN 3337918*, accessed on May 14, 2019, https://papers.ssrn.com/sol3/papers.cfm?abstract id=3337918.

Mugerman, Y., Y. Hecht, and Z. Wiener, 2019, On the Failure of Mutual Fund Industry Regulation, *Emerging Markets Review*, 38, 51–72.

Nicoletti, B., 2017, *Future of FinTech*, Basingstoke, Palgrave Macmillan.

Niedderer, K., 2007, Designing Mindful Interaction: The Category of Performative Object, *Design Issues*, 23(1), 3–17.

Niedderer, K., 2014, Mediating Mindful Social Interactions Through Design, *The Wiley Blackwell Handbook of Mindfulness*, 345–366.

Noh, H., 2017, Overseas Cases of Introducing Regulatory Sandbox and Measures for Consumer Protection, *Korean Economic and Financial Review*, 22(2), 53–55.
Nonninger, L. and M. Tesfaye, 2018, Latest Fintech Industry Trends, Technologies and Research from Our Ecosystem Report, *Business Insider*, December, accessed on March 16, 2019, https://www.businessinsider.com/Fintech-ecosystem-report/?r=AU&IR=T.
Pai, S., 2017, Scaling Up Fintech Innovation, Capgemini, accessed May 14, 2019, https://www.capgemini.com/2017/07/scaling-up-Fintech-innovation/.
Patel, P., J. Dave, S. Dalal, P. Patel, and S. Chaudhary, 2017, A Testbed for Experimenting Internet of Things Applications, Cornell University, accessed March 16, 2019, https://arxiv.org/abs/1705.07848.
Philippon, T., 2016, The Fintech Opportunity, CEPR Discussion Paper No. DP11409, accessed March 16, 2019, https://ssrn.com/abstract=2814084.
Pousttchi, K., and M. Dehnert, 2018, Exploring the Digitalization Impact on Consumer Decision-Making in Retail Banking, *Electronic Markets*, 28(3), 265–286.
Puschmann, T., 2017, Fintech, *Business & Information Systems Engineering*, 59(1), 69–76.
Sajtos, P. F., and Á. Tőrös, 2018, Regulatory Tools to Encourage Fintech Innovations: The Innovation Hub and Regulatory Sandbox in International Practice, *Financial and Economic Review*, 43–67.
Saksonova, S., and I. Kuzmina-Merlino, 2017, Fintech as Financial Innovation–The Possibilities and Problems of Implementation, *European Research Studies*, 20(3A), 961.
Salampasis, D., A. L. Mention, and M. Torkkeli, 2014, Open Innovation and Collaboration in the Financial Services Sector: Exploring the Role of Trust, *International Journal of Business Innovation and Research*, 8(5), 466–484.
Sanchez, L., L. Muñoz, J. A. Galache, P. Sotres, J. R. Santana, V. Gutierrez, R. Ramdhany, A. Gluhak, S. Krco, E. Theodoridis, and D. Pfisterer, 2014, SmartSantander: IoT Experimentation over a Smart City Testbed, *Computer Networks* 61, 217–238, https://doi.org/10.1016/j.bjp.2013.12.020.
Schueffel, P., 2016, Taming the Beast: A Scientific Definition of Fintech, *Journal of Innovation Management*, 4(4), 32–54.
Schulte, S., and G. Liu, 2017, FinTech is Merging with IoT and AI to Challenge Banks: How Entrenched Interests Can Prepare, *The Journal of Alternative Investments*, 20(3), 41–57, doi: 10.3905/jai.2018.20.3.041.
Schwab, F., and S. Guibaud, 2016, The Rise of BankTech – The Beauty of a Hybrid Model for Banks. The Fintech Book: *The Financial Technology Handbook for Investors, Entrepreneurs and Visionaries*, Wiley, pp. 245–247.
Shim, Y., and D. H. Shin, 2016, Analyzing China's Fintech Industry from the Perspective of Actor–Network Theory, *Telecommunications Policy*, 40(2–3), 168–181.
Still, K., I. Lähteenmäki, and M. Seppänen, 2019, Innovation Relationships in the Emergence of Fintech Ecosystems, in *Proceedings of the 52nd Hawaii International Conference on System Sciences*, January, https://scholarspace.manoa.hawaii.edu/bitstream/10125/60071/0631.pdf.
Stern, C., M. Makinen, and Z. Qian, 2017, FinTechs in China – with a Special Focus on Peer to Peer Lending, *Journal of Chinese Economic and Foreign Trade Studies*, 10(3), 215–228.
Stewart, H., and J. Jürjens, 2018, Data Security and Consumer Trust in Fintech Innovation in Germany, *Information & Computer Security*, 26(1), 109–128.
Stoeckli, E., C. Dremel, and F. Uebernickel, 2018, Exploring Characteristics and Transformational Capabilities of InsurTech Innovations to Understand Insurance Value Creation in a Digital World, *Electronic Markets*, 28(3), 287–305.
Strange, A., and A. Rampell, 2016, Using "Infection Points" to Overcome Fintech Startup Distribution Challenges, accessed on March 16, 2019, https://a16z.com/2016/05/06/inflection-points-Fintech-distribution/.

The Economist, 2015, *Why Fintech Won't Kill Banks*, accessed on May 14, 2019, https://www.economist.com/the-economist-explains/2015/06/16/why-Fin-tech-wont-kill-banks.

Thomadakis, 2017, How Close Are We to a Capital Markets Union? *ECMI Commentary*, 17(44), 1–7, accessed on March 16, 2019, https://www.ceps.eu/download/publication/?id=9915&pdf=How%20close%20to%20a%20CMU_%20ECMI%20Commentary_%20A%20Thomadakis.pdf.

Traynor, P., K. Butler, J. Bowers, and B. Reaves, 2017, FinTechSec: Addressing the Security Challenges of Digital Financial Services, *IEEE Security & Privacy*, 15(5), 85–89.

Tsai, C.-h., and K.-J. Peng, 2017, The FinTech Revolution and Financial Regulation: The Case of Online Supply Chain Financing, *Asian Journal of Law and Society*, 4(1), 109-132, available at SSRN: https://ssrn.com/abstract=3035386.

Verhage, J., 2018, FinTech Startups Need Industry Partners to Thrive, *Bloomberg*, accessed on March 16, 2019, https://www.bloomberg.com/news/articles/2018-02-27/Fintech-startups-need-industry-partners-to-thrive-report-says.

Vecchiato, R., and C. Roveda, 2010, Strategic Foresight in Corporate Organizations: Handling the Effect and Response Uncertainty of Technology and Social Drivers of Change, *Technological Forecasting and Social Change*, 77(9), 1527–1539.

Wang, Q., and K. W. Huang, 2018, Exploring the Fintech Jobs-Skills Fit of Financial and Information Technology Professionals: Evidence From LinkedIn, in *Proceedings of the ICIS conference*, Economics and IS, accessed on May 15, 2019, https://aisel.aisnet.org/icis2018/economics/Presentations/3/.

World Economic Forum, 2015, *Beyond FinTech – A Pragmatic Assessment of Disruptive Potential in Financial Services*, accessed on March 16, 2019, https://www3.weforum.org/docs/Beyond_Fintech_-_A_Pragmatic_Assessment_of_Disruptive_Potential_in_Financial_Services.pdf.

Wonglimpiyarat, J., 2017, Fintech Banking Industry: A Systemic Approach, *Foresight*, 19(6), 590–603.

Zavolokina, L., M. Dolata, and G. Schwabe, 2016, FinTech–What's in a Name? in *Proceedings of the Thirty Seventh International Conference on Information Systems*, Dublin, pp. 1–19, accessed March 16, 2019, https://aisel.aisnet.org/icis2016/DigitalInnovation/Presentations/12/.

Zetzsche, D. A., R. P. Buckley, D. W. Arner, and J. N. Barberis, 2017, Regulating a Revolution: From Regulatory Sandboxes to Smart Regulation, *Fordham Journal of Corporate and Financial Law,* 23, 31, accessed on March 16, 2019, https://ssrn.com/abstract=3018534.

8 Open innovation in the manufacturing industry: A review and research agenda

Tena Obradović, Božidar Vlačić, Marina Dabić

Originally published by Elsevier Ltd. as Open Access under a Creative Commons BY-NC-ND 4.0 license[1] as: Obradović, Tena, Božidar Vlačić, and Marina Dabić. "Open Innovation in the Manufacturing Industry: A Review and Research Agenda." *Technovation*, January 23, 2021, 102221. doi:10.1016/j.technovation.2021.102221. No changes were made.

Highlights

- This paper provides a synthesis and outlines the trajectory of open innovation in manufacturing industries.
- This study analyzes 239 publications indexed in Web of Science and Scopus databases.
- Content analysis, is combined with the multiple correspondence analysis procedures.
- Future research avenues regarding sustainability, human resources, and additive manufacturing are presented.

Abstract

In today's competitive world, globalization touches all industries. The open innovation (OI) paradigm has garnered increasing importance in academic research and industrial applications. Considering this interest, this paper aims to synthetize up-to-date findings, outline the intellectual structure of OI within the manufacturing research domain, and suggest a future research agenda. Building upon the content analysis of 239 articles indexed in Web of Science and Scopus databases, using homogeneity analysis by means of alternating least squares (HOMALS), this study reveals the theoretical underpinnings, research trends, and methodologies of this research field. Our analysis revealed that the study of sustainability, commitment-based human resource practices, and Industry 4.0 (I40) represent important future research streams for OI in the manufacturing industry. In collaborating throughout the supply chain, manufacturing firms could minimize production waste, ensure better working conditions, and adapt business models. In the "new normal" posed by the COVID-19 pandemic, it is more important than ever to study the effects of managerial competencies, employee training and

[1] https://creativecommons.org/licenses/by-nc-nd/4.0/

development, and reward systems on open cultures in manufacturing firms. This study goes on to outline research opportunities in I40, particularly regarding knowledge exchange and technology transfer among partners and OI's influence on the adoption of I40 technologies.

Keywords

Open innovation; Manufacturing industry; Multiple correspondence analysis; HOMALS; Systematic literature review

1 Introduction

The ongoing globalization and exponential growth of technological intensity (Gassmann, 2006; Chesbrough and Bogers, 2014) has increased the importance of - and necessity for - open innovation (OI) (Mitchell and Singh, 1996; Ghobakhloo and Fathi, 2019), which has been recognized as an essential part of one of the United Nations Sustainable Development Goals for 2030 (UN General Assembly, 2015; Smart et al., 2019). Simultaneously, the manufacturing industry, stimulated by globalization, has begun to invest further in OI in order to improve productivity and meet customer demands (Fajsi et al., 2016; Wang and Islam, 2017). Accordingly, the importance of OI and the acknowledgment that capable and intelligent minds exist outside of the firm has captured the attention of a large number of companies, venture capitalists, and governments around the globe who have subsequently provided additional funding opportunities (Chesbrough and Vanhaverbeke, 2018). From a strategic perspective, the expansion of available OI funding enabled companies to rethink the ways in which ideas are generated, fully embracing the era of OI (Alassaf et al., 2020).

The paradigm of OI has developed over the years and this has encouraged practitioners and researchers to study this topic from different perspectives. Furthermore, technological development and ongoing digital disruption has transformed the manufacturing industry, meaning that it is no longer seen as complex and mature. Accordingly, the manufacturing industry has begun to expand its horizons and adapt its business models. For example, P&G adopted an OI approach and developed a new strategy which ultimately led to new products incorporating elements of ideas from outside of the company (Dodgson et al., 2006). Next, NASA managers, stimulated by the reduction of a budget, created a new strategy focusing on collaboration. They sourced OI practices through a prize-winning competition and through crowdsourcing, which resulted in innovation and a new and adaptable business model (Davis et al., 2015).

Considering the importance of OI and the necessity of collaborating with all stakeholders, this paper complements the up-to-date stock of knowledge on OI (Kovács et al., 2015) by addressing the theoretical approaches, major research themes, methodological approaches, geographical scope, and industries underpinning OI research in a manufacturing context. In order to do so - and in line with the systematic literature review guidelines (Paul and Rialp-Criado, 2020) - the initial planning phase involved the formulation of research questions (RQs), creating review protocols, outlining the rules of the research, establishing a strategy for data extraction, and integrating the stages of the extracted data (Snyder, 2019). As such, this study sought to compile and categorize the application of OI in the context of the manufacturing industry by answering the following RQs:

RQ1: What are the underlying theoretical approaches, major research themes, geographical scopes, methodological approaches, and industries in open innovation in the manufacturing research field?

RQ2: What are the future research streams for open innovation in a manufacturing context, in terms of theoretical and practical approaches?

Previous literature reviews, in most cases, adopt a citation-based approach (Kovács et al., 2015), in which they compile published articles, acknowledge influential authors in the research domain, and outline notable references, institutions, etc. However, although valuable and insightful (Zupic and Čarter, 2015), this approach lacks the richness of experts' insights and content analyses (Furrer et al., 2020). Hence, in order to address these RQs, this study uses a content analysis approach by means of Multiple Correspondence Analysis (MCA). This approach enables researchers to synthetize up-to-date findings and graphically depict the intellectual structure of the research field. The advantages of this approach arise from the combination of an expert-based approach and content analysis (Furrer et al., 2020). This method is widely used when mapping fields and has been used to assess strategic management (Furrer et al., 2008), multinational enterprises (Dabić et al., 2014), international alliances and culture (López-Duarte et al., 2016), cross-border mergers and acquisition (Kiessling et al., 2019), and the internationalization of small and medium firms (Dabić et al., 2019). Unlike other text mining approaches, MCA is based on the homogeneity analysis by means of alternating least squares (HOMALS), which allows researchers to analyze content, form clusters based on former literature reviews and findings, and group the categories into dimensional spaces while anticipating the deduced insights on the relationships between categories.

This study contributes to current understandings of OI in manufacturing by consolidating previous research, proposing research opportunities, and providing recommendations for practitioners. This study interprets the role of OI in the manufacturing research domain and acknowledges contemporary research trends, such as *collaboration, open strategy, breadth, depth,* and *innovation from the firm's perspective*. Additionally, this study integrates theoretical approaches (e.g., *institutional theory, knowledge-based view, resource-based view, supply chain management,* and *transactional cost economics theory*) and proposes future research avenues regarding *sustainability, commitment-based HR practices,* and *Industry 4.0*. Moreover, the summary of the research domain offers practitioners a set of recommendations with regards to overcoming challenges pertaining to the adoption and employment of OI practices in manufacturing.

This remainder of this paper is structured as follows. The next section will outline the development of the OI paradigm over the years. The following section summaries the methodology and the systematic literature review procedure. In the fourth section, the descriptors used when mapping are explained in detail. In the fifth section, the proposal for the future research have been made. Finally, in the last section, contributions to practice and theory are outlined and concluding remarks are given.

2 Open innovation

Since Chesbrough's (2003) seminal work, scholarly awareness of OI has increased exponentially, resulting in more than 4,000,000 documents indexed on Google Scholar in 2020. Chesbrough stated that *"… valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well"* (Chesbrough, 2003, p. 43). Building upon Chesbrough's remarks on the OI paradigm (2003, p. 43), OI research has advanced over the years. In 2014, Chesbrough and Bogers (2014, p. 33) expanded upon OI's initial conceptualization, providing up-to-date definition: *"a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model"*. The evolution of the OI concept is presented in Table 1.

Table 1. Evolution of the open innovation concept.

Author	**Definition**
Chesbrough (2003, p. 43)	*"… valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well".*
Gassmann and Enkel (2004, p. 2)	*"Open innovation means that the company needs to open up its solid boundaries to let valuable knowledge flow in from the outside in order to create opportunities for co-operative innovation processes with partners, customers and/or suppliers. It also includes the exploitation of ideas and IP in order to bring them to market faster than competitors can".*
Chesbrough (2006, p. 1)	*"Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively".*
Laursen and Salter (2006, p. 43)	*"An open innovation model is using a wide range of external actors and sources to help them achieve and sustain innovation".*

West and Gallagher (2006, p. 320)	*"We define open innovation as systematically encouraging and exploring a wide range of internal and external sources for innovation opportunities, consciously integrating that exploration with firm capabilities and resources, and broadly exploiting those opportunities through multiple channels".*
Lichtenhaler (2008, p. 148)	*"An open innovation approach refers to systematically relying on a firm's dynamic capabilities of internally and externally carrying out the major technology management tasks, i.e., technology acquisition and technology exploitation, along the innovation process. Thus, open innovation processes involve a wide range of internal and external technology sources, and a wide range of internal and external technology commercialization channels".*
Lichtenhaler (2011, p. 77)	*"Open innovation is defined as systematically performing knowledge exploration, retention, and exploitation inside and outside an organization's boundaries throughout the innovation process".*
Chesbrough and Bogers (2014, p. 33)	*"We define open innovation as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model".*

Several authors have assessed OI findings and have highlighted the necessity for further explorations of OI perspectives in theory and practice. For example, Gassmann and colleagues (2010) contributed to OI's phenomena by organizing the research field and revealing gaps, emphasizing the importance of patents and intellectual property. Furthermore, these authors demonstrated the relevance of studying OI in SMEs, accentuating the effect of OI on virtual R&D teams. Next, building upon the development of the OI paradigm and growing interest among academics and practitioners, Chesbrough and Bogers (2014) depicted the scope of academic literature since the term 'open innovation' was coined in 2003. In their seminal paper, Chesbrough and Bogers advanced the definition of OI by introducing pecuniary and non-pecuniary mechanisms of inbound and outbound OI and highlighting the importance of the firm's business model. More recently, Bogers and colleagues (2017) formed an integrative framework of the levels of analysis for OI research. They contributed to the development of the paradigm by presenting future research opportunities at micro, meso, and macro levels of analysis (e.g., from individual challenges to applications of OI at an industry or national level). Overall, these scholars demonstrated that it is important to study the role and the application of OI in a manufacturing context, thus reiterating the necessity of our study.

3 Methodology

3.1 The sample of articles and data collection

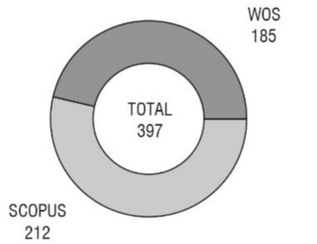
In order to complement contemporary findings related to OI, this research investigates the span of OI with regards to the manufacturing industry, which has not been thoroughly explored. Hence, the goal of this systematic literature review is to map and synthetize the field of OI in the manufacturing industry and subsequently offer future research streams. The first step involved the selection of articles to be analysed. This search was conducted among publications indexed in the well-known scientific databases of Elsevier Scopus, Thomas Reuters Social Sciences Citation Index (SSCI), and Science Citation Index Expanded (SSCI). For a publication to be considered, two conditions were required: it should contain the term "*open innovation*" AND "*manufact**" in one of the following fields: title, abstract, and/or keywords (Kiessling et al., 2019). After searching for articles, an initial database of 397 articles was obtained. Following this, all duplicates were deleted. Some articles were published in both databases and so, for consistency, duplicates from Scopus were eliminated. The third step involved reading all of the articles and removing those that did not fit the aim of the study. The criteria for accepting articles were: (1) the main topic of the article should be OI and articles dealing only with 'innovation' or 'closed innovation' were to be excluded; and (2) some articles explained the difference between OI in manufacturing and the service industry; articles with sampling proportions (in terms of sector) of more than 50% manufacturing were included, and articles mainly dealing with the service sector were excluded. A team of three international researchers separately determined whether or not each article should be excluded or included (Graneheim and Lundman, 2004). Following the results of the revision, the researchers discussed their findings and made the final decision. In the following section, the fifth step is outlined in detail. Fig. 1 shows the literature review procedure.

Ultimately, a total of 239 articles were selected. Articles dealing with this topic were published between 2003 and 2019, which was not surprising as the term "*open innovation*" has been developing since the publication of Chesbrough's book in 2003. The period of publication for the articles included in this review was between 2003 and 2019, with the following distribution: 3.77% from 2003 to 2009; 30.96% from 2010 to 2014; and 65.27% from 2015 to 2019. This distribution shows the increasing interest in the area of OI in the manufacturing industry among researchers and practitioners (see Fig. 2), providing support for conducting the review (Tranfield et al., 2003).

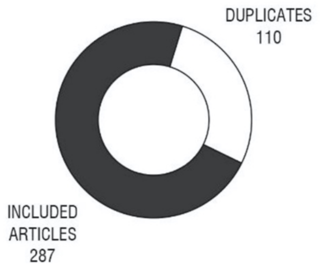
The growing number of OI publications and the increased degree of interest among practitioners was further supported by special issues published in renowned academic journals, such as *R&D Management, IEEE- Transactions on Engineering Management, Technovation, Research Policy and Research-Technology Management*, among others.

1 SEARCH FOR THE ARTICLES

	Search criteria	
	Web of Science	Scopus
Date Range	2006-2019 (maximum range available)	2003-2019 (maximum range available)
Citation database	Social Science Citation Index (SSCI) 1956 - present	/
Document type	Article and review	Article and review
Language	English	English
Search strings	"open innovation" AND "manufact*" in title, abstract, author keywords, and Keywords Plus	"open innovation" AND "manufact*" in title, abstract and author keywords



2 DELETING DUPLICATES



3 CRITERIA DETERMINATION

(1) The main topic of the article should be open innovation (articles dealing with „innovation“ or „closed innovation“ were excluded)

(2) Some of the articles compared the manufacturing industry with the service industry. Articles with sampling proportions (in terms of sector) of more than 50% manufacturing were included, and articles mainly dealing with the service sector were excluded.

4 READING THE FULL ARTICLES

5 ANALYZING DATA AND MAPPING

Multiple correspondence analysis (MCA) which is based on homogeneity analysis by means of alternating least squares (HOMALS) was used for analyzing data.

- A value of „1“ was given to papers whose title, abstract, and keywords contained a specific descriptor.
- Two dimensional coordinates for each descriptor were provided.

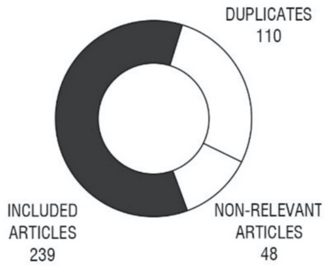


Figure 1 Literature review procedure.

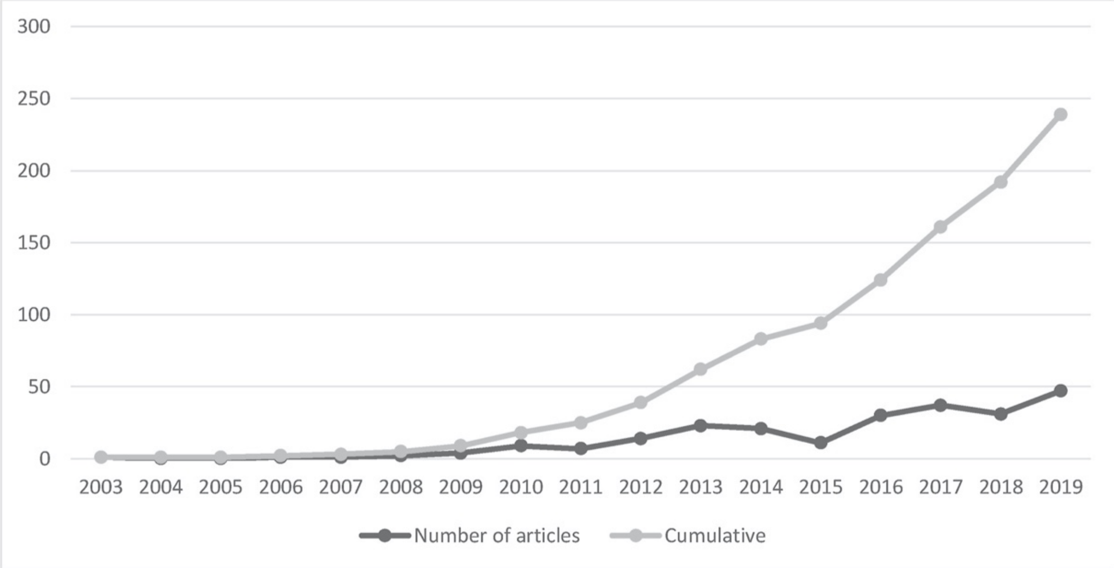


Figure 2 Number of articles per year.

3.2 The HOMALS procedure for multiple correspondence analysis (MCA)

To analyze the data, we used multiple correspondence analysis (MCA) based on homogeneity analysis by means of alternating least squares (HOMALS) (Hoffman and De Leeuw, 1992). MCA can be seen as "*a way of analyzing a subject by variable matrix with categorical variables or a subject by item matrix of multiple-choice data*" (Tenenhaus and Young, 1985, p. 91). Accordingly, a HOMALS method enables the analysis of the causal relations between the descriptors (González-Loureiro et al., 2014; Dabić et al., 2014). To form an initial list of keywords and descriptors, previous literature reviews investigating OI from different perspectives - such as OI in small- and medium-sized enterprises (SMEs) (Torchia and Calabro, 2019), OI models (Lazzarotti et al., 2010), negotiation in OI (Barchi and Greco, 2018), and collaborative based HRM practices (Hong et al., 2019) - were used. Building upon the initial list and the content analysis of 239 articles, performed using QDA Miner v.5 and Wordstat v.8 software, the final list of keywords (i.e. the codebook) consisted of 1101 keywords (see Table 6, available in the supplementary material) which were categorized into 27 groups. The 27 groups, belonging to theoretical approaches, major research themes, geographical scope, methodology, and industry, were studied thoroughly in order to better understand the connections between them. An overview of the keywords, according to the major categories, is presented in the supplementary material (see Tables 1–5, available in the supplementary material).

Each of the 239 cases were given a binary value for each of the descriptors. A value of '1' was given to papers whose title, abstract, and keywords contained a specific descriptor. The HOMALS analysis was performed using SPSS v26.

software. This procedure was used to provide an approximation of the two-dimensional coordinates of each descriptor. The result of this exploration was a "*proximity map where descriptors and articles are depicted in a low-dimensional space with two axes*" (López-Duarte, 2016, p. 517). The low-dimensional map, formed by the two first dimensions, shows that dimension one accounts for 9.65% and dimension two accounts for 18.28% of the explained variance (see Fig. 3). The map fits 27 variables into only two dimensions, causing a lower value of total variance (Lopez-Duarte et al., 2016). Following the recommendations of Hair and colleagues (1998, 2010) and Furrer and colleagues (2008, 2020), the validity and robustness of the MCA is better accessed through an overall keyword mean per article estimate, which should be greater than 1. In our case, the overall keyword mean per article was 1.21 per article, implying the fulfilment of this recommendation in performing a multivariate approach.

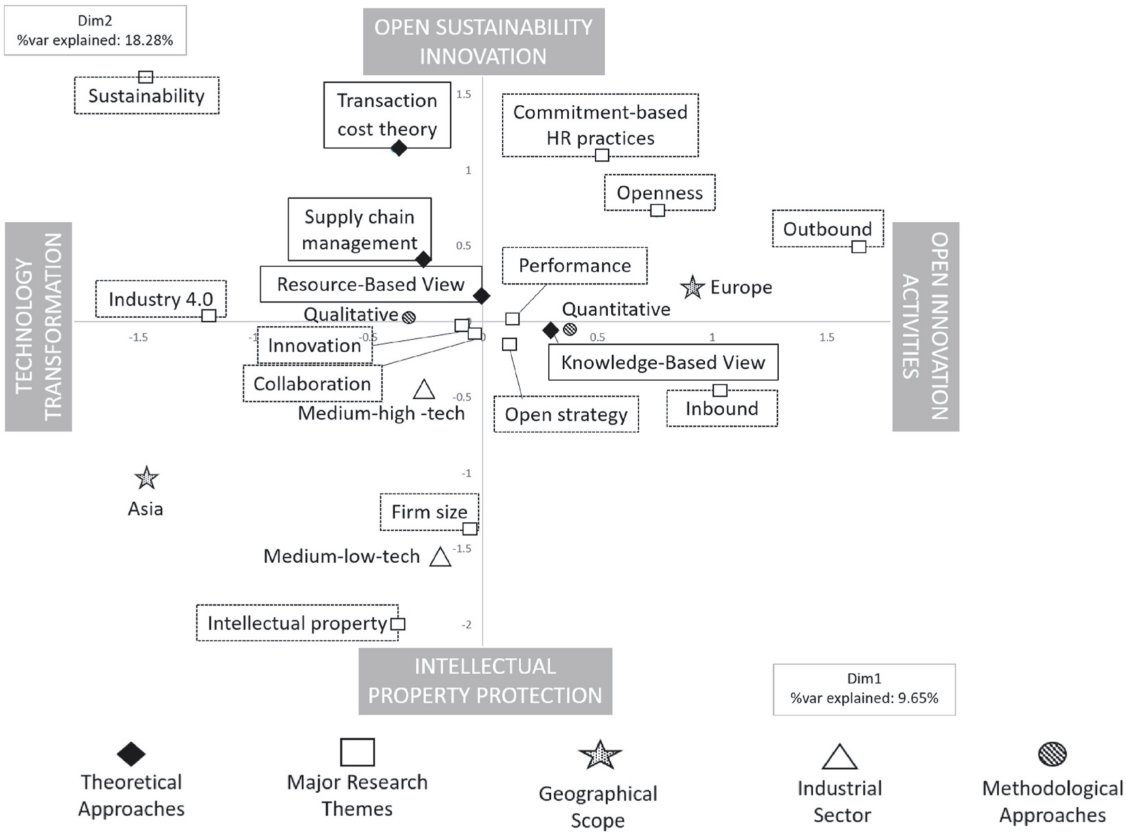


Figure 3 Mapping open innovation in the manufacturing industry.

In order to ensure the clarity and readability of the map, the authors adopted a threshold condition of 6% frequency for the descriptors to be shown on the map. As a result of this rule, five descriptors were not shown on the map. Most of these descriptors were from the geographical scope category (Africa, North America, Oceania, and South America) and one was from the provision of theoretical foundations (Institutional theory). These descriptors are explored throughout the manuscript and are considered to be potential paths for future research.

3.3 Mapping open innovation in the manufacturing industry

Building upon the guidelines of Hoffman and De Leeuw (1992) and, more recently, López-Duarte (2016), the first stage when clarifying the results obtained through the HOMALS analysis (see Fig. 3) is the labelling of poles. According to López-Duarte et al. (2016, p. 515), the poles "*should be labelled according to the most-extreme-located descriptors, but also considering that the most frequent descriptors. Therefore, the label should combine both issues*". Thus, to categorize poles, the most relevant descriptors were considered (López-Duarte et al., 2016; Kiessling et al., 2019). The descriptors positioned on the upper side of axis X shaped the label of the pole on that side. For example, inbound and outbound activities were often studied within the context of the knowledge-based view, using a quantitative approach and examining manufacturing firms based in Europe (Bianchi et al., 2016; Burchart et al., 2017). These descriptors formed the pole OI activities. In line with this, Table 2 shows the descriptors representing the poles of the axes, the keywords which best describe the poles, and the notable references (Table 3).

Table 2. Descriptors representing the poles of the axes.

Pole	Label	Descriptor	Notable References
Axis Y Upper	Open sustainability innovation	Sustainability, Transaction cost theory, Commitment-based HR practices, Supply chain management	Cappa et al. (2016) Arcese et al. (2014) Mustaquim and Nyström (2014) Yun and Yigitcanlar (2017)
Axis Y Lower	Intellectual property protection	Intellectual property, Medium-low-tech industries, Firm size	Gama (2018) Stefan and Bengtsson (2016); 2017
Axis X Upper	Open innovation activities	Inbound, Outbound, Openness, Knowledge-based view	Bianchi et al. (2016) Burchart et al. (2017) Kim et al. (2016)
Axis X Lower	Technology transformation	Industry 4.0, Medium-high-tech industries	Trantopoulos et al. (2017) Kastelli et al. (2018)

Table 3. Overview of future research avenues.

Research Theme	Future research avenues	RQs
1. Sustainability	Resource-based view	*RQ1: How can dynamic capabilities encourage more sustainable production?*
	Medium-low tech industry	*RQ2: How can open sustainability innovation reduce costs and improve time to market in the food and beverage industry?*
	New combinations of industries	*RQ3: How might the collaboration between biotechnology and the food and beverage industry reduce production waste and increase the use of renewable energies?*
	Geographical scope	*RQ4: How might collaboration between Western companies and companies based in Africa influence social sustainability?*
5. Commitment-based HR practices	Knowledge-based view	*RQ1: How can the knowledge transfer processes between a team and partners improve NPD performance, using inbound and outbound open innovation activities as mediators?*
	Implementation of the digital manufacturing	*RQ2: How can digital trust moderate the relationship between open innovation and NPD performance?* *RQ3: How can the new required managerial skills (e.g. complex problem solving, critical thinking, and people management) influence collaboration across the whole supply chain?*

	Qualitative approach	*RQ4: What is the role of HR management in creating an open innovation strategy in manufacturing?*
7. Industry 4.0	NPD performance	*RQ1: How can the implementation of additive manufacturing encourage outbound open innovation activities and, consequently, improve NPD performance?* *RQ2: How can Industry 4.0 solutions open up new potential for collaboration in the pharmaceutical industry?*
	Intellectual property	*RQ3: How does open innovation mediate the relationship between digital revolution and intellectual property rights? RQ4: What kind of digital patents are the most beneficial when protecting digital business models in the manufacturing industry?*

The left side of the map represents technological transformation. Articles located on this side dealt with the study of Industry 4.0 (the fourth industrial revolution) and an era of digital transformation. They were connected to a medium-high-tech industry (Fernandez et al., 2016; Kim and Kim, 2018). The right side of the map represents descriptors associated with OI activities: inbound and outbound. Some of the authors researched inbound and outbound activities separately (Bianchi et al., 2016), while others studied it together (Burcharth et al., 2017; Kim et al., 2016) in order to assess the ways in which they influence, for example, the performance of a manufacturing company (Cruz-González et al., 2015).

Articles at the top of the map deal with the study of open sustainability innovation (Cappa et al., 2016). In recent years, firms have become increasingly more concerned with economic, social, and environmental sustainability. The descriptor 'sustainability' is connected to transaction cost theory, as firms attempt to minimize the cost of their production and transportation in an effort to become more sustainable. Commitment-based HR practices are also a part of this cluster. For employees to accept innovations and collaborations with external parties, it is crucial to establish the correct culture in a company. It is vital that firms share information and knowledge within their society and thus become more socially sustainable. The bottom of the map shows articles connected to intellectual property, medium-low-tech industries, and firm size. Intellectual property represents a paradox in terms of OI, because firms want to share knowledge and innovation with external partners but, simultaneously, must defend themselves (Gama, 2018). Intellectual property is related to a firm's size and there are many articles dealing with the differences between patenting activities in SMEs in comparison to large firms. Stefan and Bengtsson (2016; 2017) explored the intellectual property protection mechanisms – formal, semi-formal, and informal. They concluded that different stages of the innovation process require different types of protection. In the following section, the descriptors and their positions on the map are explained in detail.

4 Intellectual structure OF OI IN the manufacturing research field

In order to synthetize OI in the manufacturing industry research field, the descriptors are arranged into five major categories: theoretical approaches, major research themes, geographical scope, methodological approaches, and industry. The categorization of these descriptors, according to these broad aspects, facilitates a better understanding of OI in the intellectual structure of the manufacturing field as it follows the good practices of the acknowledged literature reviews published in flagship journals (e.g. Kiessling et al., 2019; Furrer et al., 2020; Dabić et al., 2020). In order to outline the intellectual structure of OI in the manufacturing industry, Fig. 4 presents the visual division of major descriptors and their focused sub-topics. Additionally, in Fig. 4, notable references for each descriptor are presented, followed by a further explanation of the connections between them. Next, Fig. 5 shows the most used descriptors and their frequencies. For each category, the amount of papers using each theoretical approach, major theme, geographical scope, industry, and methodology can be seen.

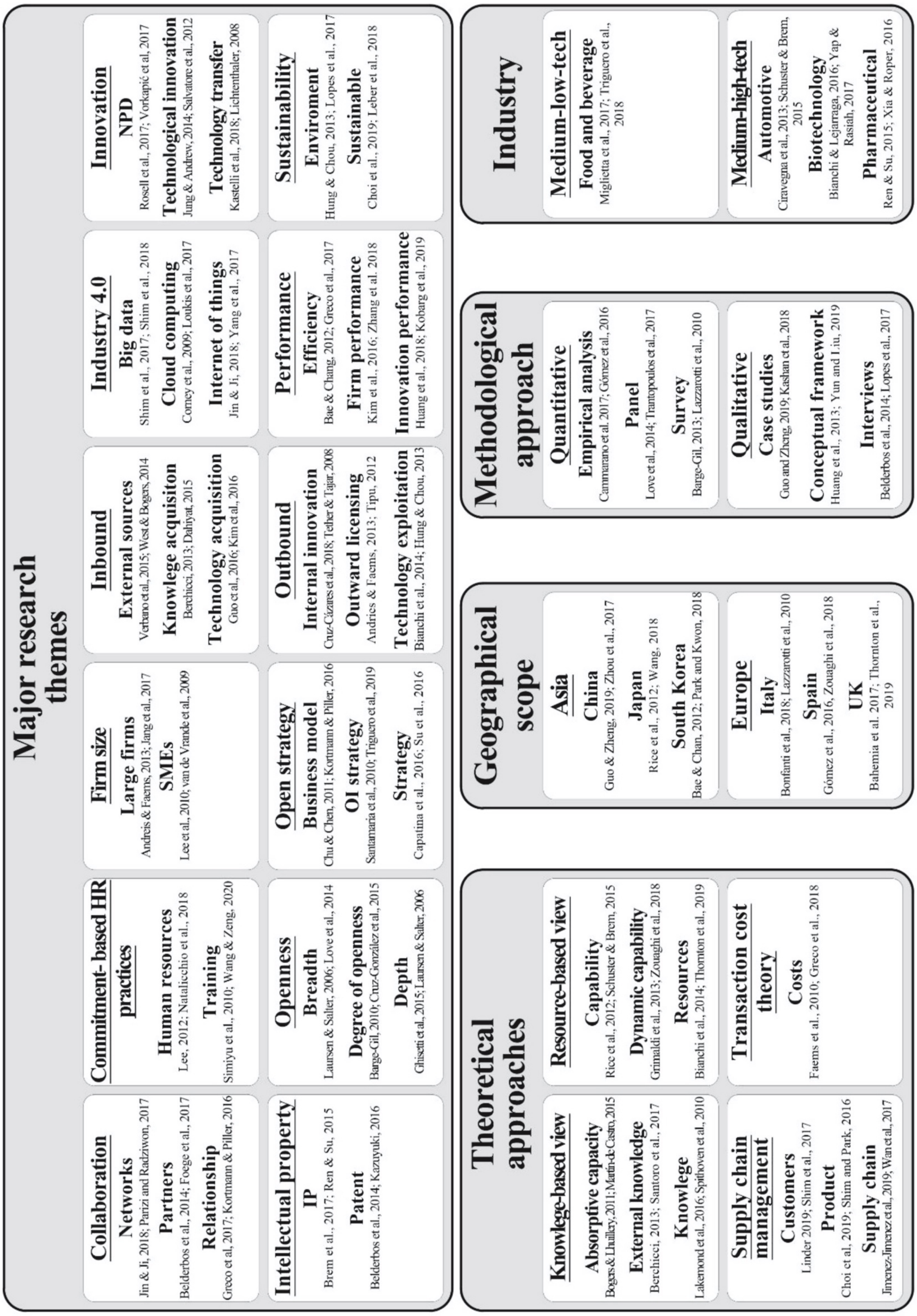


Figure 4 Notable references regarding theoretical cornerstones, the research trends of OI, geographical scope, methodology, and industry (Bae and Chang, 2012, Belderbos et al., 2014, Bianchi et al., 2014, Bianchi and Lejarraga, 2016, Bogers and Lhuillery, 2011, Capatina et al.,

2016, Carter and Rogers, 2008, Choi et al., 2019, Chu and Chen, 2011, Corney et al., 2009, Eftekhari and Bogers, 2015, Fleischmann et al., 2016, Foege et al., 2017, Ghisetti et al., 2015, Gomez et al., 2016, Hair et al., 1998, Hair et al., 2010, Jin and Ji, 2018, Kratzer et al., 2017, Lee, 2012, Linder, 2019, Loukis et al., 2017, Martín-de Castro, 2015, Natalicchio et al., 2018, Parizi and Radziwon, 2017, Rayna and Striukova, 2019, Rice et al., 2012, Rosell et al., 2017, Salvatore et al., 2012, Santoro et al., 2017, Shim et al., 2018, Spithoven et al., 2010, Su et al., 2016, Tether and Tajar, 2008, Thornton et al., 2019, Triguero et al., 2018, Vorkapić et al., 2017, Wan et al., 2017, Wang, 2018, Wang and Zeng, 2020, Yang et al., 2017, Yap and Rasiah, 2017, Zhang et al., 2018, Zhou et al., 2017, Zouaghi et al., 2018, Cheah and Ho, 2020).

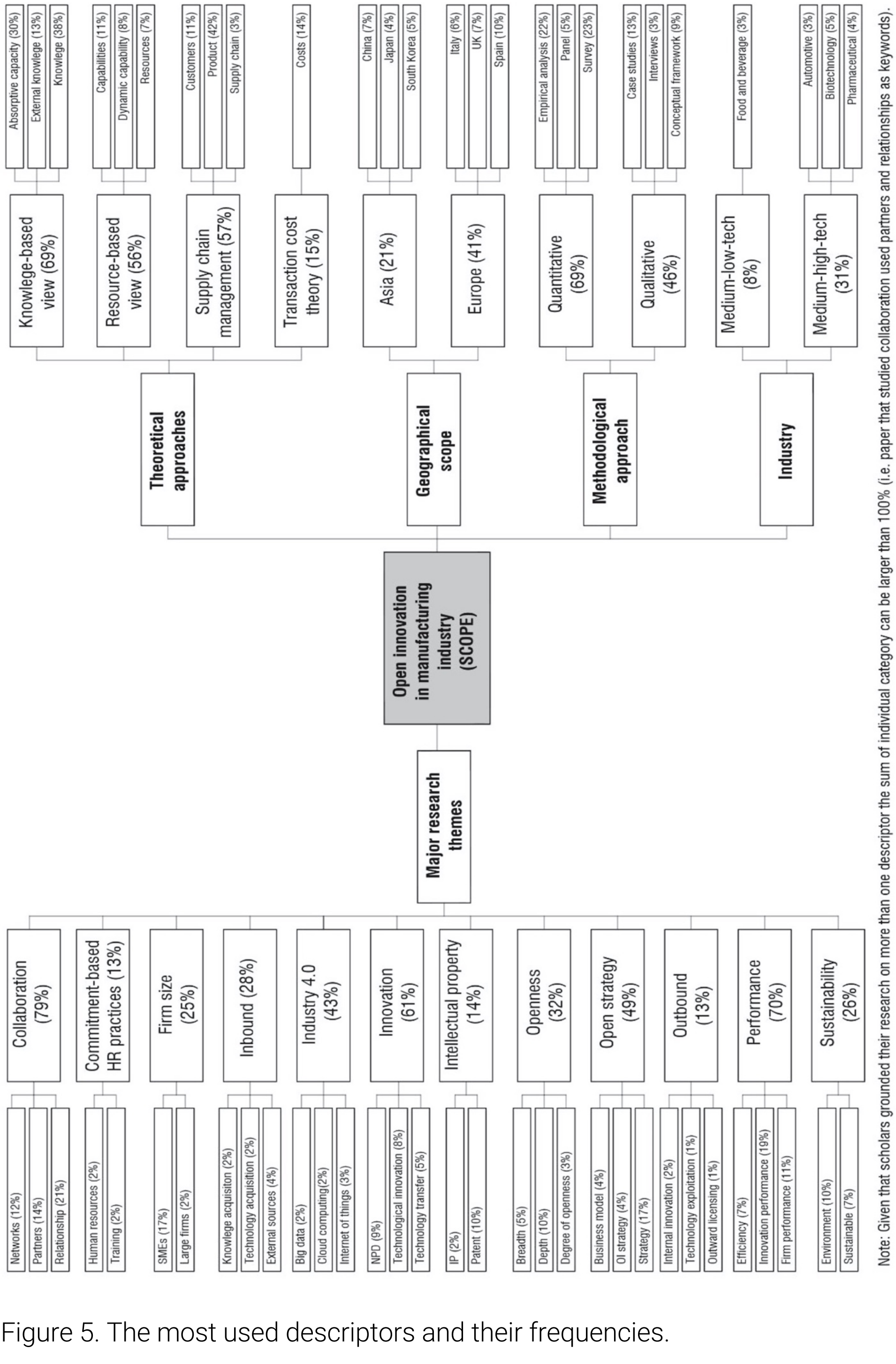


Figure 5. The most used descriptors and their frequencies.

4.1 Theoretical approaches

4.1.1 Institutional theory

Institutional theory delivers a valuable sight of organizations which is influenced by external sources (for example, state) as well as the organization itself (Zucker, 1987). The National System of Innovation is the key body when it comes to considering the ways in which nations differ in terms of their institutional support for innovation (West et al., 2005). Jung and Andrew (2014) used institutional frameworks to explore R&D collaborations between university research institutions and SMEs. Institutional theory is the least frequently used theoretical approach in this study and it is not shown on the map. Only 5% of articles have used this theory.

4.1.2 Knowledge-based view

Knowledge-based view is the most frequently employed theory in OI research within the manufacturing industry. Knowledge is the most significant resource and it often constitutes a firm's competitive advantage. In the manufacturing industry, where technology is changing every day, it is important for a firm to exchange knowledge and technology. Many authors focus their studies on absorptive capacity, which is associated with exploring external knowledge. Cohen and Levinthal (1990, p. 128) coined the term absorptive capacity as the "*ability to recognize the value of new information, assimilate it, and apply it to commercial ends*". Xia and Roper (2016) went on to consider the connection between OI in small firms' absorptive capacity and external relationships. Organizations that search more widely and deeply will have higher levels of innovative performance (Laursen and Salter, 2006). Triguero et al. (2019) established that the absorptive capacity of external knowledge can positively affect innovative performance.

The knowledge-based view is an extension of the resource-based view. It proposes that a firm's main motivation to collaborate with external associates is to allow them to profit from new technologies (Ahuja, 2000).

4.1.3 Resource-based view

Wernerfelt (1984) presented a resource-based view that honours organization-specific resources as a competitive advantage of an organization. The resource-based view and its extension, the capability-based view, both facilitate an understanding of the phenomenon of OI in manufacturing, especially in terms of dynamic capability (Kashan et al., 2018). Firms' capabilities strongly influence innovation. Teece et al. (1997, p. 516) described the notion of dynamic capabilities as "*the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments*". It is important for the organization to believe in an open approach and to open up their boundaries. In other words, they must start thinking about developing dynamic capabilities that can support competitive new strategies, for example OI procedure claims (Grimaldi et al., 2013).

4.1.4 Supply chain management

In traditional explanations of supply chain management, the manufacturer is placed between the suppliers and the customers. However, in terms of OI, collaboration with suppliers or customers can become crucial for business. With regards to the OI paradigm, the authors investigated the methods by which companies integrate external information into new product development (NPD) (Wimalachandra et al., 2014; Bahemia et al., 2017). Vahter et al. (2014) discovered that small manufacturing plants invest more in relationships within the supply chain than larger plants. Jimenez-Jimenez et al. (2019) have explored this topic in terms of supply chain collaboration, while van Blokland et al. (2012) investigated the specific value chain of an aerospace company.

4.1.5 Transaction cost economics theory

Transaction cost economics theory suggests "*that the organization of economic activities is driven by the minimization of both production and transaction costs*" (Berchicci, 2013, p. 118). A company can expand their knowledge, but this is not without costs. Transaction cost economics has a significant impact on OI, although the connection is frequently implicit (Remneland-Wikhamn and Knights, 2012). Not all R&D activities are firm-centric and so it is more efficient for firms to outsource or combine their R&D activities with other firms.

Most of the studies used more than one theoretical approach when exploring OI practices in the manufacturing industry. Resource-based views and knowledge-based views are connected and are often used together. In the supplementary material, Table 7 shows the top five cited articles per year. These articles provide insight into authors, journals, contributions, and the most frequently used theories.

4.2 Major research themes

This research aims to contribute to existing literature on OI initiatives in the manufacturing industry. The results presented in Fig. 3 outline numerous approaches categorized as: collaboration (Kobarg et al., 2019; Lichtenthaler, 2013), commitment-based human resource practices (Lattorre-Navarro et al., 2016), firm size (Cruz-Cázares et al., 2013; Fu et al., 2014), inbound OI (Bianchi et al., 2016; Lakemond et al., 2016), Industry 4.0 (Nellippallil et al., 2019; Rocha et al., 2019), innovation (Chesbrough, 2003; Love et al., 2014), intellectual property (Cammarano et al., 2017; Ren and Su, 2015), open strategy (Barge-Gil, 2013; Gama, 2018), openness (Laursen and Salter, 2006; Vahter et al., 2014), outbound OI

(Huang et al., 2013; Greco et al., 2018), performance (Kobarg et al., 2019; Park and Kwon, 2018), and sustainability (Prause, 2015; Shim and Park, 2016).

4.2.1 Collaboration

Collaboration is at the very centre of the OI paradigm. Essentially, if firms want to innovate then they have to collaborate with others as it is not possible for all relevant knowledge to exist within one firm. Our findings show that more than 79% of articles contain the keyword 'collaboration'. Firms can collaborate with different sources; for example, with customers, universities, consultants, or even competitors. Ozdemir et al. (2017) analysed new horizontal product alliances with competitors and new vertical product alliances with suppliers and research institutions. Lee et al. (2010) discovered that SMEs are better in inventions than as resources for commercialization, suggesting that SMEs should collaborate with other companies during the commercialization stage. Collaboration, innovation, and open strategy are very close to each other on the map (see Fig. 3). Collaboration is rarely investigated alone, but rather in terms of the ways in which it affects the firm's degree of openness and/or performance.

4.2.2 Openness and open strategy

One of the more notable publications in this field is a study conducted by Laursen and Salter (2006). These researchers investigated the connection between a firm's openness and its innovative performance. They introduced two new variables: breadth, as sources of knowledge or links to innovation (for example, suppliers, competitors, consultants, environmental standards, private research institutes, etc.) and depth, as the intensity to which these sources of knowledge were used. Love et al. (2014) have explored the impact of openness on learning effects, while Vahter et al. (2014) have discovered that the breadth of openness in innovation performance is more powerful for smaller manufacturing plants than for larger ones.

Barge-Gil (2010) studied Spanish firms and found that closed and semi-open strategies are the most recurrent. Three years later (2013), the same author discovered that, in comparison to semi-open innovators, open innovators are not as R&D intensive, but they are more R&D intensive than closed innovators. Xia (2013) analysed the connection between absorptive capacity and openness. It was found that exploratory openness depended more on the R&D elements of a company's prospective absorptive capacity. On the other hand, exploitative openness depended more on a firm's realized absorptive capacity.

4.2.3 Performance

Most articles showed the influence of degrees of openness on external knowledge of innovation performance (18.83%), but some articles deal with a firm's general performance (11.3%) and its financial performance (3.77%). Cruz-Gonzalez et al. (2015) approached this topic using the two open search strategies (breadth and depth) and explored their influence on a firm's performance.

Lazzarotti et al. (2010, p. 12) outlined the effect of openness on innovative performance. These authors depicted the degree of openness as: "*the number and type of partners and the number and type of phases of the innovation process open to external collaborations*". Furthermore, they divided their variables into four types of OI models: open and closed innovators, integrated collaborators, and specialized collaborators. Ultimately, their findings revealed that integrated and specialized collaborators act as intermediators. Andries and Faems (2013) studied the influence of patenting activities on the financial performance of SMEs and large firms. They found that outward licensing activities would not produce short term financial benefits and that patenting activities would not cause cost disadvantages. The descriptor 'performance' is between inbound and outbound OI actions.

4.2.4 Inbound and outbound activities

OI includes both inbound (outside-in) and outbound (inside-out) activities. West and Bogers (2014) concluded that inbound OI has been more thoroughly explored than outbound, and the authors of this article have come to the same conclusion.

Inbound OI activities - or "the purposive inflows" (Chesbrough, 2003) - allow firms to acquire new knowledge, new ideas, and new technologies from outside of the firm. This includes "*customer involvement, external networking, external participation, outsourcing R&D, and the inward licensing of intellectual property*" (van de Vrande et al., 2009, p. 425). Terms such as 'outside-in' and 'technological exploration' are also used.

On the other hand, technological exploitation implies that firms can profit from their internal knowledge by using their internal innovations. The most frequently used method of commercializing ideas is venturing outwards towards the "*licensing of intellectual property or the involvement of non-R&D workers*" (van de Vrande et al., 2009, p. 424). Technological exploitation can also be referred to as outbound OI. In existing scholarly literature, the term 'inside-out' OI is also used. All terms retain the same meaning: "the use of purposive outflows of knowledge" (Chesbrough, 2003).

Hung and Chou (2013) studied the effects of technological exploitation and exploration on a firm's performance, while Pedrosa et al. (2013) explored its association with a different set of managerial appearances and practices in OI. Many articles deal with user involvement. For example, Leber et al. (2018) sought to establish whether or not customers could contribute to product development, specifically, with regard to refrigerator door handles. Tipu (2012) concluded that inbound OI activities were common, while outbound innovation activities were not as frequently used.

Inbound activities have been more thoroughly explored than outbound activities. We thus recommend that other researchers explore more outbound activities and more ways of commercializing ideas. Inbound and outbound activities are far from both qualitative and quantitative methodological approaches. As such, future research should focus on outbound OI, as many firms can profit from their own internal knowledge and it is therefore important to share good practices in order to allow for the expansion of the market. It is also vital that firms encourage their non-R&D employees to share their ideas and innovate.

4.2.5 Commitment-based human resource practices

High commitment human resource (HR) practices result in trust, long-term employment relationships, and employment security (Lattorre-Navarro et al., 2016). These should contribute to the formation of an innovation climate (Popa et al., 2017).

Ceylan (2013) found that commitment-based human resources (HR) affect the innovation performance of the firm indirectly. She concluded that commitment-based HR practices mainly affect organizational innovation activities, which increase innovation performance. McClean and Collins (2011) explore the connection between high-commitment HR practices and firm performance. They discovered that companies are willing to build HR practices for employees that clearly produce competitive advantages for the firm. Furthermore, HR practices can affect innovation activities by creating a culture of innovation and creativity (Brockbank, 1999). The descriptor 'Commitment based HR practices' is very close to the descriptor 'openness'. When a firm chooses to open up its innovation practice, there are radical changes for employees. Managerial staff within the firm have the difficult task of bringing about new cultures and new ways of thinking (Barham et al., 2020).

4.2.6 Firm size

There are many articles related to OI in research on SMEs (van de Vrande et al., 2009; Theyel, 2013; Verbano et al., 2015) which argue that they fill the gap(s) in scholarly literature as most studies pertain to large companies, in which the concept of OI was first initiated (Lee et al., 2010). Chesbrough's theory was based on large American firms (Xerox, IBM, Intel), but OI is applicable to all industries and all enterprises (Gassmann et al., 2010).

Although OI began in large firms, only 2% of articles deal with this topic. The reason for this is that many authors have sought to fill the gap identified following the first publication in the field, and so our findings show that 18% of articles deal with OI in SMEs. Most researchers focus on one firm type - either SMEs or large firms. Crema et al. (2014) analysed company strategies, OI, and innovation performance through surveys based on SMEs in Italy. Some authors have analysed the difference between SMEs and large firms. For example, Jang et al. (2017) created an OI model for the complementary cooperation between SMEs and large firms in the manufacturing industry. Andries and Faems (2013) investigated the readiness of SMEs and large firms to participate in patenting. On the map, we can see that a firm's size is distanced from theoretical and methodological approaches and it can thus be considered a potential avenue for future research.

4.2.7 Industry 4.0

The term 'Industry 4.0' was presented by the German government as a strategic plan for their manufacturing industry, but other countries have also paid attention to digital transformation. In China, this period is referred to as "*Made in China (2025)*"; in the USA, "*Advanced Manufacturing Program*"; in the UK, "*4IR*"; and, in Japan, "*Industrial Value Chain Initiative*". All terms refer to the fourth industrial revolution. There is a significant focus on transformation within the manufacturing industry. Technological innovation, regulatory changes, and turbulent global environments force firms towards new innovations and business models (Cooper, 2017). Although most research has focused on technological perspectives, Burmeister et al. (2016) discussed business models for Industry 4.0. and Industry 4.0's influence on the entire supply chain, embracing many OI approaches (Prause, 2015). In this line, Lardo et al. (2020) studied the ways in which capability providers can influence the transformation of the sustainable Industry 4.0. business model. Their findings show that many studied cases implemented OI in order to collaborate with different partners. This practice was identified as a foundation for value co-creation. Crupi et al. (2020) concluded that Italian digital innovation hubs practice OI by acting as knowledge brokers and knowledge sources, boosting the digital transformation of SMEs.

Overall, findings of empirical studies show that the descriptor Industry 4.0 is near medium-high technology manufacturing in Asia, which is not surprising seeing as China and South Korea are known for their digitization in manufacturing as well as their intelligent manufacturing. Industry 4.0 is distanced from the research themes of performance, human resource, and intellectual property, which is why it should be considered one of the most important topics for future research.

4.2.8 Innovation

Innovation is mostly explored in terms of 'innovation processes'. On the map, it is surrounded by descriptors such as 'open strategy' and 'collaboration', and by theoretical approaches, knowledge, and resource-based views. Kashan et al. (2018) observe the governance view as an element of the OI process, but innovation is not very close to a governance view. Aspects of the OI process are linked to a firm's evolution from closed innovation to OI. Gassmann and Enkel (2004) acknowledged three essential OI processes, based on their own empirical database of 124 companies: (1) The outside-in process, wherein buyers, suppliers, and external knowledge can affect innovations in companies; (2) The inside-out process, wherein the company can sell ideas, knowledge, and technology outside of the company; and (3) The coupled process, which is the connection between outside-in and inside-out processes, wherein the firm both gives and takes information.

4.2.9 Intellectual property

Collaboration with other partners is at the core of the OI paradigm. Firms have a hard time considering whether it is worth sharing knowledge with others or not. This is why intellectual property (IP), as well as intellectual property rights (IPR), are important research themes. Stefan and Bengtsson (2016) investigate the effects of IP protection mechanisms and openness on innovation performance. The connection between IP protection and OI is distinguished through a paradox (Brem et al., 2017). Firms should consider protection before sharing their knowledge with partners, however the procedure of protecting an idea can be expensive and time consuming. Vanhaverbeke (2006) found that companies could profit from the selective use of its IP by other companies with different models.

"*Innovation activities measured by patenting are positively correlated with firm performance*" (Kazuyuki, 2016, p. 13). Ren and Su (2015) concluded how OI and IP protection both play a key role in the catch-up processes of two late-comer pharmaceutical firms. Andries and Faems (2013) explored the differences in patenting activities amongst large firms and SMEs and realized that patenting activities increased the ability of both to license out knowledge, but that the effect was more evident for larger firms. The role of intellectual property is very important in protecting innovation and around 7% of papers deal with this topic. However, there is still room for investigation, especially from a quantitative methodological approach.

"*Small and large firms have different resources and capabilities and can benefit from patenting activities in different ways*" (Andries and Faems, 2013, p. 1089). Future research should focus on the different patenting activities of different sized firms.

4.2.10 Sustainability

This topic stems from OI perspectives, specifically in the manufacturing industry, and it includes all types of sustainability: economic, social, and ecological. One quarter of articles dealt with this topic. Sustainability is often explored through the lens of the 4th industrial revolution, with special attention dedicated to production scheduling (Shim and Park, 2016; Shim et al., 2017). Shim et al. (2017) proposed an algorithm which showed improved performance in production scheduling, and this was used in real manufacturing systems. For cost reductions and better efficiency, production scheduling uses big data, the internet of things, cloud computing, and cyber-physical systems. Yun and Liu (2019) suggested the use of a conceptual framework in order to explain OI using a quadruple-helix model.

Kortmann and Piller (2016) developed a framework for the sustainability of business models in manufacturing firms, which is important across all value chains. In terms of OI, manufacturing firms are able to collaborate with domestic suppliers and, in this way, can cut transactional costs. They can also collaborate with customers and explore the ways in which clients perceive NPD processes (Leber et al., 2018). To understand sustainable supply chain management, it is important to explore all activities inside the supply-chain: designing, planning, execution, controlling, and monitoring. It is worth noting that this topic has become very popular in recent years and, with this in mind, future research suggestions have been made in the next section.

4.3 Geographical scope

The most frequent countries shown, in terms of their geographical scope, are in Europe (Costa et al., 2016; Cruz-Cázares et al., 2018) and Asia (Ren and Su, 2015; Fu et al., 2014). Only three articles concerning the topic have emerged from Africa (Simiyu et al., 2010), and two from South America (Rocha et al., 2019) and Oceania (Teng et al., 2014), respectively. In the last section of the article, researchers are encouraged to explore OI practices in manufacturing firms on other continents. Europe is characterised by articles dealing with openness and performance, while Asia frequently examines close to medium-high tech and Industry 4.0.

4.4 Methodological approaches

The quantitative method is most frequently represented in terms of methodological issues. A lot of data was collected concerning Community Innovation Surveys (CIS) (Barge-Gil, 2010; Silva et al., 2008), which are surveys implemented by national statistical offices throughout the European Union and in Norway and Iceland. Qualitative studies were mostly case-based (Guo and Zheng, 2019; Kashan et al., 2018) and qualitative research was situated between supply chain management and collaboration. Quantitative research is linked to knowledge-based views and is very close to open strategy and innovation. Intellectual property, firm size, sustainability, and commitment-based HR practices were major research themes located far from both qualitative and quantitative methods, thus offering a potential avenue for future research.

4.5 Industry

In spite of the fact that OI initially emerged in the high-tech sector, there has been an increase in articles exploring the innovation processes of the low-tech sector (Gassmann et al., 2010). The most researched industry in the low-tech sector is the food industry. Low-tech firms can develop knowledge connected to non-R&D activities, indirectly developing new products (Kastelli et al., 2018).

Based on the Statistical Classification of Economic Activities in the European Community (NACE), the industry is organized by technological intensity: low-tech, medium-low-tech, medium-high-tech, and high-technology manufacturing industries (see Table 8, available in the supplementary material). For better transparency, low-tech and medium-low-tech industries are connected and shown together on the map. The same was done for high-tech and medium-high-tech. The authors found that descriptors representing the medium-low-tech classification of the manufacturing industry was very distant for both qualitative and quantitative methods.

5 Future research

The synthesis of up-to-date literature, performed by means of content analysis combined with HOMALS statistical procedure, allows us to outline key insights and provide a roadmap for the future development of OI in the research field of manufacturing. Given that studies to date have predominantly focused on collaboration, open strategy, breadth and depth, and innovation from the firm's perspective, topics such as sustainability, human resources, and Industry 4.0 require further attention.

5.1 Sustainability

In regular supply chain management, the manufacturer exists between suppliers and customers but, in terms of OI, collaboration with suppliers or customers can prove to be crucial for business. With the help of external knowledge, a firm can improve its sustainable innovation and positively influence organizational sustainability (Lopes et al., 2017).

By optimizing their processes through the whole supply chain, manufacturing firms can minimize waste and make production more sustainable. Additionally, products marked as sustainable tend to generate more profit than those marked as non-sustainable (Whelan and Kronthal-Sacco 2019). With this in mind, the resource-based view could assist manufacturing firms in creating and modifying their dynamic capabilities by simultaneously improving their economic, environmental, and social sustainability. Furthermore, manufacturers have the potential to modify their sustainable supply chains through collaboration. With the help of external partners, manufacturers could increase their income whilst using natural resources and ensuring better conditions for their workers. Although the EU has created a strategy for implementing the UN's 2030 Agenda for Sustainable Development, there is still a gap in research when it comes to sustainable activities through OI in the manufacturing industry in Europe (UN General Assembly, 2015). To fill these gaps, future research should focus on the resource-based view, low-tech industries, and Europe as a geographical scope as initiators of sustainability for OI in the manufacturing industry.

5.1.1 Resource-based view

The resource-based view highlights the importance of a firm's resources and capabilities. In the context of OI, firms continue to develop their resources, sharing them with partners and adapting them in order to become more competitive. The results of this analysis show the lack of study into sustainability in terms of the resource-based view (see Fig. 3). It would be useful to explore how the resource-based view enhances sustainability in the long run, seeing as firms' resources are sources of competitive advantage and are often the reason behind firm's higher profit and/or better market position. In today's fast-changing environment, in which customers value personalized products, production has a great impact on the environment and society. Future research should thus focus on firms' dynamic capabilities and the ways in which the combination of internal and external competencies can be built and modified in order to make production more sustainable.

5.1.2 Low-tech industries

High-tech and medium-high tech manufacturing are much more connected to OI research than low and medium-low manufacturing (more than 30% of articles dealt with medium-high tech, and only 8% with medium-low tech). Thus, scholars are encouraged to explore the ways in which low-tech manufacturing industries - as OI strategies - are operational and effective in making internal research and development efforts more successful in both high and low-tech sectors (Santamaria et al., 2010). According to the results depicted in Fig. 3, we can conclude that the intersection of sustainability and medium-low-tech industries represent a research opportunity. Future research should focus on the influence of open sustainability innovation on the food and beverage industry in order to see how low-tech industries can reduce their costs and improve their time to market.

5.1.3 New combinations of industries

To date, scholars have payed particular attention to role of OI in industries such as the automotive industry (Schuster and Brem, 2015; Ciravegna et al., 2013; Homfeldt et al., 2019), the chemical industry (Bieringer et al., 2013), the pharmaceutical industry (Dahiyat, 2015; Gambardella and Panico, 2014), the bio-pharmaceutical industry (Cammarano et al., 2017; Xia and Roper, 2016), and the food and beverage industry (Triguero and Fernandez, 2018; Costa et al., 2016; Miglietta et al., 2017). Scholars are therefore encouraged to investigate OI in other specific industries, as well as in new combinations of industries, for example biotechnology and pharma (Bogers et al., 2017). It would be useful to explore how the collaboration between biotechnology and the food and beverage industry influences sustainability. The food and beverage production industry are one of the largest in the world and it is important to minimize waste and expand the use of a renewable energies. According to The Intergovernmental Panel on Climate

Change report (2020), around 21 to 37 per cent of the world's greenhouse gas is linked with our food systems.

5.1.4 Geographical scope

Furthermore, the results of the analysis indicate that OI in manufacturing has predominantly focused on firms in Europe, which could be partially explained by the data availability obtained through the Community Innovation Survey (CIS) (Lichtenthaler, 2013; Greco et al., 2017); as shown, for example, in relation to Italy (Lerro et al., 2016; Bonfanti et al., 2018), and the UK (Mina et al., 2014; Audretsch and Belitski, 2019). The second most frequent geographical area was Asia, for example, South Korea (Park and Kwon, 2018; Yun et al., 2018) and China (Huang et al., 2018; Guo et al., 2016).

Future research could bring to light the approaches and strategies of manufacturing firms in Oceania, South America, and Africa. As numerous manufacturing firms are located in Australia, future research could also investigate OI practices in, for example, Preshafood Limited – a food and beverage company from Melbourne - or Gecko Gear, which specializes in iPod, iPad, and iPhone accessories. Researchers could investigate the differences in OI practices between their warehouses in Australia and China. South America also offers a lot of potential in terms of the exploration of specific industries, such as OI in aircraft firms (of which there are many), such as Aero Bravo, Paradise Aircraft Advanced Composites Solutions, or Companhia Aeronàutica Paulista.

Although Europe is the most frequently researched geographical region in terms of OI in the manufacturing industry, it is still very far from achieving sustainability (see Fig. 3). Future research should therefore focus on collaborations between developed and developing countries. For example, how can the exchange of knowledge create a greater value for both countries? Or, how could OI enhance frugal innovation?

To summarize, future studies could aim to answer:

RQ1: How can dynamic capabilities encourage more sustainable production?

RQ2: How can open sustainability innovation reduce costs and improve time to market in the food and beverage industry?

RQ3: How might the collaboration between biotechnology and the food and beverage industry reduce production waste and increase the use of renewable energies?

RQ4: How might collaboration between Western companies and companies based in Africa influence social sustainability?

5.2 Commitment-based HR practices

Results show that only 13% of articles dealt with the topic of commitment-based HR practices in terms of OI in the manufacturing industry. Articles were more focused on technologies and processes of digitalization with respect to the fourth industrial revolution than on leadership and how these changes have influenced the culture of the company.

In 2020, where the whole world is affected by the COVID-19 pandemic, it is necessary for managers to have proper skills with which to motivate their team members. With this in mind, it is more important than ever to study virtual teams, training and development, skill management, change management, and other human resource practices affecting inbound and outbound firm activities, while simultaneously influencing NPD performance. The knowledge-based view, as a theory that advocates knowledge as a firm's competitive advantage, can also be a valuable approach in clarifying the ways in which knowledge can be transferred among both team members and partners in a supply chain.

5.2.1 Knowledge-based view

With new innovations and technologies, it is important to adapt new business models and cultures. Sometimes, employees do not feel comfortable when collaborating with external sources. “Not invented here” syndrome is very common in the context of OI. Van de Vrande (2009) proposes that future research should work on linking OI to HR management, as OI generates HR management problems. Markovic et al. (2020) highlighted that the training and deployment of teams are the “softer” drivers of outside-in OI.

A definitive lack of HR research, in accordance with the knowledge-based view (see Fig. 3), was observed in this study. Knowledge as an intangible capability constitutes the competitive advantage of a firm. It would be valuable for future studies to explore how knowledge transfer among both team members and partners (suppliers and customers) can influence inbound and outbound OI activities in order to improve NPD performance. Further research into HR management, specifically top management, teamwork, recruiting, and talent management, is necessary.

5.2.2 Implementation of the digital manufacturing

Industry 4.0 has shortened product life cycles and it is thus more important than ever for firms to collaborate with external partners (Mubarak and Petraite, 2020). Additive manufacturing influences the processes of creating substances by enabling manufacturing companies to create prototypes much more quickly. New technologies thus allow manufacturing firms to test more innovations and place new products on the market more rapidly.

The fourth industrial revolution represents the new digital age, with the focus on advanced technology. Future research should emphasize human resource practices in terms of formal aspects (e.g. strategy or communication) and informal (e.g. trust) and explore how they can strengthen the connection between OI and NPD performance. The World Economic Forum (2020) has identified the top required skills for managers in the future. It would be useful to study how complex problem solving, critical thinking, creativity, and/or people management can influence inbound and outbound OI activities. These new skill requirements were obtained under the influence of globalization, digitalization, and COVID-19.

5.2.3 Qualitative approach

A large amount of research has been conducted through quantitative approaches (i.e. findings show that 69% of authors use quantitative methods), especially with regards to the Community Innovation Surveys (CIS). In order to contribute to the paradigm, more qualitative and mixed methods should be relied upon. Researchers should fill this gap by seeking to develop an in-depth understanding of human behaviour, for example, by interviewing top managers to see how they have adopted OI practices in the manufacturing industry, or by asking employees to explore how external ideas and collaborations have affected their firm's culture.

In summary, the future studies should address:

RQ1: How can the knowledge transfer processes between a team and partners improve NPD performance, using inbound and outbound open innovation activities as mediators?

RQ2: How can digital trust moderate the relationship between open innovation and NPD performance?

RQ3: How can the new required managerial skills (e.g. complex problem solving, critical thinking, and people management) influence collaboration across the whole supply chain?

RQ4: What is the role of HR management in creating the open innovation strategy in manufacturing?

5.3 Industry 4.0

Industry 4.0 has been considered a trending topic for academics and practitioners (Marzi et al., 2017). It represents the fourth industrial revolution and will affect various industries: manufacturing, finance, the food industry, the cleaning industry, and many others. For the successful adoption of Industry 4.0, it is very important for firms to implement vertical and horizontal integration. The connections between OI and Industry 4.0 lie in innovation and collaboration between all partners in the production process.

The fourth industrial revolution has changed manufacturing firms' business models and this can influence performance in the long run. Firstly, companies need to invest in new technologies and make substantial efforts when reorganizing their business. In the long run, they could increase their profit, reduce costs, and position themselves as a market leader. Although companies need to collaborate with external parties in order to optimize their capabilities, they also need to be careful and protect their most valuable resources.

5.3.1 NPD performance

Researchers are encouraged to investigate the role of advanced manufacturing technologies - for example, additive manufacturing - with specific focus on the ways in which these technologies could be implemented in digitalized manufacturing systems. Additive manufacturing plays an important role in industries such as aerospace, aircraft, the biomedical industry, and the pharmaceutical industry. It would be useful to explore how the implementation of additive manufacturing might boost outbound OI activities and improve NPD performance.

5.3.2 Intellectual property

The fourth industrial revolution has changed the way in which we protect innovations. In line with Industry 4.0, the focus is on the protection of intangible things, such as data and virtual systems. Companies open themselves up to risk when increasing their degree of openness and sharing their knowledge and technology with others. However, it can be useful for a firm to collaborate with their competitors, customers, or suppliers. There is a thin line between openness and protection and, as such, every business should create their own IP strategy according to their business models. In summary, the following RQs for future research are suggested:

RQ1: How can the implementation of additive manufacturing encourage outbound open innovation activities and, consequently, improve NPD performance?

RQ2: How can Industry 4.0 solutions open up new potential for collaboration in the pharmaceutical industry?

RQ3: How does open innovation mediate the relationship between digital revolution and intellectual property rights?

RQ4: What kind of digital patents are the most beneficial when protecting digital business models in the manufacturing industry?

6 Conclusions

In this increasingly dynamic business environment, it is important for manufacturing firms to open up their boundaries and exchange technology and knowledge with other external partners. Therefore, the OI paradigm is suitable for both researchers and practitioners as it offers a way by which innovation can be thought of as an open system that affects every continent and every industry.

6.1 Practical and social contributions

There are many companies that switched their closed business models and started to cooperate with other stakeholders, accomplishing results such as: new products, better performance, or more sustainable business (P&G, GE, Samsung, Lego, NASA). In this vein, researchers are encouraged to collaborate with practitioners to explore, for example, how top managers adopt OI practices (Yuan et al., 2009), and how they can buffer "not invented here" syndrome (van de Vrande, 2009). Additionally, managers and researchers from developed countries are encouraged to collaborate with developing countries, as there are indications that OI can boost frugal innovations (Hossain, 2013; Dandonoli, 2013). Hence, the collaboration between developed and developing companies could contribute to a more sustainable environment (Dandonoli, 2013). In short, empirical studies have noted that higher degrees of openness to external knowledge improves firms' performance in the manufacturing industry (Berchicci, 2013; Cruz-Gonzalez et al., 2015; Greco et al., 2018; Wang et al., 2012).

6.2 Theoretical implications

This systematic literature review extends former literature reviews such as those pertaining to OI in SMEs (Hossain and Kauranen, 2016; Torchia and Calabro, 2019), OI models (Lazzarotti et al., 2010), and negotiations in OI (Barchi and Greco, 2018), by examining OI in the manufacturing industry without any time constraints. This study sought to compile and categorize the application of OI in the manufacturing industry context by answering the following RQs:

RQ1: What are the underlying theoretical approaches, major research themes, geographical scopes, methodological approaches, and industries in open innovation in the manufacturing research field?

RQ2: What future research streams exist in open innovation research in a manufacturing context, in terms of theoretical and practical approaches?

With regards to the first research question (RQ1), the literature review synthesized five theories which best describe the OI paradigm in a manufacturing industry context. The most frequently used theories are the knowledge-based view, supply chain management, and the resource-based view, while transaction cost economics theory and the institutional theory are the least studied theories. The results show that resource-based and knowledge-based views are often studied together, along with topics such as open strategy, innovation, and collaboration.

With regards to the second research question (RQ2), future research guidelines were based on the outcome of the authors' in-depth study of reviewed papers, combined with the results of the HOMALS statistical approach. This paper highlighted the opportunity for the resource-based view to be studied as a theory that could influence manufacturing firms' sustainable strategies. Through the adjustment of their dynamic capabilities, manufacturing firms could accomplish more sustainable production. On the other hand, the knowledge-based view has been recognized as a potential way of studying the manufacturing industry's "soft side". During the COVID-19 pandemic, it is more important than ever to study managers' skills, teamwork, change management, and the ways in which knowledge transfer between team members and partners can influence OI activities and improve NPD performance.

The literature review confirms the diversity of the theoretical approaches and major research themes used to define the OI paradigm in the manufacturing industry. This review contributes to the creation of current and future knowledge by amplifying the methodology.

6.3 Limitations

The scope of OI is very wide and the manufacturing and service industries are very different, meaning that they should, therefore, be explored separately. We therefore suggest that other authors explore the adoption of OI in the service industry and look at, for example, how the implementation of OI in the service sector changes business models through knowledge exchange.

Only articles and reviews were selected for this analysis, while books and conference proceedings were left out. Furthermore, some of the most prolific languages were excluded, as only articles and reviews in English were applicable. These omissions could offer interesting avenues for future research.

To identify the current state and the future research directions of OI in the manufacturing industry, this paper used a hybrid review method: the outcome of the authors' in-depth analysis of the reviewed papers was combined with the results of the HOMALS statistical approach. Thus, future researchers are encouraged to study OI in the manufacturing industry from a different methodological perspective. Our results show that there are many papers using the quantitative approach when studying OI in the manufacturing industry. Therefore, further meta-analytical reviews studying the connections between variables in OI in the manufacturing industry will be valuable.

Acknowledgment

This research has received funding from the Horizon 2020 Programme of the European Union within the OpenInnoTrain project under grant agreement no. 823971. The content of this publication does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the publication lies entirely with the author(s).

References

Ahuja, G., 2000. The duality of collaboration: inducements and opportunities in the formation of interfirm linkages. Strat. Manag. J. 21 (3), 317–343.
Alassaf, D., Dabí c, M., Shifrer, D., Daim, T., 2020. The impact of open-border organization culture and employees' knowledge, attitudes, and rewards with regards to open innovation: an empirical study. J. Knowl. Manag. 24 (9), 2273–2297. https://doi.org/10.1108/JKM-02-2020-0122.
Andries, P., Faems, D., 2013. Patenting activities and firm performance: does firm size matter? J. Prod. Innovat. Manag. 30 (6), 1089–1098.
Arcese, G., Flammini, S., Lucchetti, M.C., Martucci, O., 2014. Open sustainability innovation in the food sector. World Sustainability Forum 2014-Conference Proceedings Paper 7, 8067–8090.
Audretsch, D.B., Belitski, M., 2019. The limits to collaboration across four of the most innovative UK industries. Br. J. Manag. https://doi.org/10.1111/1467-8551.12353. Available online ahead of print.
Bae, Y., Chang, H., 2012. Efficiency and effectiveness between open and closed innovation: empirical evidence in South Korean manufacturers. Technol. Anal. Strat. Manag. 24 (10), 967–980.
Bahemia, H., Squire, B., Cousins, P., 2017. A multi-dimensional approach for managing open innovation in NPD. Int. J. Oper. Prod. Manag. 37 (10), 1366–1385.
Barchi, M., Greco, M., 2018. Negotiation in open innovation: a literature review. Group Decis. Negot. 27 (3), 343–374.
Barge-Gil, A., 2010. Open, semi-open and closed innovators: towards an explanation of degree of openness. Ind. Innovat. 17 (6), 577–607.
Barge-Gil, A., 2013. Open strategies and innovation performance. Ind. Innovat. 20 (7), 585–610.
Barham, H., Dabic, M., Daim, T., Shifrer, D., 2020. The role of management support for the implementation of open innovation practices in firms. Technol. Soc. 63, 101282.
Belderbos, R., Cassiman, B., Faems, D., Leten, B., Van Looy, B., 2014. Co-ownership of intellectual property: exploring the value-appropriation and value-creation implications of co-patenting with different partners. Res. Pol. 43 (5), 841–852.
Berchicci, L., 2013. Towards an open R&D system: internal R&D investment, external knowledge acquisition and innovative performance. Res. Pol. 42 (1), 117–127.
Bianchi, M., Lejarraga, J., 2016. Learning to license technology: the role of experience and workforce's skills in Spanish manufacturing firms. R D Manag. 46, 691–705.
Bianchi, M., Croce, A., Dell'Era, C., Di Benedetto, C.A., Frattini, F., 2016. Organizing for inbound open innovation: how external consultants and a dedicated R&D unit influence product innovation performance. J. Prod. Innovat. Manag. 33 (4), 492–510.
Bianchi, M., Frattini, F., Lejarraga, J., Di Minin, A., 2014. Technology exploitation paths: combining technological and complementary resources in new product development and licensing. J. Prod. Innovat. Manag. 31, 146–169.

Bieringer, T., Buchholz, S., Kockmann, N., 2013. Future production concepts in the chemical industry: modular-small-scale-continuous. Chem. Eng. Technol. 36 (6), 900–910.
Bogers, M., Lhuillery, S., 2011. A functional perspective on learning and innovation: investigating the organization of absorptive capacity. Ind. Innovat. 18 (6), 581–610.
Bogers, M., Zobel, A.K., Afuah, A., Almirall, E., Brunswicker, S., Dahlander, L., Frederiksen, L., Gawer, A., Gruber, M., Haefliger, S., Hagedoorn, J., Hilgers, D., Laursen, K., Magnusson, M.G., Majchrzak, A., McCarthy, I.P., Moeslein, K.M., Nambisan, S., Piller, F.T., Radziwon, A., Rossi-Lamastra, C., Sims, J., Ter Wal, A.L.J., 2017. The open innovation research landscape: established perspectives and emerging themes across different levels of analysis. Ind. Innovat. 24 (1), 8–40.
Bonfanti, A., Del Giudice, M., Papa, A., 2018. Italian craft firms between digital manufacturing, open innovation, and servitization. Journal of the Knowledge Economy 9 (1), 136–149.
Brem, A., Nylund, P.A., Hitchen, E.L., 2017. Open Innovation and Intellectual Property Rights: how do SMEs benefit from patents, industrial designs, trademarks and copyrights? Manag. Decis. 55 (6), 1285–1306.
Brockbank, W., 1999. If HR were really strategically proactive: present and future directions in HR's contribution to competitive advantage. Hum. Resour. Manag. 38 (4), 337–352.
Burcharth, A., Præst Knudsen, M., Søndergaard, H.A., 2017. The role of employee autonomy for open innovation performance. Bus. Process Manag. J. 23 (6), 1245–1269.
Burmeister, C., Luettgens, D., Piller, F.T., 2016. Business model innovation for industrie 4.0: why the 'industrial internet' mandates a new perspective on innovation. Swiss Journal of Business Research and Practice 70 (2), 124–152.
Cammarano, A., Caputo, M., Lamberti, E., Michelino, F., 2017. Open innovation and intellectual property: a knowledge-based approach. Manag. Decis. 55 (6), 1182–1208.
Capatina, A., Bleoju, G., Yamazaki, K., Nistor, R., 2016. Cross-cultural strategic intelligence solutions for leveraging open innovation opportunities. Journal of Intelligence Studies in Business 6 (3), 27–38.
Cappa, F., Del Sette, F., Hayes, D., Rosso, F., 2016. How to deliver open sustainable innovation: an integrated approach for a sustainable marketable product. Sustainability 8 (12), 1341.
Carter, C.R., Rogers, D.S., 2008. A framework of sustainable supply chain management: moving toward new theory. Int. J. Phys. Distrib. Logist. Manag. 38 (5), 360–387.
Ceylan, C., 2013. Commitment-based HR practices, different types of innovation activities and firm innovation performance. Int. J. Hum. Resour. Manag. 24 (1), 208–226.
Cheah, S.L.Y., Ho, Y.P., 2020. Effective industrial policy implementation for open innovation: the role of government resources and capabilities. Technological Forecasting and Social Change. Available at: https://doi.org/10.1016/j.techfore.201 9.119845, 151.
Chesbrough, H., 2006. Open innovation: a new paradigm for understanding industrial innovation. In: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.), Open Innovation: Researching a New Paradigm. Oxford University Press, Oxford, pp. 1–12.
Chesbrough, H., Bogers, M., 2014. Explicating Open Innovation: clarifying an emerging paradigm for understanding innovation. In: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.), New Frontiers In Open Innovation. Oxford University Press, Oxford, pp. 3–28.
Chesbrough, H.W., 2003. Open Innovation: the New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Boston, MA.
Chesbrough, H.W., Vanhaverbeke, W., 2018. Open Innovation and Public Policy in the EU with Implications for SMEs. World Scientific Book Chapters, pp. 455–492.
Choi, S., Park, K., Shim, S.O., 2019. The optimal emission decisions of sustainable production with innovative baseline credit regulations. Sustainability 11 (6), 1635.

Chu, P.Y., Chen, W.C., 2011. Open business models: a case study of system-on-a-chip (soc) design foundry in the integrated circuit (IC) industry. Afr. J. Bus. Manag. 5 (21), 8536–8544.
Ciravegna, L., Romano, P., Pilkington, A., 2013. Outsourcing practices in automotive supply networks: an exploratory study of full-service vehicle suppliers. Int. J. Prod. Res. 51 (8), 2478–2490.
Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation. Adm. Sci. Q. 35 (1), 128–152.
Cooper, S., 2017. Rethink manufacturing, KPMG. Designing a UK Industrial Strategy for the Age of Industry 4.0. Available at: https://assets.kpmg/content/dam/kpmg/uk /pdf/2017/04/rethink-manufacturing-a-uk-industrial-strategy-for-industry-4-final-r eport-2.pdf. (Accessed 2 February 2020).
Corney, J.R., Torres-Sánchez, C., Jagadeesan, A.P., Regli, W.C., 2009. Outsourcing labour to the cloud. Int. J. Innovat. Sustain. Dev. 4 (4), 294–313.
Costa, A.I.A., Greco, M., Grimaldi, M., Cricelli, L., Corvello, V., 2016. Inter-organisational innovation processes in the European food and drink industry. Int. J. Manag. Enterprise Dev. 15 (2/3), 191–208.
Crema, M., Verbano, C., Venturini, K., 2014. Linking strategy with open innovation and performance in SMEs. Measuring Business Excellence 18 (2), 14–27.
Crupi, A., Del Sarto, N., Di Minin, A., Gregori, G.L., Lepore, D., Marinelli, L., Spigarelli, F., 2020. The digital transformation of SMEs – a new knowledge broker called the digital innovation hub. J. Knowl. Manag. 24 (6), 1263–1288.
Cruz-Cázares, C., Bayona-Sáez, C., García-Marco, T., 2013. Make, buy or both? R&D strategy selection. J. Eng. Technol. Manag. 30 (3), 227–245.
Cruz-Cázares, C., Bayona-Sáez, C., García-Marco, T., Berends, H., Smits, A., Reymen, I., 2018. Public funds and internal innovation goals as drivers of formal and informal open innovation practices: a European regional comparison. Management Research 16 (2), 159–178.
Cruz-González, J., López-Sáez, P., Navas-Lo ́pez, J.E., Delgado-Verde, M., 2015. Open search strategies and firm performance: the different moderating role of technological environmental dynamism. Technovation 35, 32–45.
Dabić, M., González-Loureiro, M., Furrer, O., 2014. Research on the strategy of multinational enterprises: key approaches and new avenues. Business Research Quarterly 17, 129–148.
Dabić, M., Maley, J., Dana, L.P., Novak, I., Pellegrini, M.M., Caputo, A., 2019. Pathways of SME Internalization: a bibliometric and systematic review. Small Bus. Econ. 55, 705–725. https://link.springer.com/article/10.1007/s11187-019-00181-6.
Dabić, M., Vlačić, B., Paul, J., Dana, L.-P., Sahasranamam, S., Glinka, B., 2020. Immigrant entrepreneurship: a review and research agenda. J. Bus. Res. 113, 25–38.
Dahiyat, S.E., 2015. An integrated model of knowledge acquisition and innovation: examining the mediation effects of knowledge integration and knowledge application. Int. J. Learn. Change 8 (2), 101–135.
Dandonoli, P., 2013. Open innovation as a new paradigm for global collaborations in health. Glob. Health 9 (1), 41.
Davis, J.R., Richard, E.E., Keeton, K.E., 2015. Open innovation at NASA: a new business model for advancing human health and performance innovations. Res. Technol. Manag. 5 (3), 52–58.
Dodgson, M., Gann, D., Salter, A., 2006. The role of technology in the shift towards open innovation: the case of Procter & Gamble. R D Manag. 36 (3), 333–346.
Eftekhari, N., Bogers, M., 2015. Open for entrepreneurship: how open innovation can foster new venture creation. Creativ. Innovat. Manag. 24 (4), 574–584.
Fajsi, A., Tekic, Z., Moroca, S., 2016. Open innovation in manufacturing SMEs – integration into value networks. In: Katalinic, B. (Ed.), Proceedings of the 26th DAAAM

International Symposium. Published by DAAAM International, Vienna, Austria, ISBN 978-3-902734-07-5, pp. 1076–1081. ISSN 1726-9679.
Fernandez, V., Puel, G., Renaud, C., 2016. The open innovation paradigm: from outsourcing to open-sourcing in shenzhen, China. International Review for Spatial Planning and Sustainable Development 4 (4), 27–41.
Fleischmann, K., Hielscher, S., Merritt, T., 2016. Making things in Fab Labs: a case study on sustainability and co-creation. Digit. Creativ. 27 (2), 113–131.
Foege, J.N., Piening, E.P., Salge, T.O., 2017. Don't get caught on the wrong foot: a resource-based perspective on imitation threats in innovation partnerships. Int. J. Innovat. Manag. 21, 3.
Fu, X., Li, J., Xiong, H., Chesbrough, H., 2014. Open innovation as a response to constraints and risks: evidence from China. Asian Econ. Pap. 13 (3), 30–58.
Furrer, O., Kerguignas, J.Y., Delcourt, C., Gremler, D.D., 2020. Twenty-seven years of service research: a literature review and research agenda. J. Serv. Market. 34 (3), 299–316.
Furrer, O., Thomas, H., Goussevskaia, A., 2008. The structure and evolution of the strategic management field: a content analysis of 26 years of strategic management research. Int. J. Manag. Rev. 10 (1), 1–23.
Gama, F., 2018. Managing collaborative ideation: the role of formal and informal appropriability mechanisms. Int. Enterpren. Manag. J. 15 (1), 97–118.
Gambardella, A., Panico, C., 2014. On the management of open innovation. Res. Pol. 43 (5), 903–913.
Gassmann, O., 2006. Opening up the innovation process: towards an agenda. R D Manag. 36 (3), 223–228.
Gassmann, O., Enkel, E., 2004. Towards a theory of open innovation: three core process archetypes. In: Proceedings of the R&D Management Conference, Lisbon, Portugal, July 6–9.
Gassmann, O., Enkel, E., Chesbrough, H., 2010. The future of open innovation. R D Manag. 40 (3), 213–221.
Ghisetti, C., Marzucchi, A., Montresor, S., 2015. The open eco-innovation mode. An empirical investigation of eleven European countries. Res. Pol. 44 (5), 1080–1093.
Ghobakhloo, M., Fathi, M., 2019. Corporate survival in Industry 4.0 era: the enabling role of lean-digitized manufacturing. J. Manuf. Technol. Manag. 31 (1), 1–30.
Gomez, J., Salazar, I., Vargas, P., 2016. Sources of information as determinants of product and process innovation. PloS One 11, 4.
Gonzalez-Loureiro, ´ M., Dabi´c, M., Furrer, O., 2014. A content and comparative analysis of strategic management research in the Baltic area, A research agenda for qualitative studies. Baltic J. Manag. 10 (2), 243–266.
Graneheim, U.H., Lundman, B., 2004. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. Nurse Educ. Today 24 (2), 105–112.
Greco, M., Grimaldi, M., Cricelli, L., 2017. Hitting the nail on the head: exploring the relationship between public subsidies and open innovation efficiency. Technol. Forecast. Soc. Change 118, 213–225.
Greco, M., Grimaldi, M., Cricelli, L., 2018. Benefits and costs of open innovation: the BeCO framework. Technol. Anal. Strat. Manag. 31 (3), 1–14.
Grimaldi, M., Quinto, I., Rippa, P., 2013. Enabling open innovation in small and medium enterprises: a dynamic capabilities approach. Knowl. Process Manag. 20 (4), 199–210.
Guo, B., Li, Q., Chen, Xl, 2016. Diversity of technology acquisition in technological catchup: an industry-level analysis of Chinese manufacturing. Technol. Anal. Strat. Manag. 28 (7), 755–767.

Guo, Y., Zheng, G., 2019. How do firms upgrade capabilities for systemic catch-up in the open innovation context? A multiple-case study of three leading home appliance companies in China. Technol. Forecast. Soc. Change 144, 36–48.
Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., 2010. Multivariate Data Analysis: A Global Perspective, seventh ed. Pearson, Upper Saddle River.
Hair Jr., J.F., Anderson, R.E., Tatham, R.L., Black, W.C., 1998. Multivariate Data Analysis, fifth ed. Prentice Hall, Upper Saddle River, NJ.
Hoffman, D.L., De Leeuw, J., 1992. Interpreting multiple correspondence analysis as a multidimensional scaling method. Market. Lett. 3 (3), 259–272.
Homfeldt, F., Rese, A., Simon, F., 2019. Suppliers versus start-ups: where do better innovation ideas come from? Res. Pol. 48 (7), 1738–1757.
Hong, J.F.L., Zhao, X., Snell, R.S., 2019. Collaborative-based HRM practices and open innovation: a conceptual review. Int. J. Hum. Resour. Manag. 30 (1), 31–62.
Hossain, M., 2013. Adopting open innovation to stimulate frugal innovation and reverse innovation. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.2197782. Available at:
Hossain, M., Kauranen, I., 2016. Open innovation in SMEs: a systematic literature review. Journal of Strategy and Management 9 (1), 58–73.
Huang, H.C., Lai, M.C., Lin, L.H., Chen, C.T., 2013. Overcoming organizational inertia to strengthen business model innovation an open innovation perspective. J. Organ. Change Manag. 26 (6), 977–1002.
Huang, S.F., Chen, J., Liang, L., 2018. How open innovation performance responds to partner heterogeneity in China. Manag. Decis. 56 (1), 26–46.
Hung, K.P., Chou, C., 2013. The impact of open innovation on firm performance: the moderating effects of internal R&D and environmental turbulence. Technovation 33 (10–11), 368–380.
Jang, H., Lee, K., Yoon, B., 2017. Development of an open innovation model for R&D collaboration between large firms and small-medium enterprises (SMEs) in manufacturing industries. Int. J. Innovat. Manag. 21, 1.
Jimenez-Jimenez, D., Martinez-Costa, M., Sanchez Rodriguez, C., 2019. The mediating role of supply chain collaboration on the relationship between information technology and innovation. J. Knowl. Manag. 23 (3), 548–567.
Jin, Y.R., Ji, S.F., 2018. Mapping hotspots and emerging trends of business model innovation under networking in internet of things. EURASIP J. Wirel. Commun. Netw. 96. https://doi.org/10.1186/s13638-018-1115-4. Available at:
Jung, K., Andrew, S., 2014. Building R&D collaboration between university-research institutes and small medium-sized enterprises. Int. J. Soc. Econ. 41 (12), 1174–1193.
Kashan, A.J., Mohannak, K., Perano, M., Casali, G.I., 2018. A discovery of multiple levels of open innovation in understanding the economic sustainability. A case study in the manufacturing industry. Sustainability 10 (12), 4652.
Kastelli, I., Tsakanikas, A., Caloghirou, Y., 2018. Technology transfer as a mechanism for dynamic transformation in the food sector. J. Technol. Tran. 43 (4), 882–900.
Kazuyuki, M., 2016. Innovation and entrepreneurship: a first look at the linkage data of Japanese patent and enterprise census. Seoul J. Econ. 29 (1), 69–94.
Kiessling, T., Vlačić, B., Dabić, M., 2019. Mapping the future of cross-border mergers and acquisitions: a review and research agenda. IEEE Trans. Eng. Manag. https://doi.org/10.1109/TEM.2019.2954799. Available online ahead of print.
Kim, H., Kim, E., 2018. How an open innovation strategy for commercialization affects the firm performance of Korean healthcare IT SMEs. Sustainability 10, 7.
Kim, S., Kim, H., Kim, E., 2016. How knowledge flow affects Korean ICT manufacturing firm performance: a focus on open innovation strategy. Technol. Anal. Strat. Manag. 28 (10), 1167–1181.

Kobarg, S., Stumpf-Wollersheim, J., Welpe, I.M., 2019. More is not always better: effects of collaboration breadth and depth on radical and incremental innovation performance at the project level. Res. Pol. 48 (1), 1–10.
Kortmann, S., Piller, F., 2016. Open business models and closed-loop value chains: redefining the firm-consumer relationship. Calif. Manag. Rev. 58 (3), 88–108.
Kovács, A., Van Looy, B., Cassiman, B., 2015. Exploring the scope of open innovation: a bibliometric review of a decade of research. Scientometrics 104, 951–983.
Kratzer, J., Meissner, D., Roud, V., 2017. Open innovation and company culture: internal openness makes the difference. Technol. Forecast. Soc. Change 119, 128–138.
Lakemond, N., Bengtsson, L., Laursen, K., Tell, F., 2016. Match and manage: the use of knowledge matching and project management to integrate knowledge in collaborative inbound open innovation. Ind. Corp. Change 25 (2), 333–352.
Lardo, A., Mancini, D., Paoloni, N., Russo, G., 2020. The Perspective of Capability Providers in Creating a Sustainable I4.0 Environment. Management Decision. https://doi.org/10.1108/MD-09-2019-1333. Available online ahead of print.
Lattorre-Navarro, M.F., Guest, D., Ramos, J., Gracia, F.J., 2016. High commitment HR practices, the employment relationship and job performance: a test of a mediation model. Eur. Manag. J. 34 (4), 328–337.
Laursen, K., Salter, A., 2006. Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. Strat. Manag. J. 37, 131–150.
Lazzarotti, V., Manzini, R., Pellegrini, L., 2010. Open innovation models adopted in practice: an extensive study in Italy. Measuring Business Excellence 14 (4), 11–23.
Leber, M., Ivanišević A., Borocki J., Radišíc M., Ślusarczyk B., 2018. Fostering alliances with customers for the sustainable product creation. Sustainability 10, 9.
Lee, S., Park, G., Yoon, B., Park, J., 2010. Open innovation in SMEs - an intermediated network model. Res. Pol. 39 (2), 290–300.
Lee, Y.G., 2012. Strengthening competency linkage to innovation at Korean universities. Scientometrics 90 (1), 219–230.
Lerro, A., Schiuma, G., Elia, G., Passiante, G., 2016. Dimensions and practices of the collaborative relationships between cultural and creative organisations and business. Int. J. Manag. Enterprise Dev. 15, 209–229, 43526.
Lichtenthaler, U., 2008. Open innovation in practice: an analysis of strategic approaches to technology transactions. IEEE Trans. Eng. Manag. 55 (1), 148–157.
Lichtenthaler, U., 2011. Open innovation: past research, current debates, and future directions. Journal of Management Perspectives 25 (1), 75–93.
Lichtenthaler, U., 2013. The collaboration of innovation intermediaries and manufacturing firms in the markets for technology. J. Prod. Innovat. Manag. 30, 142–158.
Linder, C., 2019. Customer orientation and operations: the role of manufacturing capabilities in small- and medium-sized enterprises. Int. J. Prod. Econ. 216, 105–117.
Lopes, C.M., Scavarda, A., Hofmeister, L.F., Thome, A.M.T., Vaccaro, G.L.R., 2017. An analysis of the interplay between organizational sustainability, knowledge management, and open innovation. J. Clean. Prod. 142, 476–488.
López-Duarte, C., González-Loureiro, M., Vidal-Suárez, M.M., González-Díaz, B., 2016. International strategic alliances and national culture: mapping the field and developing a research agenda. J. World Bus. 51 (4), 511–524.
Loukis, E., Kyriakou, N., Pazalos, K., Popa, S., 2017. Inter-organizational innovation and cloud computing. Electron. Commer. Res. 17 (3), 379–401.
Love, J.H., Roper, S., Vahter, P., 2014. Learning from openness: the dynamics of breadth in external innovation linkages. Strat. Manag. J. 35 (11), 1703–1716.
Markovic, S., Bagherzadehb, M., Dubielc, A., Chengd, J., Vanhaverbekee, W., 2020. Do not miss the boat to outside-in open innovation: enable your employees. Ind. Market. Manag. 91, 152–161.

Martín-de Castro, G., 2015. Knowledge management and innovation in knowledge-based and high-tech industrial markets: the role of openness and absorptive capacity. Ind. Market. Manag. 47, 143–146.
Marzi, G., Dabić, M., Daim, T., 2017. Product and process innovation in manufacturing firms: a 30-year bibliometric analysis. Scientometrics 113, 673–704.
McClean, E., Collins, C.J., 2011. High-commitment HR practices, employee effort, and firm performance: investigating the effects of HR practices across employee groups within professional services firms. Hum. Resour. Manag. 50 (3), 341–363.
Miglietta, N., Battisti, E., Campanella, F., 2017. Value maximization and open innovation in food and beverage industry: evidence from us market. Br. Food J. 119 (11), 2477–2492.
Mina, A., Bascavusoglu-Moreau, E., Hughes, A., 2014. Open service innovation and the firm's search for external knowledge. Res. Pol. 43 (5), 853–866.
Mitchell, W., Singh, K., 1996. Survival of businesses using collaborative relationships to commercialize complex goods. Strat. Manag. J. 17 (3), 169–195.
Mubarak, M.F., Petraite, M., 2020. Industry 4.0 technologies, digital trust and technological orientation: what matters in open innovation? Technol. Forecast. Soc. Change 161, 120332.
Mustaquim, M.M., Nystrom, ¨ T., 2014. Open sustainability innovation—a pragmatic standpoint of sustainable HCI. In: Johansson, B., Andersson, B., Holmberg, N. (Eds.), Perspectives in Business Informatics Research. LNBIP, 194. Springer International Publishing, pp. 101–112. https://doi.org/10.1007/978-3-319-11370-8_8. Available at:
Natalicchio, A., Petruzzelli, A.M., Cardinali, S., Savino, T., 2018. Open innovation and the human resource dimension: an investigation into the Italian manufacturing sector. Manag. Decis. 56 (6), 1271–1284.
Nellippallil, A.B., Ming, Z., Allen, J.K., Mistree, F., 2019. Cloud-based materials and product realization—fostering ICME via industry 4.0. Integrating Materials and Manufacturing Innovation 8 (2), 107–121.
Ozdemir, S., Kandemir, D., Eng, T.Y., 2017. The role of horizontal and vertical new product alliances in responsive and proactive market orientations and performance of industrial manufacturing firms. Ind. Market. Manag. 64, 25–35.
Parizi, M.S., Radziwon, A., 2017. Network-based automation for SMEs. Int. J. Bus. Glob. 18 (1), 58–72.
Park, E., Kwon, S.J., 2018. Effects of innovation types on firm performance: an empirical approach in South Korean manufacturing industry. Int. J. Bus. Innovat. Res. 15 (2), 215–230.
Paul, J., Rialp-Criado, A., 2020. The Art of Writing Literature review: what do we know and what do we need to know? Int. Bus. Rev. https://doi.org/10.1016/j.ibusrev.2020.101717. Available online ahead of print.
Pedrosa, A.D., Valling, M., Boyd, B., 2013. Knowledge related activities in open innovation: managers' characteristics and practices. Int. J. Technol. Manag. 61 (3–4), 254–273.
Popa, S., Soto-Acosta, P., Martinez-Conesa, I., 2017. Antecedents, moderators, and outcomes of innovation climate and open innovation: an empirical study in SMEs. Technol. Forecast. Soc. Change 118, 134–142.
Prause, G., 2015. Sustainable business models and structures for industry 4.0. Journal of Security and Sustainability 5 (2), 159–169.
Rayna, T., Striukova, L., 2019. Open social innovation dynamics and impact: exploratory study of a fab lab network. R D Manag. 49 (3), 383–395.
Remneland-Wikhamn, B., Knights, D., 2012. Transaction cost economics and open innovation: implications for theory and practice. Creativ. Innovat. Manag. 21 (3), 277–289.

Ren, S.C., Su, P.R., 2015. Open innovation and intellectual property strategy: the catchup processes of two Chinese pharmaceutical firms. Technol. Anal. Strat. Manag. 27 (10), 1159–1175.

Rice, J., Liao, T.S., Martin, N., Galvin, P., 2012. The role of strategic alliances in complementing firm capabilities. J. Manag. Organ. 18 (6), 858–869.

Rocha, C.F., Mamédio, D.F., Quandt, C.O., 2019. Startups and the innovation ecosystem in Industry 4.0. Technol. Anal. Strat. Manag. 31 (4), 1–14.

Rosell, D.T., Lakemond, N., Melander, L., 2017. Integrating supplier knowledge in new product development projects: decoupled and coupled approaches. J. Knowl. Manag. 21 (5), 1035–1052.

Salvatore, P., Massari, C., Marino, V., Fulea, M., Brad, S., 2012. Supporting technology innovation processes in manufacturing small and medium enterprises. Quality - Access to Success 13 (Suppl. 5), 421–426.

Santamaria, L., Nieto, M.J., Barge-Gil, A., 2010. The relevance of different open innovation strategies for R&D performers. Cuadernos de Economía y Dirección de la Empresa 13 (45), 93–114.

Santoro, G., Vrontis, D., Pastore, A., 2017. External knowledge sourcing and new product development evidence from the Italian food and beverage industry. Br. Food J. 119 (11), 2373–2387.

Schuster, G., Brem, A., 2015. How to benefit from open innovation? An empirical investigation of open innovation, external partnerships and firm capabilities in the automotive industry. Int. J. Technol. Manag. 69 (1), 54–76.

Shim, S.O., Park, K., 2016. Technology for production scheduling of jobs for open innovation and sustainability with fixed processing property on parallel machines. Sustainability 8 (9), 904.

Shim, S.O., Park, K., Choi, S., 2017. Innovative production scheduling with customer satisfaction based measurement for the sustainability of manufacturing firms. Sustainability 9 (12), 2249.

Shim, S.O., Park, K., Choi, S., 2018. Sustainable production scheduling in open innovation perspective under the fourth industrial revolution. Journal of Open Innovation: Technology, Market, and Complexity 4 (4), 42.

Silva, M.J., Leitao, J., Raposo, M., 2008. Barriers to innovation faced by manufacturing firms in Portugal: how to overcome it for fostering business excellence? Int. J. Bus. Excel. 1 (1/2), 92.

Simiyu, K., Masum, H., Chakma, J., Singer, P.A., 2010. Turning science into health solutions: KEMRI's challenges as Kenya's health product pathfinder. BMC Int. Health Hum. Right 10 (Suppl. 1), S10.

Smart, P., Holmes, S., Lettice, F., Pitts, F.H., Zwiegelaar, J.B., Schwartz, G., Evans, S., 2019. Open Science and Open Innovation in a socio-political context: knowledge production for societal impact in an age of post-truth populism. R D Manag. 49 (3), 279–297.

Snyder, H., 2019. Literature review as a research methodology: an overview and guidelines. J. Bus. Res. 104, 333–339.

Spithoven, A., Frantzen, D., Clarysse, B., 2010. Heterogeneous firm-level effects of knowledge exchanges on product innovation: differences between dynamic and lagging product innovators. J. Prod. Innovat. Manag. 27 (3), 362–381. Stefan, I., Bengtsson, L., 2016. Appropriability: a key to opening innovation internationally? Int. J. Technol. Manag. 71 (3–4), 232–252.

Stefan, I., Bengtsson, L., 2017. Unravelling appropriability mechanisms and openness depth effects on firm performance across stages in the innovation process. Technol. Forecast. Soc. Change 120, 252–260.

Su, C.Y., Lin, B.W., Chen, C.J., 2016. Knowledge co-creation across national boundaries: trends and firms' strategies. Knowl. Manag. Res. Pract. 14 (4), 457–469.

Teece, D., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strat. Manag. J. 18 (7), 509–533.

Tenenhaus, M., Young, F.W., 1985. An analysis and synthesis of multiple correspondence analysis, optimal scaling, dual scaling, homogeneity analysis and other methods for quantifying categorical multivariate data. Psychometrika 50 (1), 91–119.

Teng, C.W., Oneill, P., Foley, L., 2014. Innovative manufacturing in Australias emerging regenerative medicine industry: centralised factories to decentralised facilities. Int. J. Prod. Res. 52 (21), 6538–6556.

Tether, B.S., Tajar, A., 2008. Beyond industry-university links: sourcing knowledge for innovation from consultants, private research organisations and the public sciencebase. Res. Pol. 37 (6–7), 1079–1095. The Intergovernmental Panel on Climate Change, 2020. Report on Climate Change and Land. Available at: https://www.ipcc.ch/srccl/. (Accessed 28 October 2020).

Theyel, N., 2013. Extending open innovation throughout the value chain by small and medium-sized manufacturers. Int. Small Bus. J. 31 (3), 256–274.

Thornton, S.C., Henneberg, S.C., Leischnig, A., Naud´e, P., 2019. It's in the mix: how firms configure resource mobilization for new product success. J. Prod. Innovat. Manag. 36 (4), 513–531.

Tipu, S.A.A., 2012. Open innovation process in developing-country manufacturing organisations: extending the stage-gate model. Int. J. Bus. Innovat. Res. 6 (3), 355–378.

Torchia, M.A., Calabro, A., 2019. Open innovation in SMEs: a systematic literature review. J. Enterprising Cult. 27 (2), 201–228.

Tranfield, D., Denyer, D., Smart, P., 2003. Towards a methodology for developing evidence-informed management knowledge by means of systematic review. Br. J. Manag. 14 (3), 207–222.

Trantopoulos, K., Von Krogh, G., Wallin, M.W., Woerter, M., 2017. External knowledge and information technology: implications for process innovation performance. MIS Q. 41 (1), 287–300.

Triguero, A., Córcoles, D., Fernández, S., 2019. Influence of Open Innovation Strategies on Employment Dynamics: Evidence for Spanish Manufacturing Firms. Economics of Innovation and New Technology. https://doi.org/10.1080/10438599.2019.1703754. Available online ahead of print.

Triguero, A., Fernandez, S., 2018. Determining the effects of open innovation: the role of knowledge and geographical spillovers. Reg. Stud. 52 (5), 632–644.

Triguero, A., Fernández, S., Sáez-Martinez, F.J., 2018. Inbound open innovative strategies and eco-innovation in the Spanish food and beverage industry. Sustainable Production and Consumption 15, 49–64. UN General Assembly, 21 October 2015. Transforming Our World: the 2030 Agenda for Sustainable Development. A/RES/70/1. Available at: https://www.refworld.org/docid/57b6e3e44.html. (Accessed 16 July 2020).

Vahter, P., Love, J.H., Roper, S., 2014. Openness and innovation performance: are small firms different? Ind. Innovat. 21 (7–8), 553–573.

van Blokland, W.B., Fiksinski, M.A., Amoa, S.O.B., Santema, S.C., van Silfhout, G.J., Maaskant, L., 2012. Measuring value-leverage in aerospace supply chains. Int. J. Oper. Prod. Manag. 32 (8), 982–1007.

van de Vrande, V., de Jong, J.P.J., Vanhaverbeke, W., de Rochemont, M., 2009. Open innovation in SMEs: trends, motives and management challenges. Technovation 29 (6–7), 423–437.

Vanhaverbeke, W., 2006. The inter-organizational context of open innovation. In: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.), Open Innovation: Researching a New Paradigm. Oxford University Press, Oxford, pp. 205–219.

Verbano, C., Crema, M., Venturini, K., 2015. The identification and characterization of open innovation profiles in Italian small and medium-sized enterprises. J. Small Bus. Manag. 53 (4), 1052–1075.
Vorkapić, M., Radovanović, F., Ćoćkalo, D., Đorđević, D., 2017. NPD in small manufacturing enterprises in Serbia. Teh. Vjesn. 24 (1), 327–332.
Wan, X., Hao, T., Rong, X., Meng, Q., 2017. The robust analysis of supply chain based on uncertainty computation: insight from open innovation. Cluster Comput. 22, 5. https://doi.org/10.1007/s10586-017-1043-9. Available at:
Wang, H.J., Islam, S.M.N., 2017. Construction of an open innovation network and its mechanism design for manufacturing enterprises: a resource-based perspective. Front. Bus. Res. China 11, 1. https://doi.org/10.1186/s11782-017-0006-6. Available at:
Wang, Q., Zeng, G., 2020. Spatial organization of innovation in the oil equipment manufacturing industry: case of Dongying, China. Chin. Geogr. Sci. 30 (2), 324–339.
Wang, X., 2018. The effect of inbound open innovation on firm performance in Japanese manufacturing firms: comparative study between research centre and business unit. Int. J. Innovat. Manag. 22 (7), 1850054.
Wang, Y., Roijakkers, N., Vanhaverbeke, W., Chen, J., 2012. How Chinese firms employ open innovation to strengthen their innovative performance. Int. J. Technol. Manag. 59 (3/4), 235–254.
Wernerfelt, B., 1984. A resource-based view of the firm. Strat. Manag. J. 5, 171–180.
West, J., Bogers, M., 2014. Leveraging external sources of innovation: a review of research on open innovation. J. Prod. Innovat. Manag. 31, 4. https://doi.org/10.1111/jpim.12125. Available at:
West, J., Gallagher, S., 2006. Challenges of open innovation: the paradox of firm investment in open-source software. R D Manag. 36 (3), 319–331.
West, J., Vanhaverbeke, W., Chesbrough, H., 2005. Open innovation: a research agenda. To be published. In: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.), Open Innovation: Researching a New Paradigm. Oxford University Press, 2006.
Whelan, T., Kronthal-Sacco, R., 2019. Research: actually, consumers do buy sustainable products. Harv. Bus. Rev. Available at: https://hbr.org/2019/06/research-actually-consumers-do-buy-sustainable-products. (Accessed 2 November 2020).
Wimalachandra, D.C., Frank, B., Enkawa, T., 2014. Strategic openness in quality control: adjusting NPD strategic orientation to optimize product quality. The International Journal of Industrial Engineering: Theory, Applications and Practice 21 (6), 348–359. World Economic Forum, October 2020. The Future of Jobs Report. Available at: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf. (Accessed 1 November 2020).
Xia, T., 2013. Absorptive capacity and openness of small biopharmaceutical firms – a European Union-United States comparison. R D Manag. 43 (4), 333–351.
Xia, T.J., Roper, S., 2016. Unpacking open innovation: absorptive capacity, exploratory and exploitative openness, and the growth of entrepreneurial biopharmaceutical firms. J. Small Bus. Manag. 54 (3), 931–952.
Yang, C., Lan, S., Shen, W., Huang, G.Q., Wang, X., Lin, T., 2017. Towards product customization and personalization in IOT-enabled cloud manufacturing. Cluster Comput. 20 (2), 1717–1730.
Yap, X.S., Rasiah, R., 2017. Catching up and leapfrogging in a high-tech manufacturing industry: towards a firm-level taxonomy of knowledge accumulation. Knowl. Manag. Res. Pract. 15 (1), 114–129.
Yuan, B.J.C., Chiu, H.T.P., Kao, K.M., Lin, C.W., 2009. A new business model for the gift industry in Taiwan. Eur. Bus. Rev. 21 (5), 472–480.
Yun, J.J., Liu, Z., 2019. Micro- and macro-dynamics of open innovation with a quadruple-helix model. Sustainability 11 (12), 3301.

Yun, J.J., Zhao, X.F., Hahm, S.D., 2018. Harnessing the value of open innovation: change in the moderating role of absorptive capability. Knowl. Manag. Res. Pract. 16 (3), 305–314.
Yun, J.J., Yigitcanlar, T., 2017. Open innovation in value chain for sustainability of firms. Sustainability 9 (5), 811.
Zhang, S., Yang, D.L., Qiu, S.M., Bao, X., Li, J.Z., 2018. Open innovation and firm performance: evidence from the Chinese mechanical manufacturing industry. J. Eng. Technol. Manag. 48, 76–86.
Zhou, Q., Fang, G., Yang, W., Wu, Y., Ren, L.Q., 2017. The performance effect of microinnovation in SMEs: evidence from China. Chin. Manag. Stud. 11 (1), 123–138.
Zouaghi, F., Sanchez, M., Martinez, M.G., 2018. Did the global financial crisis impact firms' innovation performance? The role of internal and external knowledge capabilities in high and low tech industries. Technol. Forecast. Soc. Change 132, 92–104.
Zucker, L.G., 1987. Institutional theories of organization. Annu. Rev. Sociol. 13, 443–464.
Zupic, I., Čater, T., 2015. Bibliometric methods in management and organization. Organ. Res. Methods 18 (3), 429–472.

Appendix A. Supplementary data

The following is the Supplementary data to this article:

SUPPLEMENTARY MATERIAL

Note: Supplementary information for reviewers. Not necessarily to be included in a final version of the article

Table 2: Theoretical Approaches

Descriptor	Keywords
Institutional theory	Institution, institutional, institutional collective action framework, institutional distance, institutional environment, institutional factor, institutional theory, institutionalization, institutions
Knowledge-based view	Absorption of external knowledge, absorptive capacity, cross border knowledge, desorptive capacity, external knowledge, general knowledge, information, interactive learning, knowledge, knowledge acquisition, knowledge-based, knowledge-based economies, knowledge-based view of the firm, knowledge co-creation, knowledge creation, knowledge development, knowledge exchange*, knowledge integration, knowledge integration approaches, knowledge management, knowledge management processes, knowledge search, knowledge sharing, knowledge sources, knowledge sourcing, knowledge spillovers, knowledge transfer, learning, learning effects, learning process, managing knowledge, perspectives on knowledge, tangible knowledge, technical knowledge, transfer of knowledge

Descriptor	Keywords
Resource-based view	Adapt*, adopting, adopt open innovation, alliance capability, assets, capabilities, capability, competitive advantage, complementary resources, core capabilities, dynamic capabilities, dynamic capability, firm capabilities, internal capabilities, learning capability, manufacturing capabilities, processes, resources, resource advantage theory, resource based, resource-based view, strategic resources, value based
Supply chain management	Agile supply chains, customers, customer and supplier, manufacturing process, manufacturing systems, new product success, NPD, NPD activities, product*, product development, product life cycle, product life cycle management, suppliers, supply chain(s), supply chain management, value chain
Transaction cost economics theory	Cost, costs, contracting cost, coordination cost, cost minimization, minimization of production cost, minimization of transaction cost, search cost, transaction cost(s), transaction cost economics, transaction cost theory

Table 3: Major research themes

Descriptor	Keywords
Collaboration	Alliance(s), business network, collaborate, collaboration, collaboration activities, collaboration on innovation performance, collaborative, collaborative open innovation, collaborative relationship, competitiveness, cooperate, cooperating, cooperation, cooperative, corporate innovation communities, corporate innovation community, government, innovation communities, innovation cooperation partnership, innovation intermediaries, intermediary(ies), interorganizational collaboration, inter-firm collaboration, mediating role, network(s), networking, partner(s), partnership(s), partner heterogeneity, public science base, public subsidies, relationship(s), smart networks, specialist knowledge providers, strategic alliances, trust, universities, university, virtual collaboration
Descriptor	**Keywords**
Commitment based human resource practices	Compensation, highly educated employees, human capital, human resource(s), human resource(s) practice(s), job design, participation, training, training activities
Firm size	Corporations, large companies, medium enterprises, medium(-)size enterprises, micro and small enterprises, SME(s)

Inbound OI	Collaborative inbound open innovation, consumers, externally acquired design, externally developed knowledge, ideas from external sources, inbound innovation, inbound OI, inbound open innovation activities, inflows, integrating external knowledge, international inbound open innovation, knowledge exploration, knowledge inflows, technology exploration
Industry 4.0	Additive manufacturing, automation big data, CC, cloud computing, cloud manufacturing, fourth industrial revolution, industry 4.0, innovative production scheduling, internet of things, IOT, radio frequency identification, smart factory
Innovation	CAPI, innovate, innovation(s), innovation activities, innovation management research, innovation model, innovation output, innovation project(s), innovative, innovativeness, innovators, radical innovation, regional innovation, SOC
Intellectual property	Intellectual property(es) model, intellectual property, intellectual property rights, IPPMS, patent, patenting activities
Open strategy	Competitive strategy, diverz(s)ification, inbound open innovation strategies, innovation management, innovation strategy(ies), strategic, strategic intelligence solutions, strategic management, strategy(ies), vertical integrated, vertical integration
Openness	Breadth, connection, connectivity, depth, depth of collaboration, innovation climate, norms, opening, opening of innovation, opening up, opening up of the innovation process, openness, openness degree, openness to external knowledge, partner newness, semi open
Outbound OI	Exploitation of external knowledge, knowledge exploitation, licensed(-)out the new drug, license out, outbound OI, outbound open innovation, outward licensing, technology exploitation, venturing
Performance	Effectiveness, efficiency, financial performance, innovation efficiency, innovation performance, innovation success, innovative performance, international performance, NPD performance, optimal, performance, performance at the firm level, profitability, success(ful), success factors, turnover
Sustainability	Climate change, deliver more sustainable, eco innovation, eco innovation mode, ecological compatibility, economic responsibility, economic sustainability, efficient transportation, environment(s), environmental, environmental dynamism, environmental impact, environmental innovation, environmental policy, environmental turbulence, green innovation, green innovation manufacturing industry, green innovation system, natural environment, sustainability, sustainable, sustainable enterprises, sustainable innovation(s), sustainable management, sustainable paradigm, sustained, transparency, values

Table 4: Methodological approaches

Descriptor	Keywords
Qualitative	Action research, case, case stud*, comparative case study, comparative study, concept, conceptual framework, face-to face interviews, face to face, face to face communication, focus group, grounded, interview, interviewing, interviews, knowledge mapping, multiple case stud*, qualitative, qualitative data, qualitative research, qualitative study, review, single case study, stories, structured interviews
Quantitative	ANOVA, binary logistic regression model, covariance based, binary behavior-based simulation, cluster analysis, common method variance, correlation, discriminant analysis, econometric, empirical, empirical analysis, equations, factor, factors, factor analysis, frequency, hypothesis, logistic regression, logistic regression model, longitudinal, mediating, multiple regression, multivariate, panel, panel data, partial least squares, path analysis, quantitative, regression, regression analysis, regression model(s), robust, SEM, significant, squares, statistic*, structural, structural equation modeling, structural equation modelling, variance

Table 5: Industry

Descriptor	Keywords
Medium-high-tech manufacturing	Aerospac*, aerospace industry, aircraft, automotiv*, automotive industry, biomanufact*, biomedical, biopharma*, biotech*, chemical*, computer, electronic products, medical instruments, pharmaceutic*, stem, tech, tech sectors, Volvo group
Medium-low-tech manufacturing	Beverages, craft, craft firms, food chain, food industry, low-tech, low-tech manufacturing, low-tech sectors food*, pulp and paper, Rubber, tire manufacturer, wood

Table 6: Descriptors frequency

Category	Descriptors	Frequency % (N=239)
Theoretical approaches	Institutional theory	5.02%*
	Knowledge-based view	69.46%
	Resource-based view	55.65%
	Supply chain management	56.90%
	Transaction cost economics theory	15.48%
Methodological approaches	Qualitative	46.44%
	Quantitative	69.46%
Focal units of analysis	Collaboration	79.08%
	Commitment based human resource practices	13.39%
	Firm size	25.10%
	Inbound activities	28.03%
	Industry 4.0	43.10%
	Innovation	61.09%
	Intellectual property	13.81%
	Openness	31.80%
	Open strategy	48.54%
	Outbound activities	12.97%
	Performance	69.87%
	Sustainability	25.94%
Industry	Medium-high-tech manufacturing	30.54%
	Medium-low-tech manufacturing	8.37%
Geographical scope	Africa	1.26%*
	Asia	21.34%
	Europe	41.00%
	South America	0.84%*

Category	Descriptors	Frequency % (N=239)
	North America	4.17%*
	Oceania	0.84%*

*Descriptors are not shown on the map.

Table 7: Main keywords on papers dealing with open innovation in the manufacturing industry.

Keyword	Frequency	Total papers	Keyword	Frequency	Total papers
Product	42,68%	102	*Technology transfer*	5,02%	12
Performance	38,49%	92	*Breadth*	5,02%	12
Knowledge	38,08%	91	*Learning*	5,02%	12
Industry 4.0	37,66%	90	*Competitiveness*	4,60%	11
Absorptive capacity	30,96%	74	*Innovation activities*	4,60%	11
Collaboration	28,03%	67	*Alliances*	4,18%	10
Relationship	21,34%	51	*Firm size*	4,18%	10
Innovative	19,25%	46	*Business model*	4,18%	10
Innovation performance	18,83%	45	*Innovation management*	4,18%	10
SMEs	17,15%	41	*Resource based view*	4,18%	10
Strategy	17,15%	41	*Networking*	3,77%	9
Processes	16,32%	39	*External sources*	3,77%	9
Openness	14,64%	35	*Process innovation*	3,77%	9
Information	14,23%	34	*Open innovation strategy*	3,77%	9
Cost	13,81%	33	*Financial performance*	3,77%	9
Partners	13,81%	33	*Adopting*	3,77%	9

External knowledge	12,55%	30	*Value chain*	3,35%	8
Networks	12,13%	29	*Mediating role*	3,35%	8
Firm performance	11,30%	27	*External knowledge acquisition*	3,35%	8
Success	11,30%	27	*Innovation model*	3,35%	8
Capabilities	11,30%	27	*Radical innovation*	3,35%	8
Customers	11,30%	27	*Effectiveness*	3,35%	8
Patent	10,04%	24	*Sustainability*	3,35%	8
Environment	10,04%	24	*Supply chain*	3,35%	8
Depth	9,62%	23	*Knowledge sources*	2,93%	7
Cooperation	8,79%	21	*Medium sized enterprises*	2,93%	7
Network	8,79%	21	*Innovators*	2,93%	7
New product development	8,79%	21	*Open innovation performance*	2,93%	7
Strategic	8,37%	20	*Knowledge transfer*	2,51%	6
Knowledge management	7,95%	19	*Internet of things*	2,51%	6
Competitive advantage	7,95%	19	*Innovativeness*	2,51%	6
Dynamic capability	7,95%	19	*Degree of openness*	2,51%	6
Universities	7,95%	19	*Innovation strategy*	2,51%	6
Development cooperation	7,53%	18	*Interorganizational collaboration*	2,09%	5
Product innovation	7,53%	18	*Culture*	2,09%	5
Technological innovation	7,53%	18	*Human resources*	2,09%	5
Resources	7,53%	18	*Training*	2,09%	5
Sustainable	7,11%	17	*External technology*	2,09%	5

Moderating role	6,69%	16	*Knowledge acquisition*	2,09%	5
Efficiency	6,69%	16	*Innovation projects*	2,09%	5
Strategic alliances	6,28%	15	*Regional innovation*	2,09%	5
Inbound open innovation	6,28%	15	*Outbound open innovation*	2,09%	5
Successful	6,28%	15	*NPD performance*	2,09%	5
Environmental	6,28%	15	*Eco innovation*	2,09%	5
Government	5,44%	13	*Providers*	2,09%	5
Intellectual property	5,44%	13	*Adapt*	2,09%	5

Table 8: Notable publication within the research field

Author (year)/Title	van De Vrande, V; de Jong, J.P.J.; Vanhaverbeke, W; de Rochemont, M (2009) Open Innovation in SMEs: Trends, Motives and Management Challenges
Cited per year	58
Journal	Technovation
Method	Survey database was collected by EIM.
Sample	605 innovative SMEs from Netherlands with no more than 500 employees.
Key findings	Smaller firms are less involved in open innovation then medium-sized firms. The main encouragement for SMEs to use OI is market-related. There is no considerable distinction between manufacturing and service industries.
Contribution	With eight innovation practices, reflecting technology exploration and exploitation, open innovation in measured.
Theoretical foundations	Knowledge-based view, resource-based view
Major research themes	Firm-size, innovation, performance

Author (year)/Title	**Cited per year**	**Journal**	**Method**	**Sample**	**Key findings**	**Contribution**	**Theoretical foundations**	**Major research themes**
Lee, S; Park, G; Yoon, B; Park, J (2010) Open Innovation in SMEs-an intermediated network model	39	Research Policy	Survey published by STEPI.	2414 Korean SMEs	At the commercialization phase, SMEs should collaborate with other firms in order to reinforce OI. Networks are pointed out as useful way to encourage OI among SMEs.	Intermediated network model is explored, develop collaboration models. Models are classifying into several modes, according to the actors in the models with defined actor's role. Intermediated network model is investigated.	Knowledge-based view	Firm size, collaboration, performance

Author (year)/Title	**Cited per year**	**Journal**	**Method**	**Sample**	**Key findings**	**Contribution**	**Theoretical foundations**	**Major research themes**
Berchicci, L (2013) *Towards an Open R&D System: Internal R&D Investment, External Knowledge Acquisition and Innovative Performance*	23	Research Policy	Surveys of Italian manufacturing firms (SIMFS) conducted by the research department of Capitalia banking group were used.	Final sample consists of 2,905 observations and 2,537 firms.	Advantages and disadvantages of R&D outsourcing depend on firm's own ability to develop internal stock of knowledge. Firms that rely on external R&D activities are more effective in acknowledging and using crucial knowledge from their collaborating partners. Also, firms with a high level of R&D capacity have a better innovative performance.	The study investigates how R&D configuration effects firm's innovative performance. The moderating role of a firm's R&D capacity is also explored.	Transaction cost theory (TCE), knowledge-based view, resource-based view	Performance, collaboration

Author (year)/Title	Tether, Bs; Tajar, A (2008) Beyond Industry-University Links: Sourcing Knowledge for Innovation from Consultants, Private Research Organisations and The Public Science-Base
Cited per year	20
Journal	Research Policy
Method	UK's version of the third European community innovation survey (CIS) based on the OECD's Oslo manual
Sample	8172 responses were received (a response rate of 41.7%) in 2001
Key findings	Firms that are open to innovation are more occupied by specialist knowledge providers. SKP are beneficial for firm's own internal innovation activities and they supplement firm's information from external sources (for example suppliers, customers, competitors). There is a great difference in manufacturing and service industries when choosing a type of SKP.
Contribution	The paper explores the use of specialist knowledge providers: consultancies, private research organizations and the public science-base as sources of innovation activities of manufacturing and service firms.
Theoretical foundations	Knowledge-based view, resource-based view
Major research themes	Collaboration, innovation

Ghisetti, C; Marzucchi, A; Montresor, S (2015) *The Open Eco-Innovation Mode. An Empirical Investigation of Eleven European Countries*	**Author (year)/Title**
18	**Cited per year**
Research Policy	**Journal**
CIS 2006-2008	**Method**
Final working sample of 14,366 firms.	**Sample**
Sometimes firms can turn away from accepting environmental innovation (EI) because acquired external knowledge can become too complicated to manage. But, searching for external knowledge can be beneficial for environmental innovators when extending the portfolio because it can help them reduce all the unnecessary inputs from the outside.	**Key findings**
The study considered affection of breadth and depth on the firm's environmental innovations (EIs). Also, they discuss the moderating role of the firm's absorptive capacity.	**Contribution**
Knowledge-based view, resource-based view	**Theoretical foundations**
Sustainability, performance, openness	**Major research themes**

Table 9: Classification of manufacturing industries (based on NACE Rev.2)

High-technology
Manufacture of basic pharmaceutical products and pharmaceutical preparations (21);
Manufacture of computer, electronic and optical products (26);
Manufacture of air and spacecraft and related machinery (30.3)
Medium-high-technology
Manufacture of chemicals and chemical products (20);
Manufacture of weapons and ammunition (25.4);
Manufacture of electrical equipment (27);
Manufacture of machinery and equipment n.e.c. (28);
Manufacture of motor vehicles, trailers and semi-trailers (29);
Manufacture of other transport equipment (30) excluding Building of ships and boats (30.1) and excluding Manufacture of air and spacecraft and related machinery (30.3);
Manufacture of medical and dental instruments and supplies (32.5)
Medium-low-technology:
Reproduction of recorded media (18.2);
Manufacture of coke and refined petroleum products (19);
Manufacture of rubber and plastic products (22);
Manufacture of other non-metallic mineral products (23);
Manufacture of basic metals (24);
Manufacture of fabricated metal products, except machinery and equipment (25) excluding Manufacture of weapons and ammunition (25.4);
Building of ships and boats (30.1);
Repair and installation of machinery and equipment (33)
Low-technology:
Manufacture of food products (10);
Manufacture of beverages (11);
Manufacture of tobacco products (12);
Manufacture of textiles (13);

Manufacture of wearing apparel (14);
Manufacture of leather and related products (15);
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (16);
Manufacture of paper and paper products (17);
Printing and reproduction of recorded media (18)
Manufacture of furniture (31);
Other manufacturing (32)

9 CleanTech: Prospects & Challenges

Shah Rukh Shakeel

Originally published by Associação Journal of Innovation Management as Open Access under a Creative Commons BY 3.0 license[1] as: Shakeel, S.R., 2021. Cleantech: Prospects and Challenges. Journal of Innovation Management 9, VIII–XVII. https://doi.org/10.24840/2183-0606_009.002_0002. Edited version.

Abstract

The issue of climate change, greenhouse gas emissions, global warming, and their effect on nature and the ecosystem has raised serious concerns. The desire to sustain economic growth and development while keeping a check on the environmental footprints is one of the leading challenges the contemporary world is currently facing. To ensure sustained growth, there is a need for technologies and solutions that has the potential to meet industrial needs without compromising the environment. Cleantech offers a possibility to address these needs in a sustainable and environmentally friendly manner. Cleantech, being an umbrella term, is often confused and misunderstood, in terms of its definition and scope. This study seeks to explore what cleantech actually is, how this sector came into prominence, what are the driving factors behind its surge, and what kind of socio-economic, technical, and regulatory prerequisites are necessary for the advancement of this sector.

Keywords

Cleantech, Socio-economic, Technical, Regulatory, Emergence, Diffusion, Ecosystem, Drivers, Barriers.

1 CleanTech – An umbrella term

1.1 CleanTech definitions

The unprecedented growth and development of technologies emphasising cleaner aspects – often referred to as *CleanTech* – offer a great deal of opportunities and challenges for business across the globe. The term *CleanTech* is a compound formed of the words ‘clean’ and ‘technology’. ‘Clean’ here refers to the characteristic of having relatively little or no environmental footprints, whereas ‘tech’, short from ‘technology’, refers to the apparatus through which the cleaner outcomes can be achieved. CleanTech is a relatively new term and its early use

[1] https://creativecommons.org/licenses/by/3.0/

can be traced back to the mid-1990s by North America's venture capital community (O'Rourke, 2009). However, it was not until the early 2000s that the term started to appear relatively regularly in the mainstream media, sessions, and conferences (Caprotti, 2012). Traditionally, CleanTech was often used to refer to businesses that are cleaner in nature compared to the alternatives or their predecessors. The term became a buzzword and, with the passage of time, sequentially transcended into what today is known as the CleanTech sector. Since its early use, CleanTech as a sector has seen enormous growth. Smart Prosperity Institutes estimates that the global investment will surpass 2.5 trillion dollars by the end of 2022 (SPI, 2018). Not been around for long and yet becoming one of the key sectors in today's global economy, leads us to ask what CleanTech actually is, what makes it important, and what are the driving factors behind its surge.

A review of the literature reveals that *CleanTech* has been defined in numerous ways. Pernick and Wilder (2007) define *CleanTech* as "any product, service, or process that delivers value using limited or zero non-renewable resources and/or creates significantly less waste than conventional offerings". Shakeel and Juszczyk (2019) explain *CleanTech* as "technologies, products or services that seek to lower the negative environmental impact by bringing efficiencies, reducing waste, encouraging the use of sustainable resources and environmental protection". EU's practical guide broadly refers to CleanTech as "any process, product, or service that reduces negative environmental impacts: through environmental protection activities, through the sustainable use of natural resources, or through the use of goods that have been specifically modified or adapted to be significantly less energy -or resource- intensive than the industry standard" (EU, 2020b). These definitions are a little different from one another in terms of scope. However, they address more or less the same entity, which is a technology (here the word *technology* refers to technologies, products, materials, processes, business models, or any related activities or systems) that helps to achieve cleaner outcomes (i.e., having minimal or comparatively little impact on the environment).

Following the specification above, any products, technologies, services, processes, or related activities can be covered under the umbrella of CleanTech, if they comply with the aforementioned criteria – irrespective of the nature, scope or the sector it belongs to. According to CleanTech Group, CleanTech covers companies operating in different sectors including energy & power, resources & environment, transportation & logistics, agriculture & food, enabling technologies, and material & chemicals (Cleantech Group, 2021). It is important to note that CleanTech, as is often assumed, is not a new sector that has emerged with its own set of technologies. Rather, many of the technologies currently attributed to the CleanTech sector have been around for decades, well before the *CleanTech* term became popular. These technologies have been labelled differently[2] in the past,

[2] such as renewable energy technologies, green technologies, green tech, environmentally friendly technologies, sustainable technologies, and so on, some of which are still in used.

however, none has been able to gain the legitimisation and the support that *CleanTech* has as a ‘distinctive sectoral identity’ (Caprotti, 2012). The fact that *CleanTech* is a broad and general term used for a wide variety of technologies spanned across different sectors actually makes it challenging to specify what constitutes CleanTech and which technologies should be included or excluded from the list. Hence, there are a number of limitations that should be considered while classifying CleanTech (O’Rourke, 2009).

1.2 Cleaner application and use

The first one is concerning the scope of the technology’s application. To date, a wide majority of products are deemed clean and thus labelled as *CleanTech*, based on their use, which actually is only one aspect of the technology life cycle[3]. How technologies were produced and disposed of, whether the principles of cleaner production were also adopted during other phases of life cycle, apparently remains out of the scope. For instance, a technology used for harnessing a renewable energy source can be labelled as *CleanTech* as it produces energy with zero or minimal emissions. However, how the technology was manufactured in the first place, what materials were used, whether the company’s operations and processes also adhered to the principles of cleanliness are hardly considered. Similarly, once a technology reaches the end of its life cycle, considerations to whether there were mechanisms in place to ensure it is recycled or disposed in an environmentally friendly manner are rare. The current definitions, more often than not, consider the ‘use’ aspect as a primary criterion for establishing whether it is CleanTech or not, which can be argued to be a narrow approach.

A further challenge linked to this perspective is the varied application of these clean technologies. A technology may play a key role in achieving a cleaner outcome in one context, however, applying the same in a different setup may produce different results. For instance, a company producing microchips that are used in renewable energy systems can be categorised as a CleanTech. However, if the same solutions are also applied in a coal industry context, it would not make it so clean. The lack of information about the context of applications and the difficulty of keeping track are some of the challenges that make categorisation troublesome.

1.3 Cleaner outcomes

The second issue is related to technologies’ real impact. Actually, it is hard to determine when a technology can be referred to as a *CleanTech*, as there are no such criteria, no benchmark or threshold that the technology should match in order to be included in the group of clean technologies. Currently, a technology is

[3] A life cycle includes different stages such as extraction of raw material, manufacturing, logistics, utilisation and disposal.

considered as CleanTech if it is 'cleaner' in use compared to the incumbent technologies. According to this logic, the technology in question needs to perform better than the dirtiest alternative currently available (which is a baseline). This makes the categorisation difficult as the actual impact may vary based on the nature, scope, and the current state of the sector. It is therefore advised that the above mentioned factors should be considered, where possible, when classifying CleanTech.

2 The emergence of CleanTech

CleanTech differentiates itself with competing technologies based on a distinctively unique value offering, i.e. protection of the environment. The traditional model of development relied on the technologies and meant to support economic development and growth. The approach has brought us far, however, fundamental issues such as uncontrolled production and consumption patterns have made it impossible to continue in a similar manner (EPA, 2019). The unsustainable use of natural resources, excessive emissions, reliance on external sources, and the issue of global warming have forced us to reconsider the choices we have made in the past and adhere to the principles of sustainability and cleanliness in our operations (EU, 2018; IPCC, 2018).

Historically, the issue of environmental degradation gained prominence during the latter part of the 20th century, fuelled by extreme environmental hazards, damage to the ecosystem, and the issue of climate change (IPCC, 2013; Wuebbles et al., 2017). This forced governments and policymakers across the globe to come up with a frame of references and guidelines to limit corporations and large polluters to decelerate environmental degradation. The underlying aim was to force companies to pay for their pollutions or externalities caused by businesses. However, the approach feared stagnation and deceleration of economic activities by keeping a check on industrial activities, consequently limiting economic growth. Hoffman (1999) referred to this as a trade-off leading to a win-lose situation, where advancing on one front may significantly hamper the growth of the other. Realising this challenge, the last quarter of the twentieth century experienced a transition towards more voluntary approaches where companies adopted programs to minimise pollution, emphasised on cleaner production and eco-efficiency.

The emergence of CleanTech can be grounded into the premise that economic development and productivity should remain the centre of attention with default emphasis on the protection of the environment. Caprotti (2012) explained that both market-related and political factors can be attributed to the growth of CleanTech. The huge amount of capital investments flowing in the technologies central to the sector as well as large organisations' interest in establishing units taking care of clean technologies further legitimised the sector as investment worthy.

On the political front, the emerging discourse that the environmental challenges and issues can only be fixed by developing innovative technologies and solutions further highlighted the importance of the CleanTech sector. A recent report by Cleantech Group presents that the global effort to reduce the level of carbon emissions and reaching a net-zero target can only be made possible with the innovations made in the CleanTech sector (Cleantech Group, 2020). Reaching these ambitious environmental targets would not only require existing technologies to take a leading share but also new ground-breaking innovations. According to the International Energy Agency (IEA) estimates, 50% of the technologies needed to meet the environmental targets have not even reached the market (International Energy Agency, 2020). To address this challenge, EU has launched a fund of one billion euros dedicated to the development of CleanTech in 2020 (EU, 2020a). These indicators are encouraging for businesses, investors, and other actors in the ecosystem, reiterating the fact that the sector is only going to grow with the backing of governments and international bodies, as the political drive towards a low carbon society and for finding pathways to sustainable energy transition remains a priority.

3 Socio-economic, technical and regulatory considerations

Clean technologies differentiate themselves from conventional technologies based on their positive environmental impacts (Lane, 2011). However, being environmentally friendly alone may not guarantee success. The survival and success of a new product or technology is a complex and a multifarious process requiring a number of pieces of puzzles to fit in before it can actually make a mark in the market (Cooper, 1988; Kassicieh & Radosevich, 1994). First and foremost is the functionality of the technology. In the case of CleanTech, a technology should be able to perform its fundamental function at a similar or higher level of efficiency compared to conventional alternatives with the added feature of being in harmony with the environment. Moreover, these value offerings should be available at a price consumers are willing to pay. The products or services whose unique selling proposition is positive environmental impact alone often struggle to gain a foothold, as only a small fraction of the market is generally willing to pay for the environmental benefits alone (Balachandra, Nathan, & Reddy, 2010). Therefore, for any CleanTech solution to successfully commercialise, it is important to have a technical functionality that is valued by the customers (Shakeel, 2019).

Secondly, most of the clean technologies are disruptive in nature[4], meaning they are different from their counterparts operating in a similar sector. These

[4] Disruptive innovation is a type of innovation that disrupt the existing market by offering a product of services that is novel to the market segment, and often requires changes in the existing system and infrastructure. Disruptive innovations have a potential to considerably change the outlook of the market.

technologies often come with the value offerings that are novel to the existing markets, and, therefore, have to cope up with the challenge of establishing a new set of systems, structures, and customers segments, all making their widespread adoption and diffusion somewhat challenging (Christensen, Raynor, & McDonald, 2016; Woschke, Haase, & Kratzer, 2017). Since the existing market structure is inherently supportive of conventional technologies, it often becomes difficult for some of the clean technologies to compete on their own. The conventional technologies, being around for decades, having gone through the cycle of developments and perfecting over time, often become customer preferred choices, as they have the potential to serve the needs in an economical way as well and can be integrated into the existing infrastructure. For instance, renewable energy technologies can play a great role in meeting present day energy needs in a sustainable and environmentally friendly manner (REN21, 2019). However, despite their huge potential and the possibility of generating energy at relatively competitive prices[5], their actual contribution to the global energy mix remains limited (Ritchie & Roser, 2020). The existing energy system is highly centralized, controlled by either the state or large-scale energy utility companies. A widespread adoption and diffusion of RETs cannot be achieved unless a supporting infrastructure (physical and regulatory regimes) is set in place, which requires a great deal of motivation and investments, consequently making their diffusion challenging (Shakeel, Takala, & Zhu, 2017).

Thirdly, it is observed that small and medium sized organisations are often the source of radical technologies. These companies are usually strong in technology development. However, they often struggle to mobilise the needed infrastructural, human, and financial resources required for a successful diffusion (Brown, Hendry, & Harborne, 2007). Therefore, it is important to ensure that the companies can access the support needed during various phases of technology development and commercialisation. A support in the form of financial grants, loans, incubation facilities, and accelerator programs can be of assistance (Miller & Bound, 2011; Sarzynski, Larrieu, & Shrimali, 2012; Wonglimpiyart, 2015). Lastly, one of the most important things is the level of awareness among customers. Being environmentally friendly could only guarantee success if people value the environment and are dedicated to address this issue. There is a great need to raise the level of environmental awareness among the public. A conscious effort should be made by all stakeholders involved in the process to highlight the issue of the environment, humanity's impact on the environment and ecosystem. The production and consumption patterns that we have adopted over the years, and the impact they had in the form of increased emissions, melting of glaciers and rising sea level, extinction of species, changes in the weather patterns, frequent occurring of environmental hazards and related risks should be highlighted. Likewise, the importance of adopting cleaner solutions, at the individual and

[5] Some of the renewable energy technologies have proven to be competitive with conventional alternatives when the right set of policies and infrastructural support are provided.

community level, and their positive effect for the economy, the environment and society, both in the short term and long run, should be emphasised. This will not only elevate sustainable ways of living but will also stimulate the demand for clean technologies as well as encourage customers to pay a premium for environmentally friendly and clean alternatives.

Based on the above-mentioned factors, a significant number of clean technologies struggle to survive on their own. Considering current needs and future potential, the growth and development of clean technologies cannot be left alone to the *'invisible hand of the market'*[6], where demand and supply can create equilibrium in the market. Rather, there is a need to develop a supportive structure around clean technologies that can provide the needed support and stimulus. Assistance in the form of regulations and support schemes not only help companies in the technology development but also provide support needed at the earlier phases of market launch. The supportive policies and regulatory regimes have played an important role in the development of clean technologies and have brought these to the point where they can compete with the conventional technologies on a level playing field without any kind of favour or support. Therefore, it is important that state level support, in the form of financial incentives, subsidies, and the supportive policy regime are available for CleanTech companies to assist them throughout the process of technology development and diffusion. Solar photovoltaic (PV), one of the leading sources of renewable energy generation today was once deemed too expensive for use (Nemet, 2019). REN 21 report shows that currently 47 countries have at least 1 GW (gigawatt) installed capacity compared to only 18 countries in 2009 (REN21, 2020). The wide spread diffusion of solar PV can be attributed to the improved technical functionalities, reduced cost, possibilities of integration into the system – all made possible through the combination of incentives, subsidies, grants, and supportive policy and regulatory regimes (Hoppmann, 2015; Jacobsson & Lauber, 2006; Sahu, 2015; Zhang & He, 2013).

The proponent of supportive policies and financial incentives argues that such schemes will only be required until the technologies improve in terms of performance, reliability, cost and level of environmental awareness (Gross, Leach, & Bauen, 2003; Yang, Nie, & Huang, 2020). It is also argued that the subsidies or incentives dedicated to the development of CleanTech are not actually a favour but a need. The fact that a lot of pollutant technologies still get subsidies from the government, as well as get through without being charged for the pollution, gives them an undue advantage. Therefore, it becomes essential for CleanTech to get the support and assistance required to compete. The successful diffusion and adoption of CleanTech lie in the intersection of technology, regulatory and market related factors. Failing on any of these fronts can make the diffusion challenging.

[6] Invisible hand of market is a metaphor used by *Adam Smith,* in his famous book '*The inquiry into the nature and causes of the Wealth of Nations*' published in 1776, to explain invisible forces that drive free market

Ecosystem thinking can help in addressing some of the issues that companies face when it comes to the development and diffusion of clean technologies. Many of the clean technologies, being in the earlier phases of development, operating in the rapidly changing and evolving business environment, relying on regulatory support, and originating from the resource stricken small and medium size companies can benefit from a close collaboration with the ecosystem actors. Through collaboration, firms can share resources, gain expertise, and the support needed to carry out the operations in efficient and effective manner. Particular attention should be paid to establishing collaboration with higher education institutions. Universities are home to innovative minds and advanced research. Collaboration with higher education institutions can provide companies with an opportunity to gain access to the resources and facilities that can help improving the overall process and efficiency. An opportunity to translate results from university to industry and vice versa can be beneficial to both institutions as well as for the society at large. Research conducted by DaSilva (1998) shows the effect university-industry collaboration had in the development of the biotech sector. Lee (1996) further suggests that the potential and likelihood of collaboration is higher in technical domains. The high-tech nature of the CleanTech makes it a good avenue for collaboration. However, efforts should be made to enhance the collaboration to gain fruitful results.

Acknowledgments

This research has received funding from the Horizon 2020 Programme of the European Union within the OpenInnoTrain project under grant agreement no. 823971. The content of this publication does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the publication lies entirely with the author(s).

References

Balachandra, P., Nathan, H. S. K., & Reddy, B. S. (2010). Commercialization of sustainable energy technologies. Renewable Energy, 35(8), 1842–1851. https://doi.org/10.1016/j.renene.2009.12.020

Brown, J., Hendry, C., & Harborne, P. (2007). Developing Radical Technology for Sustainable Energy Markets: The Role of New Small Firms. International Small Business Journal, 25(6), 603–629. https://doi.org/10.1177/0266242607082524

Caprotti, F. (2012). The cultural economy of cleantech: Environmental discourse and the emergence of a new technology sector. Transactions of the Institute of British Geographers, 37(3). https://doi.org/10.1111/j.1475-5661.2011.00485.x

Christensen, C. M., Raynor, M., & McDonald, R. (2016). What is disruptive innovation? Harvard Business Review.

Cleantech Group. (2020). Cleantech for Europe: seizing the EU's man on the moon moment. Retrieved from https://www.cleantechforeurope.com/download-report

Cleantech Group. (2021). Global cleantech 100: From Chaos to Transformation- The Companies and Themes Delivering Sustainable Innovation. Retrieved from https://www.cleantech.com/the-global-cleantech-100/

Cooper, R. (1988). Winning at new products. London: Kogan.

DaSilva, E. (1998). University-industry collaboration in biotechnology: A catalyst for self-reliant development. World Journal of Microbiology and Biotechnology, 14(2), 155–181. https://doi.org/10.1023/A:1008809525628

EPA. (2019). Inventory of U.S. Greenhouse Gas Emissions and Sinks:1990-2017. Retrieved from https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-main-text.pdf

EU. (2018). The European Commission's science and knowledge service. Retrieved from https://ec.europa.eu/jrc/en/research-topic/hazards-and-risks-climate-change-impacts

EU. (2020a). Boosting the EU's green recovery: Commission invests € 1 billion in innovative clean technology projects. Retrieved from https://ec.europa.eu/clima/news/boosting-eu-green-recovery-commission-invests-1-billion-innovative-clean-technology_en

EU. (2020b). The clean technology market entry guide : A practical guide to the canadian clean technology market for European Union companies. Retrieved from https://trade.ec.europa.eu/doclib/docs/2020/november/tradoc_159030.10.20).pdf

Gross, R., Leach, M., & Bauen, A. (2003). Progress in renewable energy. Environment International, 29(1), 105–122. https://doi.org/10.1016/S0160-4120(02)00130-7

Hoffman, A. J., & Ventresca, M. J. (1999). The institutional framing of policy debates: Economics versus environment. The American Behavioral Scientist, 8(42), 1368–1392.

Hoppmann, J. (2015). The Role of Deployment Policies in Fostering Innovation for Clean Energy Technologies: Insights From the Solar Photovoltaic Industry. Business and Society, 54(4), 540–558. https://doi.org/10.1177/0007650314558042

International Energy Agency. (2020). Energy Technology Perspectives. Retrieved from https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf

IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. (T. F. Stocker, G.-K. D. Qin, M. Plattner, S. K. Tignor, J. Allen, A. Boschung, … P. M. Midgley, Eds.). Cambridge, UK and New York, USA: Cambridge University Press,. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_all_final.pdf

IPCC. (2018). An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development,. Retrieved from https://www.ipcc.ch/sr15/

Jacobsson, S., & Lauber, V. (2006). The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology. Energy Policy, 34(3), 256–276. https://doi.org/10.1016/j.enpol.2004.08.029

Kassicieh, S., & Radosevich, R. (Eds.). (1994). From Lab to Market: Commercialization of Public Sector Technology (1st ed.). New York: Springer.

Lane, E. L. (2011). Clean Tech IP Is for Real. In E. L. Lane (Ed.), Clean tech intellectual property: eco-marks, green patents, and green innovation. Oxford University Press.

Lee, Y. S. (1996). "Technology transfer" and the research university: A search for the boundaries of university-industry collaboration. Research Policy, 25(6). https://doi.org/10.1016/0048-7333(95)00857-8

Miller, P., & Bound, K. (2011). The Startup Factories: The rise of accelerator programmes to support new technology ventures. NESTA. Retrieved from

http://www.eban.org/wp-content/uploads/2014/09/14.-StartupFactories-The-Rise-of-Accelerator-Programmes.pdf
Nemet, G. F. (2019). How solar energy became cheap: a model for low-carbon innovation. New York, NY: Routledge.
O'Rourke, A. R. (2009). The emergence of Cleantech. Yale University. Retrieved from https://www.proquest.com/docview/305039537?pq-origsite=gscholar&fromopenview=true
Pernick, R., & Clint, W. (2007). The clean tech revolution: the next big growth and investment opportunity. Harper Collins.
REN21. (2019). Renewables 2019 Global Status Report. Paris. Retrieved from http://wedocs.unep.org/bitstream/handle/20.500.11822/28496/REN2019.pdf?sequence=1&isAllowed=y
REN21. (2020). Renewables 2020 global status report. Retrieved from https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf
Ritchie, H., & Roser, M. (2020). Renewable Energy. Retrieved from https://ourworldindata.org/renewable-energy
Sahu, B. K. (2015). A study on global solar PV energy developments and policies with special focus on the top ten solar PV power producing countries. Renewable and Sustainable Energy Reviews, 43, 621–634. https://doi.org/10.1016/j.rser.2014.11.058
Sarzynski, A., Larrieu, J., & Shrimali, G. (2012). The impact of state financial incentives on market deployment of solar technology. Energy Policy, 46. https://doi.org/10.1016/j.enpol.2012.04.032
Shakeel, S. R. (2019). Commercialization of Renewable Energy Technologies : A study of Socio-economic, Technical and Regulatory factors in Finland and Pakistan. Acta Wasaensia, 430. University of Vaasa. Retrieved from https://osuva.uwasa.fi/handle/10024/9753
Shakeel, S. R., & Juszczyk, O. (2019). The Role of Venture Capital in the Commercialization of Cleantech Companies. Management, 14(4). https://doi.org/10.26493/1854-4231.14.325-339
Shakeel, S. R., Takala, J., & Zhu, L.-D. (2017). Commercialization of renewable energy technologies: A ladder building approach. Renewable and Sustainable Energy Reviews, 78, 855–867. https://doi.org/10.1016/j.rser.2017.05.005
SPI. (2018). To win the clean innovation race, Canada needs stronger competitiveness measures to match tough environmental rules. Smart Prosperity: Leaders' Initiative. Retrieved from https://www.smartprosperity.ca/content/308
Wonglimpiyart, J. (2015). Technology Financing and commercialization: exploring te challenges and how nations can build innovative capacity. Hampshire: Palgrave Macmillan UK.
Woschke, T., Haase, H., & Kratzer, J. (2017). Resource scarcity in SMEs: effects on incremental and radical innovations. Management Research Review, 40(2). https://doi.org/10.1108/MRR-10-2015-0239
Wuebbles, D. J., Fahey, D. W., Hibbard, K. A., DeAngelo, B., Doherty, S., Hayhoe, K., … Weaver, C. P. (2017). Executive summary. In D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, & T. K. Maycock (Eds.), Climate Science Special Report: Fourth National Climate Assessment, Volume I. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/J0DJ5CTG
Yang, Y. cong, Nie, P. yan, & Huang, J. bo. (2020). The optimal strategies for clean technology to advance green transition. Science of the Total Environment, 716. https://doi.org/10.1016/j.scitotenv.2019.134439
Zhang, S., & He, Y. (2013). Analysis on the development and policy of solar PV power in China. Renewable and Sustainable Energy Reviews, 21, 393–401. https://doi.org/10.1016/j.rser.2013.01.002

10 Approaching FoodTech: some preliminary considerations

Elena Casprini, Antje Gonera, Carsten Nico Hjortsø

1 Introduction

In this chapter, we aim to introduce and characterize the concept of FoodTech and discuss this practice field in relation to knowledge translation. Today, ensuring effective knowledge translation in relation to the FoodTech sector is an important issue because food production and consumption is estimated to contribute between 20 and 40 percent of CO_2 emissions (Vermeulen et al. 2021). Changes in food consumption patterns are important to reduce this level, but FoodTech solutions will also play a significant role in contributing to make the food sector more sustainable by reducing environmental impact along the entire food supply chain (Willett et al. 2019; De Bernardi & Azucar 2020). Another important challenge is caused by a growing world population, which is estimated to result in an increase in food demand by 60 percent by 2050 (Alexandratos & Bruinsma 2012). This will put a significant pressure on the shrinking natural resources available for food production and will require a significant increase in the food sector's productivity.

The prominent role of FoodTech is highlighted in the 'A farm to fork strategy' published by The European Commission in 2020 (EC 2021). In this strategy, the importance of creating a food chain capable of satisfying both the demand and supply side requirements, while simultaneously taking care of both the climate and the environment is emphasised as a means of reaching a climate-neutral society. An additional EU initiative is the 'Food 2030', which is the European Commission's research and innovation policy to transform food systems and ensure everyone has enough affordable, nutritious food to live a healthy life (EC 2018). The Food 2030 is a policy blueprint for transforming food systems and places nutrition, resilience, reduction of carbon emissions, and public trust and involvement at the core of the transformation. These strategies and policies highlight the importance of FoodTech and place research and technology development in the food sector at the center of the EU policies and programs in the future decade. In this light, understanding how FoodTech research findings are most effectively transformed through innovation into long-term impact becomes of significant importance.

In the following, we first describe the food system and its context. We then aim to define the concept of FoodTech. This is followed by a review of recent technological developments with relevance for the food industry, and finally we highlight some recent developments in how knowledge translation occurs within the FoodTech practice field.

2 Food: from the oldest need of human beings to a locus for innovation

The role of food for society has been well documented by archaeologists (Ambrose 1998), historians of art (Riley 2014), but also humanists and by the broader literature since the first classical poems. Food scarcity has often been a reason for migration (Maharatna 2014), for war (Cribb 2019) and, consequently, an important driver of change.

Historically, people have innovated how food is produced, processed, preserved, distributed, and stored. *"The first agricultural revolution occurred when humans started farming around 12,000 years ago. The second was the reorganization of farmland from the 17th century onwards that followed the end of feudalism in Europe. And the third (also known as the green revolution) was the introduction of chemical fertilizers, pesticides and new high-yield crop breeds alongside heavy machinery in the 1950s and 1960s"* (Rose & Chivers 2020). However, only very recently, the negative impact of food production and consumption on the environment has gained attention. This is caused by deeper awareness about the pollution associated with food production (Sutton et al. 2013) as well as the importance of not losing biodiversity (Tscharntke et al. 2012). Additionally, climate changes have also urged policy makers and food producers to consider how to prevent food scarcity.

A fourth agricultural revolution has started and is enabled by technological advancements such as precision agriculture, smart farming and cellular agriculture (Barrett et al. 2021). With advancement in technologies, attention has also been posited to how food could be transported (e.g., by drones) and produced (e.g., using fermentation, 3D printing and genetic modification) in innovative ways, both following and driven by changes in consumers' behavior and taste. Whereas food is strongly embedded in cultural traditions and practices, it is also highly affected by advancements in knowledge and technology. The two are not mutually exclusive, but rather self-reinforcing.

3 What are food systems and how may they be changed?

FoodTech is concerned with the application of technology in the food system. FAO (2018, p. 1) defines the food system as encompassing:

> *"… the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded."*

Thus, one way to conceptualize the food system is to identify the chain and interdependencies of activities involved from input production to consumption. This chain is captured by the concept of the supply chain when the focus is on the processes of production and distribution of a product from raw material to the table and the 'bin' (e.g., from farmers to restaurants and actors who take care of food waste). The concept of value chain is used when the focus is on identifying the distribution of the value generated through the activities that constitute the supply chain.

The main activities involved in a (simplified) food supply chain typically include (Li et al. 2017; Papargyropoulou et al. 2014; Van der Vorst et al. 2001):

- Research and development
- Agriculture/Raw material production (e.g., vegetables, animals or fish)
- Food processing, manufacturing and packaging
- Storage and distribution
- Retail and sales
- Consumption
- Waste disposal, recycle, or upcycling

These activities are organised in many ways depending on, for example, the geographical extension of the specific food supply chain or the desired characteristics of the marketed food products. Today, many food products involve a global supply chain, where input materials are sourced from low production cost regions with favorable growing conditions such as Africa and Asia, processed through several steps in various locations, and eventually marketed in European and North American supermarkets. The evolution of global supply chains is closely linked with increasing globalisation during the last fifty years. Globalisation and widespread market liberalisation have created a food sector dominated by multinational enterprises, with an emphasis on standardisation, globalised supply chains and low-cost mass production (McMichael 2009; van Otterloo 2012). The dominant governance model at a given time is referred to as a 'food regime', which is defined as "a rule governed structure of production and consumption of food on a world scale" (Friedmann 1993, p 30). The present dominant food system is characterised as the *corporate food regime* (Friedmann 2005).

The corporate food regime has had a negative impact on the livelihood of rural smallholders as well as the environment, for example, through concentration of land ownership and a shrinking natural resource base (Holt-Gimenez & Shattuck 2011). As a reaction to this development, several movements have emerged that challenge the present dominant regime. One significant social movement is the *food sovereignty paradigm* that proposes restoration for national autonomy over food policy, territorial understanding of food security, and encourages ecosystem stewardship through a central ethic which would be 'food as a right, not a commodity' (McMichael 2013, p. 6). This movement also emphasizes the need to recognize the role of agriculture and farmers in the daily life of people, to give preference to family-based production rather than intensive export-oriented industry production, and to produce safe and healthy food, promote community, culture and the care for the environment as well as the preservation of local and traditional knowledge (Carrasco & Tejada 2008). The case of *Slow Food* is emblematic of this new paradigm of localised consumption and offering of geographically typical food products (Nosi & Zanni 2004). Another important example is the *geographical indicator* (GI) and *appellation of origin* (AO) labelling systems which are internationally defined and legally protected, as for example in the case of the wine industry where products have been protected and regulated by an AO system for several decades. In general, there seems to be a consumer trend, at least in the affluent western markets, towards willingness to pay an added value for preservation, protection and valorisation of food specificities.

Recently, non-conventional production approaches have gained ground in the food sector including hydroponics, vertical agriculture, intelligent farming, cropping, agro-ecology, permaculture, organic farming, and urban farming (De Bernardi & Azucar 2020). Many of these approaches are enabled by recent technological developments and explicitly address the above-mentioned challenges. Another contemporary development is the circular economy, which has also raised significant interest within the food sector. Circular economy constitutes a significant challenge because it may in many cases imply a total redesign of the existing supply chains in the food system and FoodTech is envisioned to play a central role in accommodating such fundamental transitions. These alternative approaches are claimed to contribute to alleviate some of the corporate food regime's negative social, economic and environmental impacts, but many of the associated technologies are still in an initial stage. This places a significant challenge on FoodTech and the sectors' ability to translate research findings into impact. Ramirez-Portilla et al. (2016, cited from De Bernardi & Azucar (2020, p. 111)) provide an overview of trends, and a breakdown of associated areas in the current food systems in need of further research and development:

- Fresh, local, and convenient:
    - New ingredients
    - Emerging regulations
    - Foods on the go
    - Proximity to customers
- Automated solutions:
    - Food bots
    - Advanced processing
    - Waste and resource minimisation

- Safety and quality:
  - Food authenticity and traceability
  - Quality management across the supply chain
  - Sanitation
- Supply chains:
  - Short product life cycles
  - Intelligent packaging
  - Sustainable sourcing

The above list combined with the diverse structures of contemporary food supply chains illustrate the multi-actor, multi-function, and multi-factor nature that characterizes food systems, and thus the potential field of application of FoodTech solutions. In the next section, we will zoom in on the notion of FoodTech with the aim of understanding how it may be defined in different contexts.

Food system transition builds on the theory of systemic innovation as a process of renewal of a system (Elzen et al. 2004). Transitions come about because of interaction between different analytical levels and the theoretical model developed by Geels (2011) shown in Figure 1. These levels include *innovative niches*, the *socio-technical regime*, and the *socio-technical landscape*.

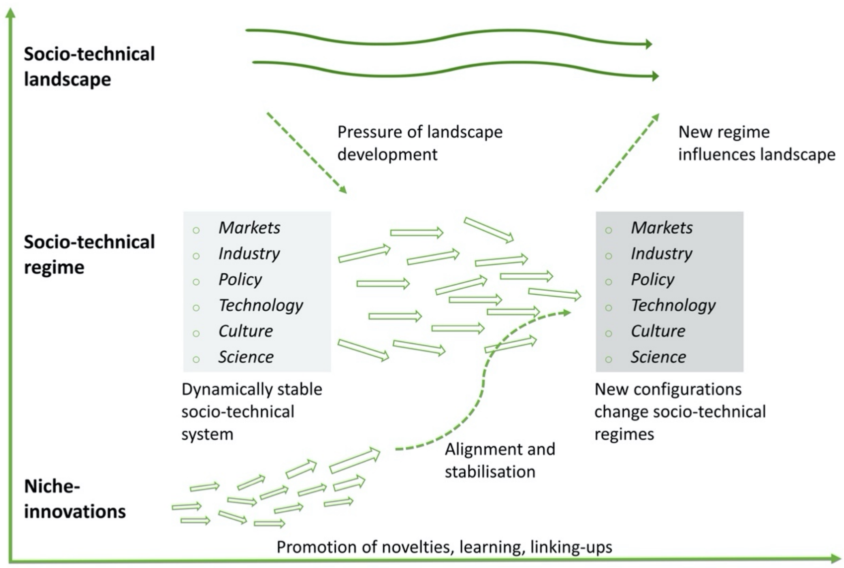


Figure 1 Transition to sustainability (modified by the authors from Geels (2011))

The socio-technical regime is the core concept. The regime is understood as relatively durable, stable and difficult to change. In the food industry context, the regime corresponds to what we know as the mainstream *corporate food regime*. Regime change - or systemic change - is slow and difficult because the regime is constantly reproduced and held together by what is known as lock-in mechanisms. There are material lock-in mechanisms such as artifacts, instruments and infrastructure, or economic lock-in mechanisms such as sunk cost investments, economies of scale and favorable price-performance relations, and vested interests that exclude novelty.

In this model, it is argued that innovation happens in *niches* – protected and 'away' from the dominant or ongoing everyday business of the regime. Examples include alternative food networks (Randelli & Rocchi 2017) and organic farming (Smith 2006). Other examples of innovative food niches include new technologies in genetics and preventive health, precision farming, in vitro/cellular farming, social innovation, and organisational changes. The idea of alternative food networks started in the 1970's as a reaction to concerns about globalised and industrialised food production. In much of the literature about alternative food networks, environmental sustainability is associated with organic farming (Randelli & Rocchi 2017). Alternative food networks often evoke a sense of place, a social connection to the food or social embeddedness.

The third analytical level in a transition perspective, is the notion of a *landscape*. The landscape in which a system operates includes the economic environment and the sociotechnical environment. Landscape level changes are caused by external shocks or long-term trends. Examples include the financial crisis, and demographic trends. In terms of the food system, landscape factors include the ongoing discourse about climate change, increasing awareness of animal welfare issues, and public health concerns. For example, in the mid-1990's consumers were faced with the debate on genetically modified organisms (GMOs) and a series of livestock disasters such as BSE/Creuzfeld-Jacobs. Events that triggered new interest in alternative foods and a new skepticism about the intensification of the livestock industry (Van Otterloo 2012). The COVID-19 pandemic is one such shock to the food system that triggered innovations and technology disruptions towards a food system change (Galanakis et al. 2021).

4 What is FoodTech?

The notion of FoodTech may be defined more or less broadly. Some very closely related concepts include AgriTech (Krishnan et al. 2020) and Agriculture 4.0 (Kovács & Husti 2018; Liu et al. 2021) which are related terms that may emphasize a focus on a particular node or segment of the food value chain, in this case the upstream segment. These terms are often used interchangeably and in this chapter, we adopt an inclusive definition of FoodTech, considering AgriTech and Agriculture 4.0 as part hereof.

No unanimous definition of the term FoodTech exists, but FoodTech is closely linked to the broader discipline of food science. This relation is recognised in Wikipedia's definition of FoodTech:

> *"Food technology as a scientific field is a branch of food science that deals with the principles and processes involved in production,*

> *preservation, quality control, distribution, and research and development of the food products" (Wikipedia n.d.).*

Institute of Food Technologists, a professional organisation for food technologists and scientists helps us place FoodTech in a disciplinary context:

> *"Food technology is the application of food science to the selection, preservation, processing, packaging, distribution, and use of safe food. Related fields include analytical chemistry, biotechnology, engineering, nutrition, quality control, and food safety management" (IFT n.d.).*

The consulting firm Forward Fooding highlights the link between technology, efficiency, and sustainability:

> *"At Forward Fooding we define Food Tech as 'the emerging sector exploring how technology can be leveraged to create efficiency and sustainability in designing, producing, choosing, delivering and enjoying food." (Forward Fooding n.d.)*

Finally, in the last example, we highlight the educational perspective, drawing on the Technical University of Denmark's description of its FoodTech MSc program:

> *"Food technology is an innovative, exciting, and highly interdisciplinary field of study; meeting the challenges related to global market requirements, changing consumer demands, sustainability, social responsibility, and competitiveness requires knowledge in a wide range of areas." (DTU n.d.)*

This description emphasizes the social, systemic, and market-oriented context and recognizes the current focus on sustainability. Moreover, the interdisciplinary nature of FoodTech is highlighted.

These four definitions drawn from the sectors of science, the professional community, consulting, and education, illustrate the inherent complexity involved in the FoodTech domain. Considering the above-mentioned R&D needs in the current food systems for which FoodTech can provide technological solutions, FoodTech emerges as a very broad and multi-disciplinary discipline or practice area. In this context, we have a special interest in the developments driven by Industry 4.0. Next, we will identify what characterizes contemporary technology development in relation to FoodTech.

5 What characterises the contemporary technological development?

The World Economic Forum (2018), in its report 'Innovation with a purpose: The role of technology innovation in accelerating food systems transformation' identified three areas of emerging Industry 4.0 technologies with a potential for rapid and large-scale change in food systems:

- *Digital building blocks*; for example, new computing technologies, big data and advanced analytics, Internet of Things, artificial intelligence and machine learning, blockchain, virtual reality and augmented reality.
- *New physical systems*; for example, next-generation biotechnologies and genomics, energy creation, capture, storage and transmission.
- *Advances in science*; for example, autonomous and near-autonomous vehicles, advanced, smart robotics, additive manufacturing and multidimensional printing, advanced materials and nanotechnologies.

Figure 2 summarizes the main established and emerging technology themes across the agri-food supply chain.

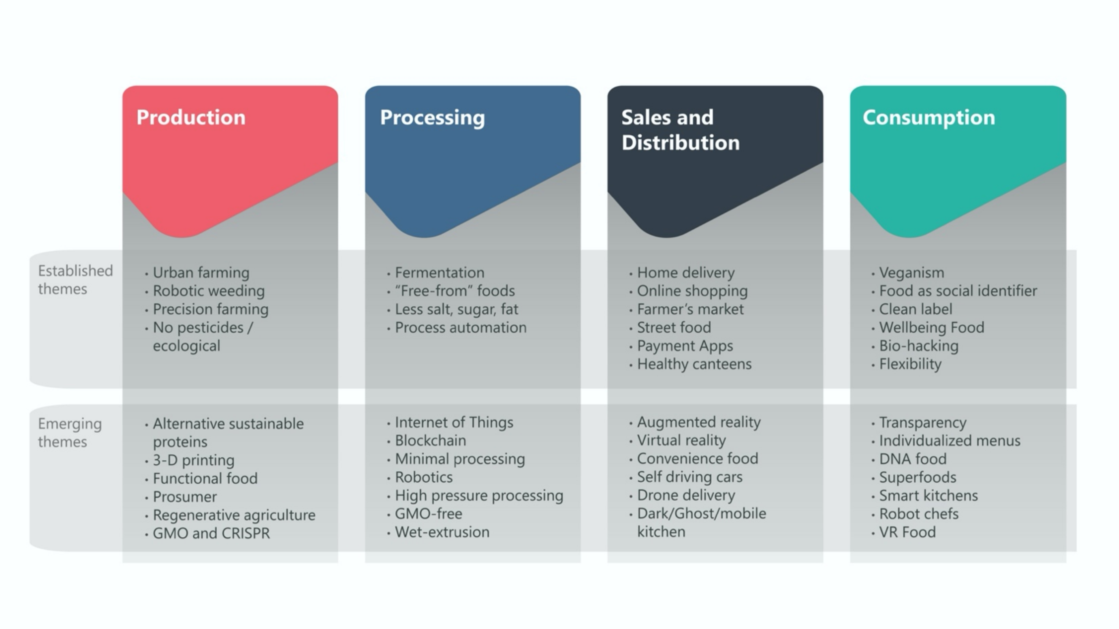


Figure 2 Illustration of FoodTech Trends (modified by the authors from the GDI Food Trend Map (2021)).

In the following, we provide a brief overview of the main technologies associated with the Industry 4.0 development and give examples of how these technologies may be applied in the food sector in the future.

- *Big data and advanced analytics*. Big data analytics help managers to make decisions and enable predictive analytics. Wolfert et al. (2017) provide a review on big data in smart farming, noticing that there are several activities constituting the "data chain", that can be analysed from a technical and a business layer and along four main stages (raw material, processing, transport and marketing).

- *The Internet of Things (IoT)*. IoT technologies are diverse and include the adoption of QR codes, radio-frequency identification (RFID) technologies, sensors, and cyber-physical systems (CPS), for example, in order to trace food products along the whole supply chain (Li et al. 2017). Sensors are also used for monitoring soil humidity and the health of plants (e.g., through dendrometry). IoT technologies can be applied to several products and at different stages in the supply chain, for example, in white appliances, where companies are developing 'smart fridges'.
- *Artificial Intelligence (AI) and machine learning*. A recent article on Forbes notices that AI is crucial for the safety of the food. For example, some companies are using AI-based models for identifying the steps to be followed for washing hands and monitoring employees' hand washing or for identifying unsuitable food items through the use of e-noses (Koksal 2021).
- *Blockchain*. Blockchain is used in tracing the origin (and the development) of products - from soil to table. Feng et al. (2020, pp. 3-4) define a blockchain as "*a shared, distributed and tamper proof digital ledger that consists of immutable digital record data [...]; an innovative application of distributed data, peer-to-peer transmission, consensus mechanism, encryption algorithm, and other information technologies*", and provide several examples, including for the traceability of poultry products.
- *Virtual and augmented reality*. These technologies are particularly important for consumers since they enable the creation of new experiences as well as helping people change consumption habits and shifting preferences towards healthy food.
- *Next generation biotechnology and genomics*. Omics[1] and gene editing technologies such as CRISPR are used to engineer probiotic cultures and to enhance yield, drought tolerance and nutritional value in crops. An emerging biotechnology is cellular agriculture, which is used for production of enzymes or lab grown meat, fish and seafood.
- *Autonomous (unmanned aerial vehicles - UAVs) and near-autonomous vehicles*. These technologies help improve production efficiency as in the case of tractors equipped with radars and GPSs that help farmers to remotely monitor and control sowing, fertilizing, spraying and harvesting (Parker 2016).
- *Robots*. Robots can be introduced in several processes. For example, in food manufacturing the use of robots may happen from cooking to palletizing.
- *Additive manufacturing and multidimensional printing*. 3D printing; that is applied in food design.

[1] Omics refers to the collective technologies used to explore the roles, relationships, and actions of the various types of molecules that make up the cells of an organism (AltTox.org. n.d.).

- *Advanced materials and nanotechnologies*. Nanotechnologies, i.e. the understanding and control of matter at dimensions of roughly 1 to 100 nm (Sastry et al. 2010), are important in the agri-food sector since they can be adopted along the supply chain. These technologies are important in food safety, preservation and security.

As it appears from the above list, the FoodTech sector is highly engaged in Industry 4.0 technologies, but this does not automatically mean that society will harvest the potential fruits to the degree envisioned by institutional actors such as the EU and WEF. The impact of these technologies depends on the extent to which research findings are translated through innovation into practical solutions adopted by the food sector. In the final section, we will address the translation process as well as recent developments in research on FoodTech innovation processes.

6 How does FoodTech knowledge translation take place?

The heterogeneity of actors, technologies, and fields involved in food systems requires us to consider how knowledge is translated from research to practice and vice versa. Once created, scientific knowledge has to be transferred, translated, transformed and used in order to have an impact in society (Greenhalgh & Wieringa 2011; Rybnicek & Konigsgruber 2019). These processes happen not only within universities or corporate R&D labs, but are increasingly also the result of a broader network of relations between food system actors (Strand et al. 2003; Pigford et al. 2018).

Born in the health sector, 'research translation' (Mention et al. 2020) is an emerging concept that aims to complement the traditional knowledge transfer perspective with an increased attention to how knowledge is not only created and translated to the industry or other societal sectors, but how this knowledge is efficiently translated into societal impact through innovation resulting in new products, services, practices, policies, or business models (Woolf 2008). In the FoodTech context, we identify some important aspects that should be addressed in future research in relation to emerging research translation practices:

- The role of *translational developers*, i.e., a function or person who closes the gap between research and practice (Norman 2010). The translational developer can play an important role as a boundary spanner who facilitates the use of knowledge across organisational boundaries and knowledge domains.
- The increasing need for transdisciplinary collaboration between industry and academia driven by the introduction of industry 4.0 technologies into traditional food supply chains (EC 2018).

- New emerging forms of research such as co-creation and open innovation (Filieri 2013; Sarkar & Costa 2008), foresight (Barrett et al. 2021), and design science (Gonera & Pabst 2019).
- The role of universities in supporting entrepreneurship both among students and academic staff also constitutes an area that has been promoted significantly during the last decade, and which provides a promising venue for translating FoodTech research findings into practical use (De Bernardi & Azucar 2020).
- Finally, entrepreneurial (agrifood-)ecosystems (Hernández-Chea et al. 2021) provide an interesting empirical phenomenon and theoretical perspective which has gained increasing attention and importance as a means of understanding the contemporary context of translation processes.

7 Conclusions

In conclusion, we contend that FoodTech is a highly interdisciplinary field, which offers a significant potential for contributing to the needed transformation towards a more social, economic and environmental sustainable food system. It is widely recognised that, in order to realize the significant transformative potential offered by the new Industry 4.0 technologies, FoodTech and associated scientific disciplines cannot only rely on traditional linear knowledge transfer processes, but need to engage more deeply in the food systems transformation through new modes of university-industry collaboration to foster innovation with social impact.

We argue that FoodTech knowledge creation and use need to be seen as an integrated element of more complex knowledge and innovation systems, for example in relation to Industry 4.0 technologies. Future research should contribute to enhancing our understanding of the different functions and processes that characterize the interaction among actors throughout supply chains from 'farm to fork'. We contend that the concept of research translation can be useful for enriching our understanding of the nature of the collaboration across multiple fields of knowledge and actors needed to realize the potential impact expected from emerging developments within FoodTech.

References

Alexandratos, N. and Bruinsma, J. 2012. World agriculture towards 2030/2050: the 2012 revision. ESA Working Paper No. 12-03, Agricultural Development Economics Division, Food and Agriculture Organization of the United Nations.

AltTox.org. n.d. Omics, bioinformatics, computational biology. Accessed June 3 2021: http://alttox.org/mapp/emerging-technologies/omics-bioinformatics-computational-biology/.

Ambrose, S.H. 1998. Chronology of the later stone age and food production in East Africa. Journal of Archaeological Science, 25(4), 377–392.

Barrett, C.B., Beaudreault, A.R., Meinke, H., Ash, A., Ghezae, N., Kadiyala, S., Nigussie, M., Smith, A.G. and Torrance, L. 2021. Foresight and trade-off analyses: Tools for science strategy development in agriculture and food systems research. Q Open, 1(1), p.qoaa002.

Carrasco, H., and Tejada, S. 2008. Soberanía alimentaria: La libertad de elegir para asegurar nuestra alimentación. Lima: Soluciones Prácticas - ITDG.

Cribb, J. 2019. Food or war. Cambridge University Press.

De Bernardi P., and Azucar D. 2020. Innovation in food ecosystems. Contributions to management science. Springer, Cham.

DTU (Technical University of Denmark). n.d. Food Technology MSc program homepage. Accessed May 11 2021: https://www.dtu.dk/english/education/msc/programmes/food_technology.

EC. 2021. Farm to fork strategy: For a fair, healthy and environmentally-friendly food system. Accessed June 11 2021: https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en.

EC. 2018. Food 2030: Innovative EU research ensures food system is future-ready. Accessed June 11 2021: https://ec.europa.eu/info/publications/food-2030-innovative-eu-research-ensures-food-system-future-ready_en.

Elzen, B., Geels, F.W., and Green, K. 2004. System innovation and the transition to sustainability: theory, evidence and policy. Edward Elgar Publishing.

FAO. 2018. Sustainable food systems: Concept and framework. Rome: FAO. Accessed June 28 2021: http://www.fao.org/3/ca2079en/CA2079EN.pdf.

Feng, H., Wang, X., Duan, Y., Zhang, J. and Zhang, X. 2020. Applying blockchain technology to improve agri-food traceability: A review of development methods, benefits and challenges. Journal of Cleaner Production, 260, 121031.

Filieri, R. 2013. Consumer co-creation and new product development: A case study in the food industry. Marketing Intelligence and Planning, 31, 40–53.

Forward Fooding. n.d. What is food tech? Accessed May 11 2021: https://forwardfooding.com/what-is-food-tech/.

Friedmann, H. 1993. The political economy of food: A global crisis. New Left Review, 197, 29-57.

Friedmann, H. 2005. From colonialism to green capitalism: Social movements and emergence of food regimes. In F. H. Buttel, P. McMichael (Eds.), New directions in the sociology of global development (Research in rural sociology and development, volume 11), pp. 227-264. Bradford: Emerald Group Publishing Limited.

Galanakis, C.M., Rizou, M., Aldawoud, T.M., Ucak, I. and Rowan, N.J. 2021. Innovations and technology disruptions in the food sector within the COVID-19 pandemic and post-lockdown era. Trends in Food Science & Technology, 110, 193-200.

GDI Food Trend Map 2021. Accessed May 9 2021: https://www.gdi.ch/en/publications/trend-updates/gdi-food-trend-map-whats-changing.

Geels, F.W. 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. Environmental Innovation and Societal Transitions, 1(1), 24-40.

Gonera, A. and Pabst, R. 2019. The use of design thinking in transdisciplinary research and innovation consortia: challenges, enablers, and benefits. Journal of Innovation Management, 7(3), 96-122.

Greenhalgh, T. and Wieringa, S. 2011. Is it time to drop the 'knowledge translation' metaphor? A critical literature review. Journal of the Royal Society of Medicine, 104(12), 501-509.

Hernández-Chea, R., Mahdad, M., Minh, T. T., and Hjortsø, C. N. (2021). Moving beyond intermediation: How intermediary organizations shape collaboration dynamics in entrepreneurial ecosystems. Technovation, 108, 102332.

Holt-Giménez, E., and Shattuck, A. 2011. Food crises, food regimes and food movements: rumblings of reform or tides of transformation? The Journal of Peasant Studies, 38(1), 109-144.

IFT (Institute of Food Technologists). n.d. About food science and technology. Accessed 12 May 2021: https://www.ift.org/career-development/learn-about-food-science/food-facts/about-fs-and-t.

Koksal, I. 2021. Using AI to increase food quality. Forbes 8/5/2021. Available at: https://www.forbes.com/sites/ilkerkoksal/2021/05/08/using-ai-to-increase-food-quality/?sh=4ae89a0d1827.

Krishnan, A., Banga, K., and Mendez-Parra, M. 2020. Disruptive Technologies in Agricultural Value Chains: Insights from East Africa. EIF/ODI. Accessed 12 May 2021: https://cdn.odi.org/media/documents/disruptive_agritech_-_5_mar_2020_-_final_draft.pdf.

Kovács, I. and Husti, I. 2018. The role of digitalization in the agricultural 4.0 – How to connect the industry 4.0 to agriculture? Hungarian Agricultural Engineering, 33, 38-42.

Li, Z., Liu, G., Liu, L., Lai, X. and Xu, G. 2017. IoT-based tracking and tracing platform for prepackaged food supply chain. Industrial Management & Data Systems,117(9), 1906-1916.

Liu, Y., Ma, X., Shu, L., Hancke, G.P., and Abu-Mahfouz, A.M. 2021. From Industry 4.0 to Agriculture 4.0: Current status, enabling technologies, and research challenges. IEEE Transactions on Industrial Informatics, 17(6), 4322–4334.

Maharatna, A. 2014. Food scarcity and migration: An overview. Social Research, 81(2), 277-300.

McMichael, P. 2009. A food regime genealogy. The Journal of Peasant Studies, 36(1), 139-169.

McMichael, P. 2013. Historicizing food sovereignty: A food regime perspective. Paper presented at Conference Food Sovereignty: A Critical Dialogue, held September 14-15, 2013 at Yale University. Retrieved on February 16 2021 from https://www.tni.org/files/download/13_mcmichael_2013.pdf.

Mention, A.-L., Bhimani, H., and Menichinelli, M. 2020. Executive report on state of play in UIC and research translation in Europe and Australia. Report. OpenInnoTrain.

Norman, D. A. 2010. The research-practice gap: The need for translational developers. Interactions, 17(4), 9-12.

Nosi, C. and Zanni, L. 2004. Moving from 'typical products' to 'food-related services': The Slow Food case as a new business paradigm. British Food Journal, 106, 779-792.

Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N. and Ujang, Z. bin. 2014. The food waste hierarchy as a framework for the management of food surplus and food waste. Journal of Cleaner Production, 76, 106–115.

Parker, M. 2016. Autonomous vehicles enter agriculture market with debut of robot tractor. Industry Week, 01/09/2016. https://www.industryweek.com/technology-and-iiot/article/21980253/autonomous-vehicles-enter-agriculture-market-with-debut-of-robot-tractor.

Pigford, A.A.E., Hickey, G.M. and Klerkx, L. 2018. Beyond agricultural innovation systems? Exploring an agricultural innovation ecosystems approach for niche design and development in sustainability transitions. Agricultural Systems, 164, 116-121.

Ramirez-Portilla, A., Cagno, E., and Zanatta-Alarcon, A. 2016. Open food - Revisiting open innovation in the food industry. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-180557.

Randelli, F., and Rocchi, B. 2017. Analysing the role of consumers within technological innovation systems: The case of alternative food networks. Environmental Innovation and Societal Transitions, 25, 94-106.

Riley, G. 2014. Food in art: From prehistory to the renaissance. Reaktion Books.

Rose, D. and Chivers, C.-A. 2020. The fourth agricultural revolution is coming – but who will really benefit? Website accessed June 12 2021 https://theconversation.com/the-fourth-agricultural-revolution-is-coming-but-who-will-really-benefit-145810#:~:text=The%20first%20agricultural%20revolution%20occurred,farming%20around%2012%2C000%20years%20ago.&text=Other%20farming%2Dspecific%20technologies%20include,and%20synthetic%20lab%2Dgrown%20meat.

Rybnicek, R. and Königsgruber, R. 2019. What makes industry–university collaboration succeed? A systematic review of the literature. Journal of Business Economics, 89(2): 221-250.

Sarkar, S. and Costa, A. 2008. Dynamics of open innovation in the food industry. Trends in Food Science & Technology, 19(11), 574–580.

Sastry, R.K., Rashmi, H.B., Rao, N.H. and Ilyas, S.M. 2010. Integrating nanotechnology into agri-food systems research in India: A conceptual framework. Technological Forecasting and Social Change, 77(4), 639–648.

Smith, A. 2006. Green niches in sustainable development: The case of organic food in the United Kingdom. Environment and Planning C: Government and Policy, 24(3), 439-458.

Strand, K., Marullo, S., Cutforth, N.J., Stoecker, R. and Donohue, P., 2003. Principles of best practice for community-based research. Michigan Journal of Community Service Learning, 9(3), 5-15.

Sutton, M.A., Bleeker, A., Howard, C.M., Erisman, J.W., Abrol, Y.P., Bekunda, M., Datta, A., Davidson, E., De Vries, W., Oenema, O. and Zhang, F.S. 2013. Our nutrient world. The challenge to produce more food & energy with less pollution. Centre for Ecology & Hydrology, Edinburgh UK. Accessed June 21 2021 at: https://library.wur.nl/WebQuery/wurpubs/fulltext/249094.

Tscharntke, T., Clough, Y., Wanger, T.C., Jackson, L., Motzke, I., Perfecto, I., Vandermeer, J. and Whitbread, A. 2012. Global food security, biodiversity conservation and the future of agricultural intensification. Biological Conservation, 151(1), 53-59.

Van der Vorst, J.G., Dijk, S.J.V. and Beulens, A.J. 2001. Supply chain design in the food industry. The International Journal of Logistics Management, 12(2), 73-86.

Van Otterloo, A. 2012. Healthy, Safe and Sustainable: Consumers and the public debate on Food in Europe and the Netherlands since 1945. In G. Spaargaren, P. Oosterveer, & A. Loeber (Eds.), Food Practices in Transition: Changing Food Consumption, Retail and Production in the Age of Reflexive Modernity. New York: Routledge.

Vermeulen T., Machiels B., and Van Zand J. 2021. The food processing industry in spain. Accessed May 11 2021: https://www.flandersinvestmentandtrade.com/export/sites/trade /files /market studies.

Wikipedia. n.d. Food technology. Accessed May 11 2021: https://en.wikipedia.org/wiki/Food_technology.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., and Wood, A. 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet, 393(10170), 447-492.

Wolfert, S., Ge, L., Verdouw, C. and Bogaardt, M.-J. 2017. Big data in smart farming: A review. Agricultural Systems, 153, 69–80.

Woolf, S.H. 2008. The meaning of translational research and why it matters. JAMA, 299(2), 211-13.

World Economic Forum. 2018. Innovation with a purpose: The role of technology innovation in accelerating food systems transformation. Accessed May 11 2021: http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf.

11 Exploring the Food Value Chain Using an OI Approach: A Bibliometric Review of the Literature

Avni Misra, Anne-Laure Mention

Preprint version to be published by Emerald Publishing Limited in the British Food Journal as Open Access under a Creative Commons BY 4.0 license[1]. No changes were made.

Abstract

This paper reviews the literature, foundational works, and current trends related to the adoption of open innovation practices in the food industry, through the lens of the food value chain, using a bibliometric and content analysis approach of 84 documents obtained using the Scopus database. This study provides an integrated framework of the intersection of OI and the food value chain, including under-researched, emerging areas, and critical challenges for open and collaborative innovation across the food industry. The framework can guide future research and inform policymakers and industry leaders alike on the vital areas of focus for innovation in the food industry.

Purpose: This paper reviews the literature, foundational works and current trends related to the adoption of open innovation (OI) practices in the food industry, with a particular focus on the food value chain, using a bibliometric and content analysis approach.

Design / Methodology / approach: This study is based on 84 published documents in the field of food OI obtained using the Scopus database. First, a bibliometric analysis was conducted using a bibliographic coupling and co-citation analysis approach to understand the common themes and key clusters of food OI research. It further highlighted authors, countries, journals, years of publication and subject areas to comprehend the scope of the established literature. Second, a content analysis was undertaken to examine the titles and abstracts of the documents to explore the intersection of OI and the food value chain.

Findings: This study provides an integrated framework of the intersection of OI and the food value chain, including information about under-researched and emerging areas in the field of food innovation. It also highlights the critical challenges associated with OI food research and practices.

[1] https://creativecommons.org/licenses/by/4.0/

Originality / Value: By adopting a multi-step approach involving a computer-assisted bibliometric examination complemented by a manual review undertaken through the lens of the food value chain, this literature review provides fresh and even unique insights into the past and present of research on OI in the food industry and paves for the way for future studies by laying out specific research avenues.

Keywords

Open innovation, Food value chain, Bibliometric analysis, Food innovation trends, VosViewer

Acknowledgement

We sincerely appreciate the insightful feedback the three anonymous reviewers provided and the co-editors' efforts. This research has received funding from the Horizon 2020 Programme of the European Union within the OpenInnoTrain project under grant agreement no.823971. The content of this publication does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the publication lies entirely with the author(s).

1 Introduction

The world's population has increased from 3 billion to over 7.8 billion in the last 60 years. The food supply has increased simultaneously, with farmers consistently growing enough food to feed 1.5 times the population of the day (Holt-Giménez et al., 2012; Richie and Rose, 2020). However, the OECD (2020) reports that over 800 million people have less food than they need, and even larger populations remain malnourished. Technological breakthroughs afforded by the fourth industrial revolution are creating new opportunities for large-scale and rapid change in food systems: how we produce, process, and consume food. However, between 2010 and 2018, when healthcare enjoyed US$145 billion in technological investments, food systems received only US$14 billion (World Economic Forum, 2018). This low attraction of resources coupled with lower adoption and ability to harness the benefits of emerging technologies (e.g., big data, machine learning, the Internet of Things), calls for an overhaul that will facilitate the holistic management of our food systems. Additionally, while technical and structural changes have benefited larger, well-resourced stakeholders in the food supply chain, the future of nearly 500 million smallholder farmers who produce about 80% of the world's food remains uncertain. Economic and political instability is causing an occupation decline as young farmers search for better-paying and more attractive jobs (World Economic Forum, 2018).

Governments in developing and middle-income countries are taking steps to manage the global food system. Since the 2009 G8 Summit, China, India and other emerging nations have made significant progress in curbing hunger and stimulating innovation in food technologies. These efforts have improved crop yield and productivity but also increased food waste and global gas emissions. Nearly one-third of the world's food production goes to waste, and food systems are responsible for almost 20%-30% of global greenhouse gas emissions (United Nations, 2017). Ironically, climate change due to increased greenhouse gas emissions threatens nearly a quarter of the world's crop yield (World Bank, 2017). Thus, among policymakers, academics, and other stakeholders, there is a consensus that our food systems need to be more inclusive, practical, nourishing, and beneficial for a sustainable future (Bogers et al., 2020; Farley and Scherr, 2020; World Economic Forum, 2018).

The COVID-19 pandemic created further challenges for the global food system, with acute hunger risks increasing from 135 million people to 265 million (World Economic Forum, 2020). On the one hand, there is a need for more sustenance and food support. On the other, a sudden decrease in demand due to closures and lockdowns during COVID-19 saw farmers having to dump milk and destroy harvests that could not be delivered due to disrupted supply chains (Wiener-Bronner, 2020).

Indeed, global food systems were distorted even before COVID-19, facing challenges like hunger and obesity, production and livelihood, yield and emissions, mass production and waste. For the most part, policy and strategies related to agriculture and food systems have been developed in silos. This isolation has both benefitted and harmed a fragile yet life-forming system – increasing mass production to deliver cheaper, faster food. At the same time, increasing health risks and obesity and investing in production efficiencies have limited farmers' flexibility to adapt to changing social and environmental conditions. However, recent calls in academic journals (e.g., Dabić et al., 2020; Marinova and Bogueva, 2021) and world forums (e.g., OECD, 2020; World Economic Forum, 2020) are drawing attention to the need for more holistic, open and collaborative practices in the food industry. Responding to these calls is the central purpose of this paper, which reviews the literature on open innovation (OI) practices in the food industry to sketch theoretically informed and pragmatically grounded avenues for further research. To do so, a multi-step approach is adopted. First, a descriptive review is presented, after which a computer-assisted bibliometric analysis is performed, complemented by a narrative literature review using the food value chain (FVC) as a guiding framework.

The remainder of the paper is structured as follows: the next section provides a brief overview of this paper's core concepts. The methodology for the multi-step review process is then described, followed by a presentation of the findings. This section culminates with the production of an integrative framework that paves the way for future research avenues. The paper continues with a discussion and concludes with managerial implications and limitations.

2 Setting the Scene: Open Innovation (OI) and the Food Value Chain (FVC)

2.1 OI

Since Chesbrough coined OI in 2003, its popularity and underlying reality have enjoyed increased momentum in both academic and practitioner communities. OI refers to the 'purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively'; according to this paradigm, firms 'can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technologies' (Chesbrough, 2006). The pervasiveness of the OI paradigm across innovation studies is undeniable. However, most research has focused on knowledge-intensive, high-tech industries and largely overlooked contexts characterized by lower levels of knowledge intensiveness or exhibiting lower levels of technological sophistication (Flor et al., 2019). The food industry, which is traditionally depicted as a low-tech industry (Eurostat), has been largely ignored in the mainstream OI literature (Bayona-Saez et al., 2017; Martinez et al., 2014). Scholars (Blasi et al., 2015; Devaux et al., 2018) have examined the level of innovativeness within the food industry at an organizational level by examining activities in the FVC. However, the theoretical research in the FVC context is limited to anecdotal reporting and needs a more systematic explanation.

2.2 The FVC

The FVC model has been widely used in the literature to examine different innovation contexts (Caiazza et al., 2014; Diamond and Barham, 2012; Rao et al., 2017). According to Humphrey and Memedovic (2006), the FVC consists of four key stages – input, production, processing (manufacturing), and output. The first stage consists of supplier-based activities related mainly to sourcing. The suppliers of different biological (seeds, soil, and animal and plant health items) and non-biological (equipment, chemical-based items, and services) goods and services provide those products and services to their primary consumers: farmers. In the second stage, the key activities produce raw materials such as crops, livestock, animal and plant breeding and farm management. Farmers supply raw materials to their primary customers, food and beverage processing and manufacturing companies. The third stage is when all manufacturing-related activities take place. The manufacturing and processing companies use raw materials to generate food and beverage products for distribution through multiple channels to downstream intermediaries and end consumers. In the fourth stage, retailers and wholesalers sell products to consumers. Although some relevant research has been conducted to understand food industry innovation, there is limited information available about the intersection and integration of OI practices and the FVC. It is thus essential, given the wide acceptance of the FVC approach both academically and in practice, to identify what has been examined to establish future research areas.

3 Methodology

3.1 Data collection

The literature for this paper was explored using a bibliometric analysis and a thematic content analysis approach to answer the following research question: 'What are the current and emerging research practices in the food sector related to open innovation?' In the bibliometric analysis, a combination of bibliographic coupling and co-citation analysis methods was applied, with the VosViewer 1.6.16 software used to present the results.

3.2 Inclusion and Exclusion Criteria

The researchers initiated the search with a keyword analysis using a Boolean search by running a query with the terms 'Food' AND 'Open Innovation' in titles, abstracts, or keywords. The keyword search was conducted using the Scopus database. Scopus has been demonstrated to be a comprehensive and widely accepted database consisting of most of the journals indexed by Web of Science and Google Scholar (Gölgeci et al., 2021; Harzing and Alakangas, 2016; Martín-Martín et al., 2018; Mongeon and Paul-Hus, 2016). Scopus is also an effective tool for searching literature as it facilitates searching by allowing the use of whole search strings such as" food " and "open innovation"(Bouzembrak et al., 2019).

As Figure 1 shows, the initial keyword search identified 182 documents; after an inclusion criterion - selected documents that were published in English and peer reviewed- 162 documents remained. Peer review serves as a valuable exclusion criterion, as documents reviewed by scholars are considered high quality and contain more reliable findings than non-peer-reviewed documents (Gölgeci et al., 2021; Secinaro and Calandra, 2020; Tang and Musa, 2011). To further ensure the relevance of the documents, the researchers read the titles and abstracts of the 162 documents and excluded 78 that did not primarily examine OI in a food industry-related discipline. This resulted in a refined sample of 84 documents for the final analysis. As Table I shows, all items were retrieved from Scopus (N=84).

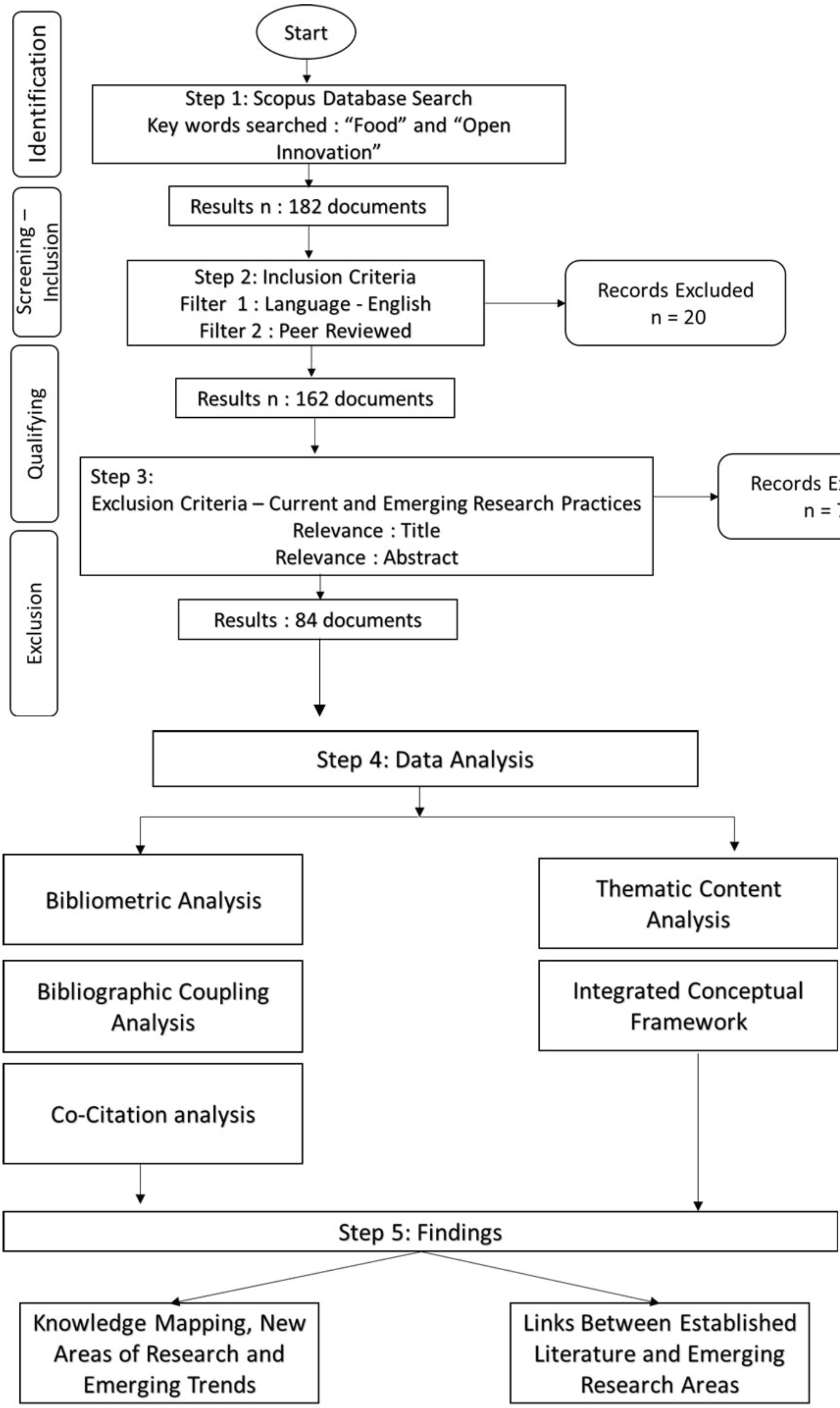


Figure 1 Flowchart of research methodology

3.3 Data Analysis

Using the final sample of 84 documents, the data were examined using bibliometric analysis and then a thematic content analysis approach. In previous bibliometric studies, a combination of methods including bibliographic coupling, co-citation analysis, and content analysis has been considered reliable as it provides a comprehensive understanding of the theoretical roots and defines the intricate links between established and emerging research areas (Casprini et al., 2020; Lyu et al., 2020; Opejin et al., 2020; Zeba et al., 2021). For example, the content analysis approach allowed Casprini et al. (2020) to link the findings from the co-citation approach to the results of bibliographic coupling, which provided a holistic view of future research areas. Zeba et al. (2021) applied a content analysis approach to gather a hierarchical clustering of keywords that co-occurred and find links between the past and current literature. Lyu et al. (2020) and Opejin et al. (2020) applied content analysis to generate key research themes and trends from the documents they studied.

3.3.1 Bibliometric Analysis

Bibliometric analysis is a well-recognized and practical, non-biased data analysis approach in food innovation and OI research (Dabic et al., 2020; Luo et al., 2018; Lyu et al., 2020; Randhawa et al., 2016; Vlačić et al., 2020; Vila-Lopez and Küster-Boluda, 2020). The 84 documents extracted from Scopus were analysed based on publication year and classified by author, affiliation, country, type, subject area and funding sponsors. The data are represented using a variety of tables and graphs with a summarised description of the critical indicators. The sample was then analysed using the VosViewer software, which facilitated building a network visualization (Bouzembrak et al., 2019). That software allowed the researchers to conduct a quantitative analysis of a large volume of literature for mapping knowledge, new research areas and hotspots, future trends and emerging research paths in the food OI field (Meng et al., 2020; Van Eck et al., 2010). The network and overlay visualization techniques illustrate different knowledge domains' hierarchies (Bouzembrak et al., 2019; Chen and Hsieh, 2007). The bibliometric analysis was conducted using the bibliographic coupling approach to identify key emerging research themes, while the co-citation analysis was used to identify the links between emerging research themes and previously established research (Casprini et al., 2020; Dabic et al., 2020; Meng et al., 2020; Vlačić et al., 2020). In addition, a hybrid network visualisation approach such as a combination of bibliographic coupling and co-citation analysis has proven to be a useful combination of techniques to comprehensively capture complex research links and address a wide range of research problems within a given context (Yan and Ding, 2012).

3.3.2 Bibliographic Coupling

A bibliographic coupling approach analysis was conducted using VosViewer 1.6.16 (Casprini et al., 2020; Meng et al., 2020). The coupling approach clusters recent documents by linking documents that quote the same set of cited papers and evaluating the links between citing documents (Boyack and Klavans, 2010; van Oorschot et al., 2018). Using the 84 documents in the final set, the software returned 4 clusters. The cluster resolution was one, and the minimum cluster size (size = 1) maintained the default values of random start at 10, with iterations equal to 10. Each cluster was examined based on the key concepts, theoretical framework, research problem, methodology and critical findings.

3.3.3 Co-Citation Analysis

A co-citation analysis was conducted using VosViewer 1.6.16 (Casprini et al., 2020; Meng et al., 2020; Vlačić et al., 2020). A co-citation analysis enables the identification of documents cited in several other sources, which helps establish the links between the papers for thematic evaluation (Casprini et al., 2020; Ferreira, 2018). From the 4,433 cited references in the 84 papers, using the minimum number of 5 cited references, 20 papers met the threshold and were grouped into 3 clusters. The abstracts and keywords were collected to categorize the clusters under a thematic cluster name for all documents in the three clusters. All papers were manually analysed to understand the links between them and identify future research areas within food OI.

3.3.4 Content Analysis: Developing an Integrative Framework

The bibliographic coupling and co-citation analyses resulted in clusters that provided sufficient information about existing knowledge on food OI. Those analyses produced clusters with 49 documents, of which 29 met the bibliographic coupling criteria and 20 met the co-citation analysis criteria. While the cluster analysis provides profound information about established literature, it was essential to review the remaining documents to determine whether there were topics that remain unexplored in the field of food OI. The in-depth analysis of the remaining 35 documents was also deemed necessary, given that the present study aims to identify future research areas in food OI. Hence, a detailed examination of the titles and abstracts of the 84 documents was conducted using a thematic content analysis approach that enables the researcher to capture potential information about valuable concepts, methods applied and important themes and to assemble a wider range of future research directions (Gao et al., 2020; Lyu et al., 2020).

For the analysis, we used the four stages of the FVC process as an analytical tool. We first identified the stages of the FVC process, and the activities conducted in each stage. The 84 documents were then classified and categorized based on how much the context of each document aligned with which stage of the FVC: input, production, manufacturing, and output. Then, each document's title and abstract were further examined through a food OI lens, which allowed the researchers to map the intersection between food OI and the FVC. The authors developed an integrative framework during the final stage of the analysis. The identified themes were then studied to seek links between the established literature and emerging research areas.

4 Research Findings

4.1 Visibility of Authors in Food OI

Table I shows a ranking of authors by number of publications (including co-authored documents). Most documents published by the top 10 authors were published in the 2014-2020 period. The main subject areas of focus include agricultural and biological sciences, business management and accounting, engineering and computer science, suggesting a wide range of inter-disciplinary collaboration ranging from science, technology, engineering and mathematics (STEM) fields to business.

Table I10 Documents by author visibility

Authors (Top 10)	No. of Documents	Years Published	Subject areas	Countries
Saguy, I.S.	4	2018, 2016, 2013, 2011	Agricultural and Biological Sciences Engineering Chemistry	Israel, Australia, USA, Ireland, Switzerland
Lazzarotti, V.	3	2017, 2014	Business Management and Accounting, Economics, Econometrics, and Finance, Social Science, Agricultural and Biological Science, Computer Science, Engineering	Italy, Spain, UK
Manzini, R.	3	2017, 2014	Business Management and Accounting, Economics, Econometrics, and Finance, Social Science, Agricultural	Italy, Spain, UK

			and Biological Science, Computer Science, Engineering	
Tóth, J.	3	2020, 2016, 2014	Agricultural and Biological Science, Business Management and Accounting, Energy, Environmental Science, Social Science	Hungary, Belgium, Italy, Netherlands, Romania
Bigliardi, B.	2	2019, 2016	Business Management and Accounting, Economics, Econometrics, and Finance	Italy
Chesbrough, H.	2	2020, 2014	Business Management and Accounting, Agricultural and Biological Science	USA., Denmark, Italy
Cohen, E.	2	2018, 2016	Agricultural and Biological Science, Chemistry, Engineering	Australia, Israel, Ireland
Costa, A.I.A.	2	2016, 2018	Agricultural and Biological Science, Biochemistry, Genetics, and Molecular Biology, Decision Sciences	Portugal, Italy
Fortuin, F.T.J.M.	2	2014, 2009	Business Management and Accounting, Agricultural and Biological Science, Computer Science	Netherlands
Galati, F.	2	2019, 2016	Business Management and Accounting, Economics, Econometrics, and Finance	Italy

4.2 Year of Publications

For this paper, a time-related exclusion criterion was not applied to ensure that a thorough search was conducted, so all peer-reviewed documents related to this topic were captured. As Table II shows, the first documents for this paper were completed in 2008. From 2008 to 2012, the number of published documents ranged between two and four per year, suggesting a steady pace that was not overwhelming in terms of volume. However, there was a dramatic rise in the number of publications between 2011 and 2015. The largest number of published documents appeared in 2020.

Table II Documents by year of publication

Year of Publication	Subject Area	No. of Authors
2020	Social Science, Business Management and Accounting, Environmental Science, Economics, Econometrics and Finance, Energy, Agriculture and Biological Science, Psychology	46
2019	Agricultural and Biological Science, Business Management and Accounting, Decision Sciences, , Economics, Econometrics and Finance, Medicine, Multidisciplinary, Pharmacology, Toxicology, and Pharmaceutics, Psychology	32
2018	Agricultural and Biological Science, Business Management and Accounting, Engineering, Chemistry, Computer Science, Decision Sciences, Economics, Econometrics and Finance, Energy, environmental Science, Materials Science, Medicine, Nursing, Social Science	44
2017	Agricultural and Biological Science, Business Management and Accounting, Economics, Econometrics and Finance, Decision Sciences, Social Science	33
2016	Agricultural and Biological Science, Business Management and Accounting, Economics, Econometrics and Finance, Decision Sciences, Engineering, Social Science, Veterinary Science	34
2015	Agricultural and Biological Science, Business Management and Accounting, Economics, Econometrics and Finance, Energy, Environmental Science, Pharmacology, Toxicology, and Pharmaceutics, Social Science	7
2014	Agricultural and Biological Science, Business Management and Accounting, Economics, Econometrics and Finance, Computer Science, Social Science, Engineering, Pharmacology, Toxicology, and Pharmaceutics	21
2013	Agricultural and Biological Science, Business Management and Accounting, Arts and Humanities, Computer Science, Engineering, Environmental Science, Social Science	27
2012	Business Management and Accounting	7

2011	Agricultural and Biological Science, Business Management and Accounting, Computer Science, Biochemistry, Genetics, and Molecular Biology	8
2010	Agricultural and Biological Science, Business Management and Accounting, Computer Science, Decision Science	8
2009	Agricultural and Biological Science, Business Management and Accounting, Economics, Econometrics and Finance, Medicine, Pharmacology, Toxicology, and Pharmaceutics	4
2008	Agricultural and Biological Science, Biochemistry, Genetics, and Molecular Biology	3

4.3 Geographic Distribution by Countries and Territories

The graph in Figure 2 presents the documents based on country with research on food OI; this provides insights into different research collaborations and partners in research (Le et al., 2019; Wambu et al., 2017). The figure shows that authors from 34 countries published food OI research between 2008 and 2020 and that researchers in 15 countries made critical contributions in the field. The countries' ranking was based on the total number of documents produced by authors from those countries.

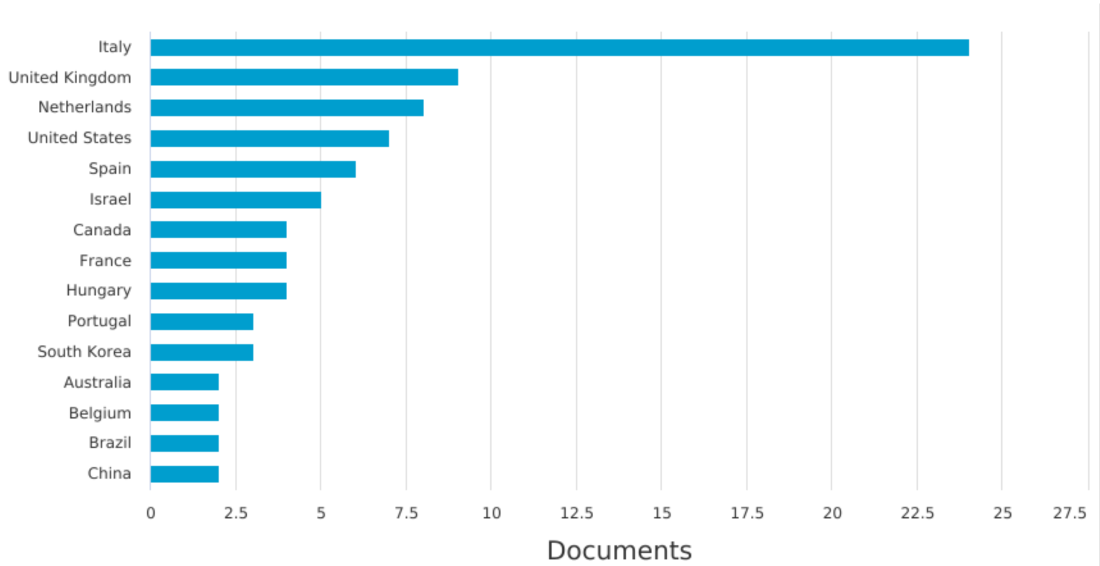


Figure 2 Documents by country or territory

4.4 Bibliographic Coupling Analysis

A total of 31 documents met the bibliographic coupling threshold of a minimum of 10 citations. The most extensive set of related items is 29. The analysis revealed 4 clusters (see Figure 3) that showed the most concentrated research focus areas in food OI.

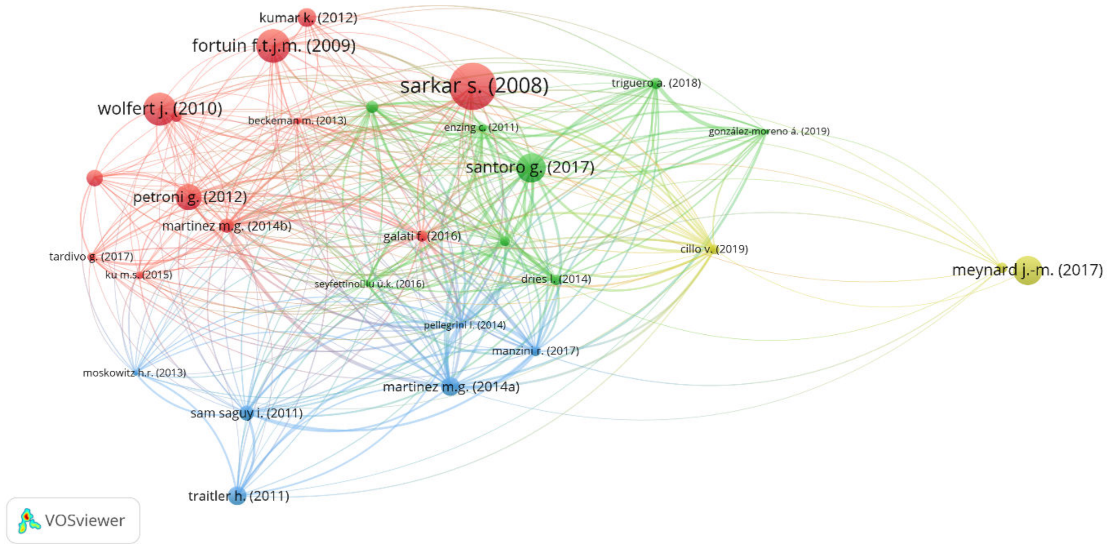


Figure 3 Bibliographic coupling (minimum 10 citations)

Cluster one (red) comprises 12 contributions between 2008 and 2016 and contains essential research on food OI; accordingly, we call it 'Drivers of OI in the food industry'. The cluster includes a mix of quantitative and qualitative approaches, though it predominantly consists of qualitative case study-based techniques using small food firms as the context (Beckeman et al., 2013; Filieri, 2013; Galati et al., 2016; Martinez, 2013; Siedlok et al., 2010; Tardivo et al., 2017; Wolfert et al., 2010). This cluster's primary emphasis is on understanding the key drivers and approaches to managing OI in food firms. Filieri (2013), Tardivo et al. (2017) and Martinez (2013) emphasized the integration of co-creation practices as a valuable tool for generating value through OI in food and beverage firms. Co-creation practices involve consumers in the innovation process to create competitive value-based innovation outcomes. This research stream has confirmed that embedding co-creation practices stimulates the OI process in a competitive direction, especially among functional SMEs in the food industry. In a similar vein, Galati et al. (2016) identified two strategic approaches (open market pull and open technology push) that drive OI in small firms. The former involves integrating consumers into innovation, and the other consists of collaborating with external entities to develop impactful innovations. Petroni et al. (2012), Fortuin and Omta (2009) and Siedlok et al. (2010) also established important driving factors for OI in the food industry such as market competition, stakeholder demands, time to market and unequal power distribution in the supply chain, explicitly indicating the supporting and competitive role of networks in food and beverage OI. The studies conducted by Ku (2015), Beckeman et al. (2013), Kumar et al. (2012), Wolfert et al. (2010) and Sarkar and Costa (2008) in this cluster indicate the growing importance of OI practices in the food sector. Empirical evidence is provided from a range of studies demonstrating that the successful orientation of food-based SMEs and food manufacturers towards an OI mindset and designing OI-centric business models is a practical approach to growth in the food sector. While implementing OI strategies is gaining attention, it is still a nascent and developing approach within the food sector.

The second cluster (green) consists of eight contributions that appeared between 2011 and 2019 and represents a growing number of recent studies in the food OI field. A quantitative methodological approach is used by most of these studies (Bayona-Saez et al., 2016; Dries et al., 2014; Enzing et al., 2011; González-Moreno et al., 2019; Santoro et al., 2017; Seyfettinoğlu, 2016; Triguero et al., 2018). Santoro et al. (2017) is the most frequently cited document in this cluster, which we call 'OI impact on food and beverage organization performance'. The type of innovation approach influences the competitive performance of a firm. Implementation of a collaborative approach for innovation has been recognized in any number of studies. This cluster indicates a similar research focus, with most studies examining the role of a collaborative OI approach and its impact on the performance of food and beverage organizations and on the type of innovation that those organizations generate (Arcese et al., 2015; Bayona-Saez et al., 2016; Dries et al., 2014; Enzing et al., 2011; González-Moreno et al., 2019; Santoro et al., 2017; Seyfettinoğlu, 2016; Triguero et al., 2018). Another critical characteristic of a group of contributions in this cluster is applying an OI approach through a sustainability lens (Arcese et al., 2015; González-Moreno et al., 2019; Triguero et al., 2018). Open, sustainable innovation approaches provide several advantages to food and beverage organizations by reducing expenditures, providing rapid access to market, decreasing environmental impacts and alleviating food insecurity and negative social impacts (Arcese et al., 2015). Inbound OI (i.e., sourcing external knowledge for in-house innovation activities) has been identified as a critical driver of eco-innovation in the food and beverage industry. The collaborative nature of OI facilitates the extensive use of external knowledge for developing eco-innovations (Triguero et al., 2018). In addition, González-Moreno et al. (2019) extended this by understanding the link between the innovating food firm and its stakeholder interactions and found that such cooperative relationships positively influence the development of eco-products and eco-processes. A group of studies in this cluster also focuses broadly on an the OI approach's capability to leverage external knowledge for developing new products in the food and beverage sector. Bayona-Saez et al. (2016) and Santoro et al. (2017) suggest a positive relationship between OI practices and an organization's innovation performance, which should be effectively employed in the food and beverage sector to gain competitive advantage through new product development. Seyfettinoğlu (2016) confirms that applying an OI approach in the food industry can increase productivity. In addition, food OI practices that consist of more open and diverse network relationships increase a product's market performance (Enzing et al., 2011). These results all suggest a constructive association between firm performance and OI approaches.

In contrast to OI practices' positive influence, a group of scholars in the cluster applied a process-based approach to understand OI practices. These researchers found that OI practices should be limited to certain stages of the innovation process, specifically idea generation. They also found that an overreliance on OI can hamper production efficiency and firm performance, specifically in the development and commercialization stages (Dries et al., 2014; Santoro et al., 2017; Seyfettinoğlu, 2016).

In cluster three (blue), six contributions spanning from 2011 to 2017 were linked; the cluster is concerned with the 'New precursors of OI' in the food industry. This research stream provides information about the different models and frameworks that explain the antecedents that are important for successful OI implementation to achieve valuable innovation outcomes in food and beverage organizations. Pellegrini et al. (2014) highlight the need for the food and drink sector to open up its innovation processes, a point that managers and academics have previously made when discussing how to obtain advanced knowledge in OI practice. For example, Traitler et al. (2011) suggest using an interdependent, sharing-is-winning (SiW) and innovation partnerships approach for reinventing research and development (R&D) structures and consumers' role in an OI ecosystem. The application of an SiW approach enables the co-development of sustainable innovation with less effort. It reduces resource and time management complexities by efficiently allowing for the division of key activities amongst innovation partners. Saguy (2011) offers another example regarding the implications of the SiW and innovation partnership approach in academia and the food industry setting for better using OI's benefits. This would allow academia to conduct valuable fundamental research and engage industry in inventions. Moskowitz and Saguy (2013) studied the changing role of consumer research in OI to improve new product development. Their research pushes boundaries by suggesting that the role of consumer research is to move beyond testing towards design and gatekeeping for consumer responses, change leaders and intellectual capital providers. Other important precursors of OI include the context, business environment and degree of firm openness (Martinez et al., 2014). Technology pressure exerted by ever-changing trends pushes innovating firms to collaborate extensively with external partners, which is a fundamental element of all OI practices. This further increases the degree of openness and leads to better innovation outcomes. The need for greater transparency is also reported by Manzini et al. (2017) in their study of the Lindt approach to innovation. Despite the successful implementation of a closed innovation approach, a stout requirement for a sophisticated degree of openness was identified for the focal firm to increase creativity to sustain its place in the European Union market. The identified precursor for OI in such cases is competitive pressure.

Cluster four (yellow) comprises three contributions (Berthet et al., 2018; Cillo et al., 2019; Meynard et al., 2017). These papers provide a new perspective on OI's application in the food and beverage industry; hence, the cluster is named 'Nuanced OI approaches in agriculture'. The level of OI knowledge in this cluster provides a higher degree of complexity in implementing OI strategies in the agriculture industry. The cluster sheds light on the open design, coupled innovations and technologically integrated OI approaches to knowledge management. For example, Berthet et al. (2018) examined OI using a co-design and co-innovation perspective in an agricultural context. Meynard et al. (2017) applied a coupled innovation approach to explain the importance of combining the dynamics of two different domains of the agricultural system and focusing on design as a critical stage of innovation. Adopting a digital perspective, Cillo et al. (2019) studied crowdfunding platforms' integration in agri-food businesses to understand their relationship with the OI approach's successful implementation. All studies in this cluster propose findings that instigate discussions around future implications and expand the OI approach. It is also worth noting that this cluster focuses explicitly on the upstream end of the FVC, concentrating on the food and beverage industry's agricultural activities. This is a further indication of the lack of sufficient FVC research focused on the downstream end of the chain.

Table III The four clusters of bibliographic coupling

Cluster nr.	**Colour**	**Nr. of items**	**Time span**	**Total link strength**	**Keywords**	**Authors**	**Cluster re-named**
1	Red	12	2008-2016	22-156	Open innovation, Food firms, SMEs, Low tech, Customer orientation, Business process management, Knowledge management, R&D organization, Customer co-creation	Tardivo et al. (2017) Galati et al. (2016) Ku (2015) Martinez et al. (2014) Beckeman et al. (2013) Filieri (2013) Kumar et al. (2012)	Drivers of OI in the food industry'

						Petroni et al. (2012) Siedlok et al. (2010) Wolfert et al. (2010) Fortuin and Omta (2009) Sarkar and Costa (2008)	
2	Green	8	2011-2019	104-183	Open innovation, Innovation network, Innovation performance, Dynamic capabilities, Food sector, New product development, Eco-innovation	González-Moreno et al. (2019) Triguero et al. (2018) Santoro et al. (2017) Bayona-Saez et al. (2017) Seyfettinoğlu (2016) Arcese et al. (2015) Dries et al. (2014) Enzing et al. (2011)	OI impact on food and beverage organization performance’
3	Blue	6	2011-2017	49-241	Food industry, Open innovation, Collaborative innovation strategies, Consumer research, Paradigm shift,	Manzini et al. (2017) Pellegrini et al. (2014) Martinez (2014) Moskowitz and	New precursors of OI

					Innovation partnerships, Strategic alliances	Saguy (2013) Saguy (2011) Traitler et al. (2011)	
4	Yellow	3	2017-2019	2-125	Knowledge exploitation, Knowledge exploration, Knowledge management, Network management, Open innovation, Value chain, Innovative design	Cillo et al. (2019) Berthet et al. (2018) Meynard et al. (2017)	Nuanced OI approaches in agriculture

4.5 Co-citation analysis

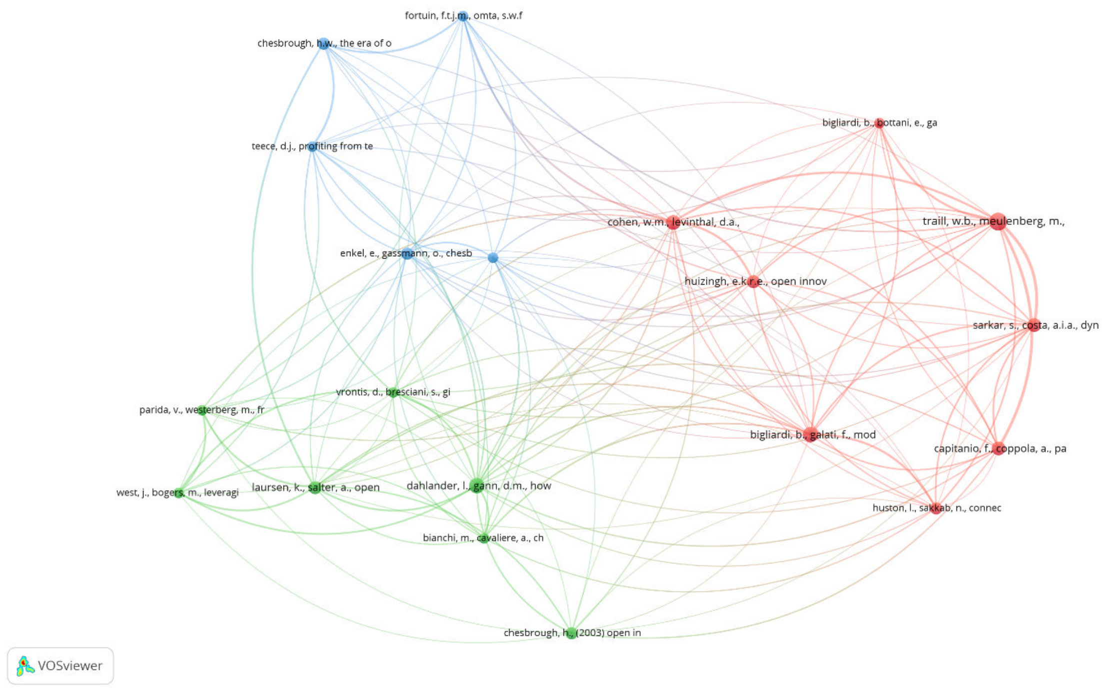


Figure 4 Co-citation analysis (minimum five citations)

In the second stage of the bibliometric analysis, a co-citation analysis was conducted to identify the different theoretical perspectives that are relevant and make contributions to the field of food OI, as shown in Table IV. The perspectives were categorized into three clusters.

Table IV The three clusters of co-citation analysis

Cluster nr.	**Colour**	**Nr. of items**	**Time span**	**Total link strength**	**Key contributions**	**Cluster re-named**
1	Red	8	1990 - 2013	4-12	Bigliardi et al. (2010) Bigliardi and Galati (2013) Capitanio et al. (2010) Cohen and Levinthal (1990) Huizingh and EKRE (2011) Huston and Sakkab (2006) Sarkar and Costa (2008) Traill and Meulenberg (2002)	Convergence in OI
2	Green	7	2003 - 2016	3-9	Bianchi et al. (2011) Chesbrough et al. (2003) Dahlander and Gann (2010) Laursen and Salter (2006) Parida et al. (2012) Vrontis et al. (2016) West and Bogers (2014)	Degree of openness
3	Blue	5	1986 - 2010	5	Chesbrough et al. (2003) Enkel et al. (2009) Fortuin and Omta (2009) Gassmann et al. (2010) Teece (1986)	Emerging arenas of OI

As Figure 5 shows, the first cluster (red) consists of eight contributions that run from 1990 to 2013. The primary sources of publication were *Trends in Food Science and Technology* (2) and *Agribusiness* (2). The major contributions include Cohen and Levinthal (1990), Bigliardi and Galati (2013), and Traill and Meulenberg (2002). The documents in this cluster focus primarily on understanding the internal and external factors that will shape future OI processes and portfolios of food-based organizations. Therefore, the cluster is named 'Convergence in OI'. Studies conducted by Huizingh (2011) and Cohen and Levinthal (1990) can be applied to understand the influence of internal factors on OI in a broad sense. Examples include the context in which an OI process operates and its dependence on that context, an organization's absorptive capacity and its influence on the innovation activities related to adoption and diffusion. Internal factors are a firm's R&D capabilities, demographics, strategic approaches, process orientation and innovation type, all of which influence OI's successful implementation. Traill and Meulenberg (2002) and Sarkar and Costa (2008) emphasize that a firm's method of innovation, motivation, choice of product versus process orientation, nature of ownership, technological and marketing capabilities and size are some of the internal factors that can wield significant influence on the organization's innovation decisions. Another internal perspective applied by authors in this cluster is the ability to collaborate for resource management. Huston and Sakkab (2006) suggest the 'connect and develop model' to explain the role of networking and engagement capabilities and their influence on innovation. In addition, Capitanio et al.'s (2010) findings highlighted that successful product development in the food industry relies heavily on an organization's capacity to build relationships. Huston and Sakkab (2006) explain the role of external collaboration in OI using Procter and Gamble's strategic OI approach, which leads to enhanced product quality and reduces development costs and time to market. In his state of the art, sector-agnostic article, Huizingh (2011) suggests that other external factors include the market environment and the impact of globalization, technological fusion, and innovative business models. Bigliardi and Galati (2013) examined a specific food category and its innovation future in the context of the influence of health trends, technological processes and design approaches. This importance of external influence had been previously explored by Sarkar and Costa (2008), who found that OI in the food industry was still an emerging approach. However, its effectiveness can be improved by incorporating actors both internal and external to the FVC. Actors involved in the FVC perceive innovation differently, based on which they form collaborative relationships that support the innovation process. Bigliardi et al. (2010) indicated that not all actors in the FVC had adopted the OI paradigm to the same extent. While the downstream actors (manufacturers and customers) were actively participating and implementing the OI approach, the upstream end (suppliers) was still learning.

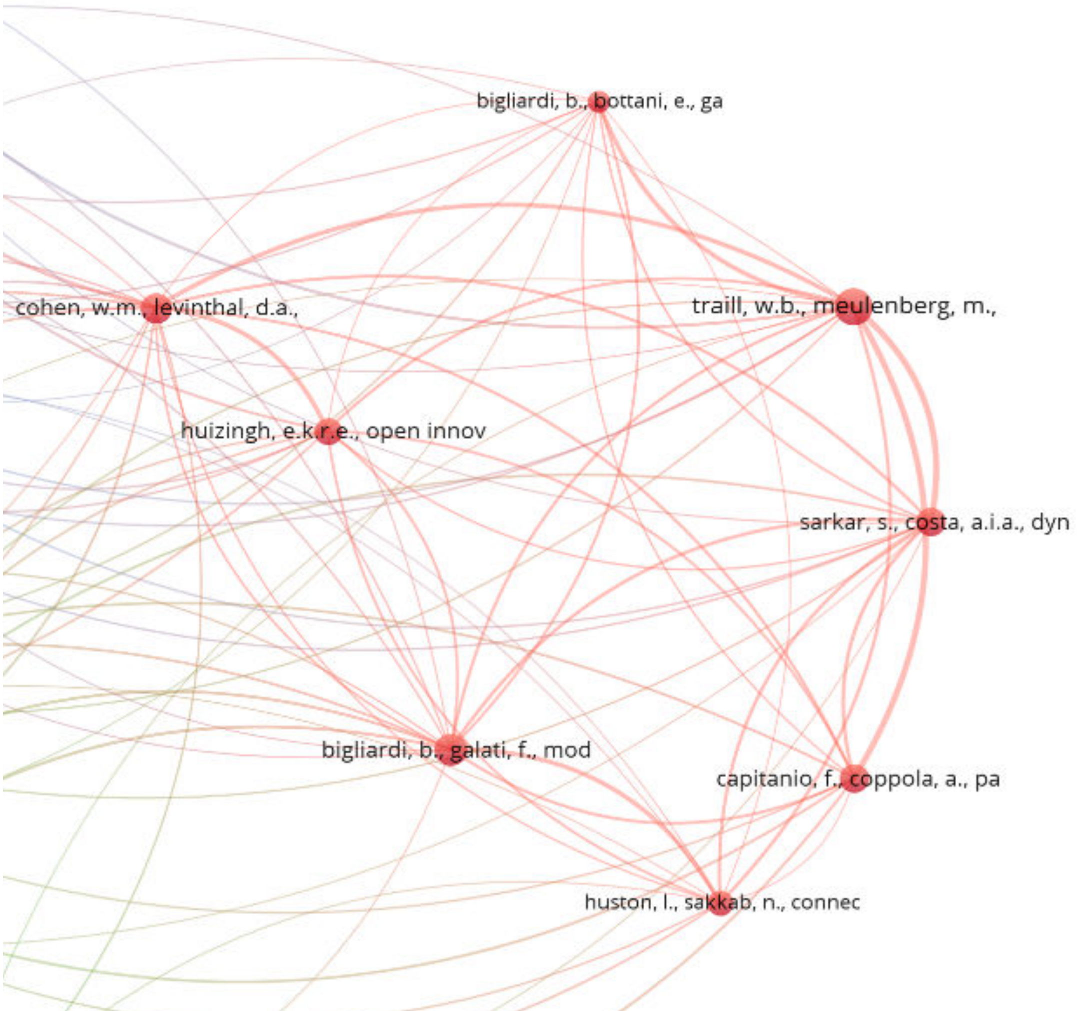


Figure 5 Co-citation analysis cluster 1 (red)

In the second cluster (green), which is shown in Figure 6, seven key contributions were included, bridging research from 2003 to 2016. The main contributions of the cluster were Dahlander and Gann (2010), Laursen and Salter (2006) and Chesbrough (2003). The cluster relies mainly on examining the importance of openness in innovation from a theoretical point of view, leading to the cluster being named 'Degree of openness'. The cluster's core contributions examine the role of openness and its influence on innovation outcomes (Bianchi et al., 2011; Dahlander and Gann, 2010; Laursen and Salter, 2006; Parida et al., 2012; West and Bogers, 2013). This cluster consists of critical contributions to OI, with Chesbrough (2003) establishing OI's theoretical foundation and its implementation as a robust innovation strategy. That foundation is reflected in several contributions in this cluster, as in Laursen and Salter (2006), who extend the understanding of OI by examining the concepts of 'breadth and depth' as crucial components of openness in firms and their effect on the firms' innovation performance. The findings accord with Chesbrough's (2003) perspective of exploring the external environment to gather more innovation opportunities using a balanced OI approach. In their bibliometric analysis, Dahlander and Gann (2010) confirmed that the established OI literature suggests that openness is necessary, at least to some extent and at selected stages of innovation, depending on context. Some attributes of creation should be accessible, while others should remain closed. Assessing the success of a given OI strategy should be carried out on a case-by-case basis across different technologies and industries to better understand the barriers and enablers linked to OI implementation.

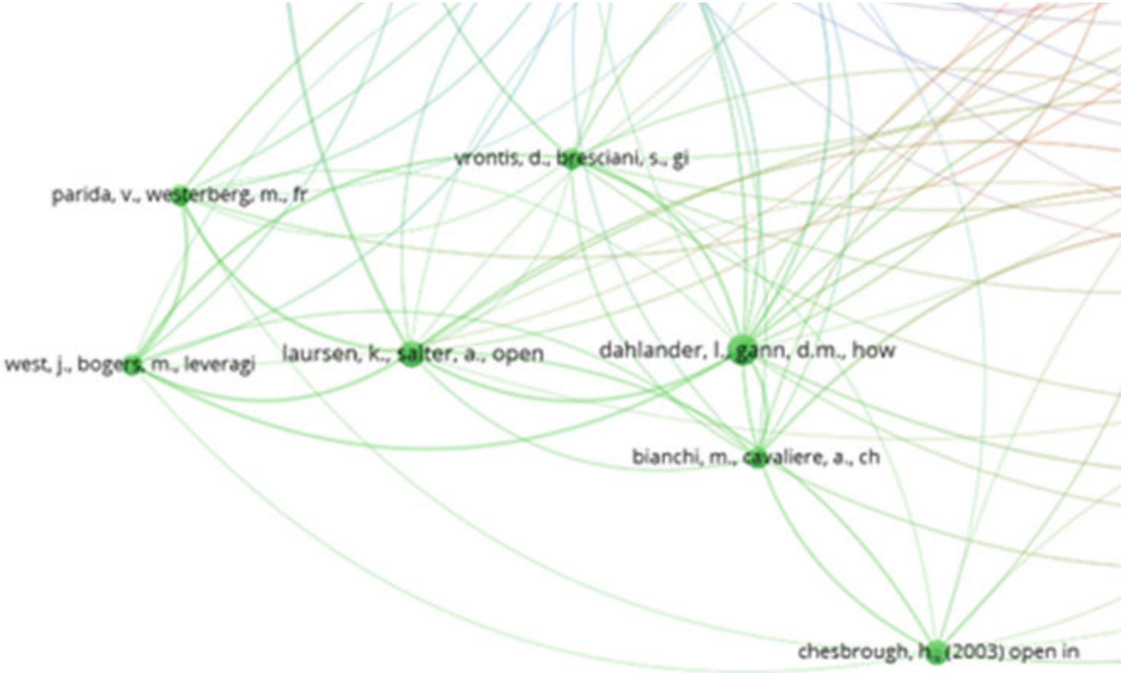


Figure 6 Co-citation analysis cluster 2 (green)

It is notable that the foundational work of Bianchi et al. (2011) offers a major advance in understanding the different combinations of organizational modes of collaboration and inbound and outbound OI strategies; of particular importance is the authors' emphasis on the degree of openness. Their findings indicated that increases in external partners and alliances to access resources had improved the new product development process. In the same vein, Vrontis et al. (2016) report that combining tradition and innovation strategies can provide competitive innovative outcomes. The cluster offers a good mix of studies examining large and small organizations. For example, Bianchi et al. (2011) used a mix of large and small pharmaceutical firms as a context to study openness, while Parida et al. (2012) examined the impact of integrating an open approach in SMEs. Their findings confirm that implementing an OI approach in SMEs led to improved innovation performance with different types of innovation. It is striking that researchers across other innovation domains have extensively supported the integration of external collaborations; however, the level of openness for the exploitation of innovation is not well grounded (West and Bogers, 2014).

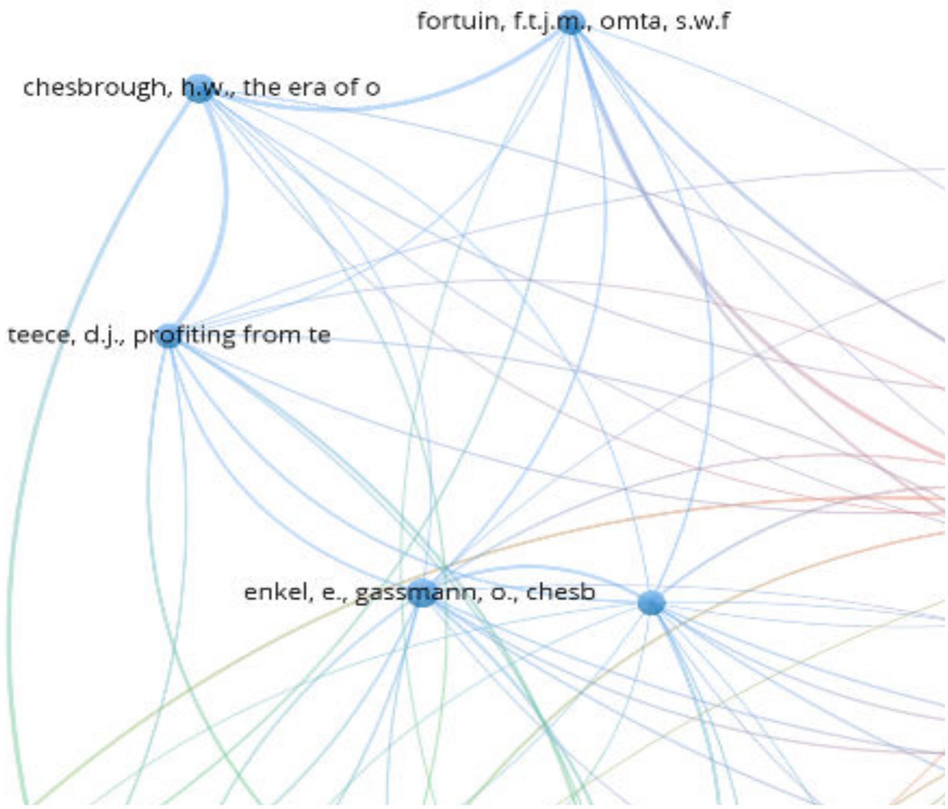


Figure 7 Co-citation analysis cluster 3 (blue)

Cluster three (blue), shown in Figure 7, is comprised of five contributions that range from 1986 to 2010. The primary sources are *R&D Management* (2) and *Research Policy* (1). Chesbrough (2003) and Enkel et al. (2009) have the most frequently cited contributions. A deeper analysis reveals that the cluster thematically focuses on identifying OI's most promising research areas, indicating the need for further research using multiple perspectives to examine OI's implementation in different industry contexts. Therefore, the cluster is named 'Emerging arenas of OI' This cluster's core contributions emphasize the need for more research to understand the OI approach and its management in SMEs (Chesbrough, 2003; Enkel et al., 2009; Gassmann et al., 2010).

Further research is also needed to identify intellectual property and patent management issues (Teece, 1986; Gassmann et al., 2010; Enkel et al., 2009). Other areas of need include developing OI models that integrate boundaries for innovation from a spatial perspective. The cluster highlights some critical areas that future authors can explore using an FVC approach to emerging research areas in food OI.

4.6 An Integrative Framework of FVC and OI

The proposed integrative framework provides directions for future research by drawing on the links between existing food OI research and the four stages of the FVC. In Table V, a matrix shows the intersection of the FVC and published food OI research. The table shows how the four stages of the FVC intersect with existing research regarding types of OI approaches, knowledge management capabilities, antecedents of OI, barriers to OI and the impact of OI across different stages of the FVC. The authors categorised the content from the titles and abstracts of 84 documents based on the FVC stages and present the observations under different research indicators in the matrix in Table V. That table reveals areas where scholarship has made rigorous contributions and highlights areas where there is room for theoretical development. In the matrix, the large black spaces indicate a lack of research at a given area of intersection.

Table V Integrative framework of FVC and OI

FVC/OI Intersection	**Input**	**Production**	**Processing**	**Output**
OI approaches	R&D Collaborations, OI Business Model, Ecosystem Model,	Information Technology Integration, Stakeholder Management, Co-Creation Approach, Coupled Innovation, Radical Circles, Co-Design, Co-Innovation, Crowdfunding	Eco-Innovative, Inter-Firm Transactions, University Collaborations, New Product Development Process, Service Blueprint, Consumer-Based Pro-Sumption, Traditions, Value-Cocreation, Process Innovation, Organisational Structures	Hybrid Business Model Approach, Consumer Integration, Open Sustainability Innovation, Integrating Lead Users, Radical Circles

Knowledge management capabilities	Knowledge Valorisation	User-Centric Approach, Customary Seed Sharing, Knowledge Sharing Ecosystems, Model of Knowledge Generation, Technology Transfer Mechanisms, Exploitation Capabilities	Absorptive Capacity, External Revealing of Knowledge, Knowledge Network, Hackathons and Crowdsourcing, External Knowledge Sourcing, Convergence and Reorientation, Sharing-Is-Winning Model	Technological Modularity, Regional and Company-Specific Factors, Value Capture Mechanisms
Antecedents of OI	Multilateral Systems, Synthesis of Stakeholders	IP Management, Technical, Regulatory Factors, Trust-Based Relationships, Responsible Research, and Innovation Tools	Innovation Sources, Type of Innovation, Market and Consumers, Open Market Pull and Technology Push, Innovation Models, Open Behaviour, Collaboration Breadth and Depth, Early Customer Integration, Innovation Patterns, Strategic Orientation,	
Barriers of OI	Access to Capital and Human Resources, Legislative Barriers, Knowledge Sharing Risk	Mental Innovation Space, Inexperience with Innovation	Degree of Openness, Innovation Resource Management, Power of Distribution	Regulatory Mechanisms, Policy and Governance Impact

Impact of OI	R&D in Agribusiness, Best Practices Approaches, Benefits for Government and Farmers, Agricultural Exploitation	Enhanced Prototyping, Validating	Financial Sustainability, Promote Eco-Innovations, Sustainability, Competitive Advantage, Adoption, Innovation Performance, Durability, Improved Product Quality	Development of Superior Value Propositions, Competitive Advantage, Adoption Process

To fully understand the intersection of OI and the FVC, it is crucial to view the stages of FVC through an innovation lens. The integration of OI can be mapped by type of innovation activity undertaken at the various FVC stages. A divergent value creation and innovation approach is applied at different stages of the FVC based on the diverse requirements of stakeholders and primary customers (Henriksen et al., 2010).

The framework will help scholars observe the FVC from an OI perspective. The critical questions here are, 'What is the influence of OI on the FVC? What are the areas in an OI-integrated FVC that remain uncharted and need research, and how is that research to be conducted?' Below we discuss the observations that emerged most prominently from the framework.

4.6.1 Research distribution across the stages of FVC

The analysis showed that stage three (the processing stage) of the FVC is prevalent amongst OI scholars. A total of 52 documents were linked to that stage, whereas 17 were related to the production stage, making it the second most researched stage. Eight documents were related to output and only five to input, making it the least explored area of the FVC from the OI perspective.

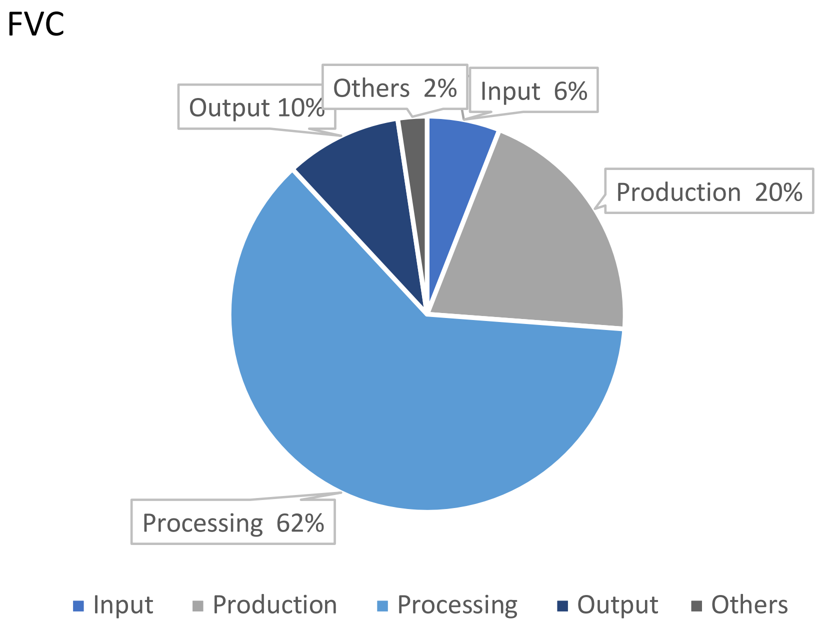


Figure 8 Distribution of documents: Intersection of FVC and OI.

4.6.2 OI Approaches

As Table V shows, all stages of the FVC have been examined using different OI approaches. The most prevalent perspectives include stakeholder management, consumer integration, process innovation, crowdfunding approaches, sustainable or eco-innovation and R&D collaborations. The production and processing stages of the FVC have been examined more intensively than input and output. Most authors have framed their analysis by understanding different actors' roles (individual, organizational, technological) and contributions to various innovation activities. One interesting OI approach uses the eco-innovation and sustainability perspective on the FVC's processing and output stages.

Figure 9 An adapted model of the range of OI perspectives examined in the FVC

The authors of the present study developed an adaptive model (see Figure 9) to show that scholars have focused on understanding the different OI approaches more by exploring consumer or customer involvement in the innovation process. The dominant approaches were consumer-based integration, co-creation, co-design and lead user integration. The least explored perspective was the integration of design experts in the innovation process. In the middle of the spectrum were other general perspectives exploring the roles of internal and external stakeholders.

4.6.3 Knowledge Management Perspective

The integration of OI has been examined from a knowledge management capability (KMC) perspective. KMC refers to a firm's ability to create, share and use knowledge across its operational limits (Lichtenthaler and Lichtenthaler, 2009). A limited number of studies focused on examining the FVC input and output stages using a KMC perspective. In the processing and production stages, the KMC assessment was predominantly applied to uncover how knowledge is shared using customary seed sharing and knowledge sharing ecosystems, technology transfer mechanisms, external revealing of knowledge and the sharing-is-winning approach. The research also refers to how knowledge is created with the user-centric model of knowledge generation, hackathons and crowdsourcing and the external knowledge sourcing approach. However, the ways knowledge is used are analysed using only a few approaches (exploitation capabilities, convergence, and reorientation) and is not well grounded.

4.6.4 OI Antecedents

The analysis of the antecedents' variables – the critical external and internal drivers – revealed that most of the studies of antecedents focused on the processing stage; there was scarce research on the input and production stages and no research linked to the output stage. The external precursors identified across the input, processing and production stages include technical and regulatory factors, innovation sources, market and consumers, open market pull and technology push. The main internal antecedents include synthesis of stakeholders, intellectual property management, responsible research and innovation types, models, patterns and behaviours. It quickly became clear that only limited research has been conducted to examine external FVC antecedents when compared to the range of internal FVC antecedents.

4.6.5 OI Barriers

The type of OI barriers was analysed across all four stages. There are more OI-related barriers associated with the input and output stages than the other two stages. Some common obstacles include access to capital, degree of openness, legislative barriers and power of distribution. Some distinctive concepts such as 'mental innovation space' were also applied at the production stage and are an essential issue related to OI barriers across the FVC. Identifying barriers across all four stages is an important aim because it could improve the design of policy interventions.

4.6.6 Impact of OI

The framework examined the link between studies that examined OI's impact at different organizational dimensions in the food context. The research revealed only limited links between the production stage and OI impact. The impact of OI on the FVC is most visible in R&D in the production stage, generating benefits for stakeholders, promoting eco-innovation, encouraging innovation performance and gaining a competitive advantage.

5 Discussion and Future Directions

Several scholars have shown increasing interest in mapping innovation activities across the FVC (Caiazza et al., 2014; Diamond and Barham, 2012; Zilberman et al., 2019). Still, the role of OI has grown dramatically in importance amongst a wide range of food innovation scholars.

The analysis revealed a gradual increase in the scholarly literature on food innovation in recent years. It remains well aligned with the emergence of new techniques, novel modified raw materials, emerging technologies and food demands. The highest number of documents in this field were from Europe, followed by the United States and Canada, proving the food industry to be a priority in these areas of the world. The geographic distribution of researchers and affiliations provides an opportunity for future researchers to consider collaborations with authors from different regions and is an opportunity for researchers from other regions to conduct similar studies to examine multiple food innovation-related contexts and improve the generalizability of the research results.

Most authors explore specific innovation activities that create value at different stages in the FVC; while they provide a comprehensive view of the influence of OI on certain FVC activities, none of the studies focuses on providing a holistic view using a process-based approach to examine the influence of OI on the FVC, which offers opportunities for future research. The statistical analysis of the subject areas reveals that the study of food innovation is gradually maturing and migrating from core research fields like agricultural and biological sciences and moving towards food business management, manufacturing, packaging, economics and management. From an innovation perspective, this multidisciplinary feature indicates an emerging research area lying at the intersection of food technology and collaborative food innovation. It is also expected that research on the UN's Sustainable Development Goals, the economics of food development, food innovation policies and social levels will show a gradual improvement in the theoretical framework and more detail in the patterns revealed.

Most authors who applied a qualitative approach used interviews and case studies to collect data over a relatively short period of time. The initial input and processing stages of the FVC primarily involve agricultural and initial product development practices, which are long-term processes; to examine the impact of OI in these stages demands longitudinal research that uses a process-mapping approach to thoroughly understand how innovation practices can be enhanced.

An important issue of food safety remains underexplored within this context. A process mapping study would provide practitioners, stakeholders and managers with essential information to improve collaboration and refine management strategies. Future research can guide food practitioners and policymakers in deploying procedures and practices that assist in the implementation of advanced OI approaches for better management of food R&D practices.

Given the growing demand for research in this field, several scholars have examined OI drivers in the FVC. Studies on the FVC and food OI (Galati et al., 2016; Schroder and McEachern, 2004; Tardivo et al., 2017) have suggested integrating consumers as a critical driver of innovation in the FVC, which can also lead to successful innovation outcomes.

The findings further confirm the need for consumer integration to improve innovation outcomes and gain competitive advantage. However, more research is needed to identify the specifics of consumers' roles at different stages of the FVC, especially the input stage.

ore broadly, this study shows that OI practices tend to be restricted to the processing and production phases stages of the FVC. A step-by-step approach aimed at understanding OI's barriers and enablers at each stage would provide more profound insights into how to foster open and collaborative innovation practices in the food industry. These insights could then inform and guide policy interventions. In addition, although a few studies have made some effort to understanding the role of sustainability to address the 'grand challenge' within the food context, there is a need for further research to understand the intersection of sustainability oriented OI practices and their role in and influence on the food industry's R&D and manufacturing processes. This calls for developing a research design for regular monitoring and evaluation of innovation practices to understand the factors that hinder the successful implementation of sustainability-related approaches for food innovation.

High-tech firms have thus far been the central area of focus for food innovation research. A deeper understanding of the innovation behaviours in an FVC of SMEs or low-tech firms and the involvement of external stakeholders across all stages of the FVC is needed. This is a crucial research area because some studies presented in this analysis have proposed adopting an OI-centric approach for food-related SMEs and larger food manufacturers. An external variable influencing this research area is the increasing automation and digital technology integration in the food industry (Coronado Mondragon et al., 2020), which calls for research into digitalized innovation in the FVC.

Overall, the studies presented in this analysis (Arcese et al., 2015; Bayona-Saez et al., 2016; Dries et al., 2014; Enzing et al., 2011; Gonzalez-Moreno et al., 2019; Santoro et al., 2017; Seyfettinoğlu, 2016; Triguero et al., 2018) show that collaborative approaches have been well understood from the OI perspective. Studies have mainly examined the impact on innovation performance. However, OI impacts other variables in the FVC that need further analysis. For example, most research has examined the initial stages of the food OI approach; there is limited research looking at performance at the FVC distribution stage. This is relevant because the food industry relies heavily on marketing and communication and sales channels. This area will be interesting to develop for scholars and managers from the commercialization strategy perspective. Distribution can also be characterized by a process of gradual diffusion of innovation in the market, which calls for research projects analysing the impact of OI in generating pathways for efficient adoption of food-based innovations, especially in lower-level economic communities.

This research field should be explored in depth all the way from the stages involving agricultural collaborative practices through the collaborative output stage (in the form of food-based products and services). In the future, researchers and practitioners should pay attention to sustainable innovation in FVC management and development from an economic, environmental, social, technological and policy-making perspective.

6 Conclusion

As the food industry grows dramatically and more and more technologies are being developed to meet the demands of an industry in need of innovation, reviewing the existing body of knowledge to sketch future research agendas is timely, if not urgent. Based on an extensive bibliometric analysis and thematic review, this study offers an integrative framework showing the intersection of OI research along the FVC, which provides researchers with insights into current gaps and directions of relevance and significance for future studies.

The present study shows the influence and challenges of OI across the several stages of the FVC. While the papers identified in our search and referred to in the proposed framework have been linked to specific stages of the FVC, no single paper has considered the entire FVC as a critical context or applied the same perspective to examine innovation activities within a single firm. Accordingly, we call for further research on food OI that adopts a broad FVC perspective.

By adopting a comprehensive methodological approach and using VosViewer as a tool for conducting bibliometric analysis, this study provides researchers with directions for conducting future content analysis-based studies by assessing clusters and themes using a cited reference-based approach. It also provides a foundation for learning network-based visualizations of data to show the interconnectedness between different research areas and researchers for future collaborations in related fields. In addition, the study can serve as a guide for new researchers because it offers a review of the food OI research conducted in the recent past, which leads to pathways for the future.

7 Limitations

The analysis presented here is based on 84 articles published in food and OI research from Scopus data. While Scopus is a high-quality database, other databases could be included in future research studies conducting similar analyses. More keywords can be applied to find more papers with extended applications of OI in the FVC context. The search results were confined to papers in their final stage of publication to assure quality. However, it would also be interesting to include grey literature (e.g., policy-oriented reports from the Food and Agriculture Organization of the United Nations) and papers in their initial stages to map the newest research areas in food OI across the FVC.

This study also showed that OI has a vital role in reshaping food systems (Food and Agriculture Organization of the United Nations, 2018). This message will resonate as world leaders convene for the 2021 Food Systems Summit and develop an action framework for the UN Convention on Biological Diversity. Stead (2018,) argues that a broader look at how various food system elements interact and using system thinking to envision future scenarios is long overdue. Of note for the OI agenda is to 1) reimagine food supply chains to be fairer, more efficient and cleaner, 2) connect policies to practices (such as tracking and managing the health of humans, crops and habitats) and 3) democratize food processing by enhancing the digital capabilities of local producers and suppliers. The framework developed in this study also provides policy-makers with insights into how to design the best possible policies, spanning the different areas of the FVC and contingent on the type of novelties that they seek to promote.

References

Arcese, G., Flammini, S., Lucchetti, M.C. and Martucci, O. (2015), "Evidence and experience of open sustainability innovation practices in the food sector", Sustainability, vol. 7, no. 7, pp. 8067-8090.

Bayona-Saez, C., Cruz-Cázares, C., García-Marco, T. and Sánchez García, M. (2017), "Open innovation in the food and beverage industry", Management Decision, Vol. 55, No. 3, pp. 526-546.

Beckeman, M., Bourlakis, M. and Olsson, A. (2013), "The role of manufacturers in food innovations in Sweden", British Food Journal, Vol. 115, No. 7, pp. 953-974.
Berthet, E.T., Hickey, G.M. and Klerkx, L. (2018), "Opening design and innovation processes in agriculture: insights from design and management sciences and future directions", Agricultural Systems, Vol. 165, pp. 111-115.
Bigliardi, B., & Galati, F. (2013). "Innovation trends in the food industry: the case of functional foods." Trends in Food Science & Technology, Vol. 31, No. 2, pp.118-129.
Bigliardi, B., Galati, F. and Pavesi, F. (2019), "How open is the food NPD process? Preliminary results from an explorative study", International Journal of Entrepreneurship and Innovation Management, vol. 23, no. 3, pp. 229-245.
Bianchi, M., Cavaliere, A., Chiaroni, D., Frattini, F., & Chiesa, V. (2011). "Organisational modes for Open Innovation in the bio-pharmaceutical industry: An exploratory analysis." Technovation, Vol. 31, No. 1, pp. 22-33.
Blasi, E., Monotti, C., Ruini, L., Landi, C., Avolio, G. and Meriggi, P. (2015), "Eco-innovation as a driver in the agri-food value chain: an empirical study on durum wheat in Italy", Journal on Chain and Network Science, Vol. 15, No. 1, pp.1-15.
Bogers, M., Chesbrough, H. and Strand, R. (2020), "Sustainable open innovation to address a grand challenge: lessons from Carlsberg and the green fiber bottle", British Food Journal, Vol. 122, No. 5, pp. 1505-1517.
Bouzembrak, Y., Klüche, M., Gavai, A. and Marvin, H.J. (2019), "Internet of Things in food safety: literature review and a bibliometric analysis", Trends in Food Science & Technology, Vol. 94, pp. 54-64.
Boyack, K.W. and Klavans, R. (2010), "Co-citation analysis, bibliographic coupling, and direct citation: which citation approach represents the research front most accurately?" Journal of the American Society for information Science and Technology, Vol. 61, No. 12, pp. 2389-2404.
Caiazza, R., Volpe, T. and Audretsch, D. (2014), "Innovation in agro-food chain: policies, actors and activities", Journal of Enterprising Communities: People and Places in the Global Economy, Vol. 8., No. 3, pp. 180-187.
Capitanio, F., Coppola, A., & Pascucci, S. (2010). "Product and process innovation in the Italian food industry." Agribusiness, Vol. 26, No. 4, pp. 503-518.
Casprini, E., Dabic, M., Kotlar, J. and Pucci, T. (2020), "A bibliometric analysis of family firm internationalization research: current themes, theoretical roots, and ways forward", International Business Review, 101715.
Chen, T.T. and Hsieh, L.C. (2007), "On visualization of co-citation networks", in Banissi, E., Burkhard, R.A., Grinstein, G., Cvek, U., Trutschl, U., Stuart, L., Wyeld, T.G., Andrienko, G., Dykes, J., Jern, M., Groth, D. and Ursyn, A (Ed.s), 2007 11th International Conference Information Visualization (IV'07), New York: IEEE, pp. 470-475.
Chesbrough, H. W. (2003). "Open innovation: The new imperative for creating and profiting from technology." Harvard Business Press.
Chesbrough, H. (2006). "Open business models: How to thrive in the new innovation landscape." Harvard Business Press.
Chesbrough, H., Kim, S. and Agogino, A. (2014), "Chez Panisse: building an open innovation ecosystem", California Management Review, Vol. 56, No. 4, pp. 144-171.
Cillo, V., Rialti, R., Bertoldi, B. and Ciampi, F. (2019), "Knowledge management and open innovation in agri-food crowdfunding", British Food Journal, Vol. 121, No. 2, pp. 242-258.
Cohen, W. M., & Levinthal, D. A. (1990). "Absorptive capacity: A new perspective on learning and innovation." Administrative Science Quarterly, pp. 128-152.
Coronado Mondragon, A.E., Coronado Mondragon, C.E. and Coronado, E.S. (2020), "Managing the food supply chain in the age of digitalisation: a conceptual approach in the fisheries sector", Production Planning & Control, Vol. 32, No. 3, pp. 242-255.

Costa, A.I.A., Greco, M., Grimaldi, M., Cricelli, L. and Corvello, V. (2016), "Inter-organisational innovation processes in the European food and drink industry", International Journal of Management and Enterprise Development, vol. 15, no. 2-3, pp. 191-208.

Dabic, M., Hjortsø, C.N., Marzi, G. and Vlačić, B. (2020), "Call for papers: open innovation in the food industry: what we know, what we don't know, what we need to know", British Food Journal. Emerald Group Publishing. Available at: https://www.emeraldgrouppublishing.com/journal/bfj/open-innovation-food-industry-what-we-know-what-we-dont-know-what-we-need-know (Accessed on 14 August 2021)

Dabić, M., Vlačić, B., Scuotto, V., & Warkentin, M. (2020), "Two decades of the Journal of Intellectual Capital: A bibliometric overview and an agenda for future research", Journal of Intellectual Capital, Vol. 22, No. 3, pp. 458-477.

Dahlander, L., & Gann, D. M. (2010). "How open is innovation?". Research Policy, Vol.39 No. 6, pp. 699-709.

Devaux, A., Torero, M., Donovan, J. and Horton, D. (2018), "Agricultural innovation and inclusive value-chain development: A review", Journal of Agribusiness in Developing and Emerging Economies, Vol. 8, No. 1, pp. 99-123.

Diamond, A. and Barham, J. (2012). Moving food along the value chain: innovations in regional food distribution, Report, Washington: DC, United States Department of Agriculture, available at: http://dx.doi.org/10.22004/ag.econ.145618 (accessed 11 August 2021).

Dries, L., Pascucci, S., Török, Á. and Tóth, J. (2014), "Keeping your secrets public? Open versus closed innovation processes in the Hungarian wine sector", International Food and Agribusiness Management Review, Vol. 17, No. 1, pp. 147-162.

Enkel, E., Gassmann, O., & Chesbrough, H. (2009). Open R&D and open innovation: exploring the phenomenon. R&D Management, Vol. 39 No. 4, pp. 311-316.

Enzing, C., Pascucci, S., Janszen, F. and Omta, O. (2011), "Role of open innovation in the short- and long-term market success of new products: evidence from the Dutch food and beverages industry", Journal on Chain and Network Science, Vol. 11, No. 3, pp. 235-250.

Food and Agriculture Organization of the United Nations. (2018), Transforming food and agriculture to achieve the SDGs, http://www.fao.org/3/I9900EN/i9900en.pdf (accessed 12 August 2021).

Farley, S. and Scherr, S. (2020), "How to reimagine our food systems for a post-COVID world", World Economic Forum, https://www.weforum.org/agenda/2020/06/we-need-to-reimagine-our-food-systems-for-a-post-covid-world (accessed 12 August 2021).

Ferreira, F.A. (2018), "Mapping the field of arts-based management: bibliographic coupling and co-citation analyses", Journal of Business Research, Vol. 85, pp. 348-357.

Filieri, R. (2013), "Consumer co-creation and new product development: a case study in the food industry", Marketing Intelligence and Planning, Vol. 31, No. 1, pp. 40-53.

Flor, M.L., Oltra-Mestre, M.J. and Sanjurjo, E.L. (2019), "An analysis of open innovation strategies in firms in low and medium technology industries", IEEE Transactions on Engineering Management, Vol., No., pp. 1-15.

Fortuin, F.T.J.M. and Omta, S.W.F. (2009), "Innovation drivers and barriers in food processing", British Food Journal, Vol. 111, No. 8, pp. 839-851.

Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The future of open innovation. R&D Management, Vol. 40 No. 3, pp. 213-221.

Gao, H., Ding, X., & Wu, S. (2020), "Exploring the domain of open innovation: Bibliometric and content analyses", Journal of Cleaner Production, 122580.

Galati, F., Bigliardi, B. and Petroni, A. (2016), "Open innovation in food firms: implementation strategies, drivers and enabling factors", International Journal of Innovation Management, Vol. 20, No. 3, 1650042.

González-Moreno, Á., Triguero, Á. and Sáez-Martínez, F.J. (2019) "Many or trusted partners for eco-innovation? The influence of breadth and depth of firms' knowledge network in the food sector", Technological Forecasting and Social Change, Vol. 147, pp. 51-62.
Golgeci, I. (2020). A bibliometric review of service ecosystems research: current status and future directions (Doctoral dissertation, University of Oulu, Finland).
Harzing, A.W. and Alakangas, S. (2016), "Google Scholar, Scopus and the Web of Science: A longitudinal and cross-disciplinary comparison", Scientometrics, Vol. 106, No. 2, pp. 787-804.
Henriksen, L. F., Riisgaard, L., Ponte, S., Hartwich, F., & Kormawa, P. (2010). "Agro-food value chain interventions in Asia. Vienna, Austria.: United Nations Industrial Development Organization (UNIDO)".
Holt-Giménez, E., Shattuck, A., Altieri, M., Herren, H. and Gliessman, S. (2012), "We already grow enough food for 10 billion people… and still can't end hunger", Journal of Sustainable Agriculture, Vol. 36, No. 6, pp. 595-598.
Huston, L. and Sakkab, N. (2006), "Connect and develop", Harvard Business Review, Vol. 84, No. 3, pp. 58-66.
Humphrey, J. and Memedovic, O. (2006), "Global value chains in the agrifood sector", New York, United Nations.
Huizingh, E. K. (2011). "Open innovation: State of the art and future perspectives." Technovation, Vol. 31, No.1, pp. 2-9.
Ku, M.S. (2015), "Recent trends in specialty pharma business model", Journal of Food and Drug Analysis, Vol. 23, No. 4, pp. 595-608.
Kumar, K., Boesso, G., Favotto, F. and Menini, A. (2012), "Strategic orientation, innovation patterns and performances of SMEs and large companies", Journal of Small Business and Enterprise Development, Vol. 19, No. 1, pp. 132-145.
Laursen, K., & Salter, A. (2006). "Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms." Strategic Management Journal, Vol. 27. No. 2, pp. 131-150.
Le, H. T. T., Dao, Q. T. M., Pham, V. C., & Tran, D. T. (2019). "Global trend of open innovation research: A bibliometric analysis." Cogent Business & Management.
Lichtenthaler, U. and Lichtenthaler, E. (2009), "A capability-based framework for open innovation: complementing absorptive capacity", Journal of Management Studies, Vol. 46, No. 8, pp. 1315-1338.
Luo, J., Ji, C., Qiu, C. and Jia, F. (2018), "Agri-food supply chain management: bibliometric and content analyses", Sustainability, Vol. 10, No. 5, 1573.
Lyu, V.C., Lai, I.K., Ting, H. and Zhang, H. (2020), "Destination food research: A bibliometric citation review (2000–2018)", British Food Journal, Vol. 122, No. 6, pp. 2045-2047.
Manzini, R., Lazzarotti, V. and Pellegrini, L. (2017), "How to remain as closed as possible in the open innovation era: the case of Lindt and Sprüngli", Long Range Planning, Vol. 50, No. 2, pp. 260-281.
Martín-Martín, A., Orduna-Malea, E., Thelwall, M. and López-Cózar, E.D. (2018), "Google Scholar, Web of Science, and Scopus: a systematic comparison of citations in 252 subject categories", Journal of Informetrics, Vol. 12, No. 4, pp. 1160-1177.
Martinez, M.G. (2014), "Co-creation of value by open innovation: unlocking new sources of competitive advantage", Agribusiness, Vol. 30, No. 2, pp. 132-147.
Martinez, M.G., Lazzarotti, V., Manzini, R. and García, M.S. (2014), "Open innovation strategies in the food and drink industry: determinants and impact on innovation performance", International Journal of Technology Management, Vol. 66, No. 2-3, pp. 212-242.
Marinova, D. and Bogueva, D. (2021), "Special issue 'Food innovation for planetary health'", Sustainability, https://www.mdpi.com/journal/sustainability/special_issues/Food_Planetary_Health (accessed 12 August 2021).

Meng, L., Wen, K.H., Brewin, R. and Wu, Q. (2020), “Knowledge atlas on the relationship between urban street space and residents' health: a bibliometric analysis based on VosViewer and CiteSpace”, Sustainability, Vol. 12, No. 6, 2384.

Meynard, J.-M., Jeuffroy, M.-H., Le Bail, M., Lefèvre, A., Magrini, M.-B. and Michon, C. (2017), “Designing coupled innovations for the sustainability transition of agri-food systems”, Agricultural Systems, Vol. 157, pp. 330-339.

Mongeon, P. and Paul-Hus, A. (2016), “The journal coverage of Web of Science and Scopus: A comparative analysis”, Scientometrics, Vol. 106, No. 1, pp. 213-228.

Moskowitz, H.R. and Saguy, I.S. (2013), “Reinventing the role of consumer research in today's open innovation ecosystem”, Critical Reviews in Food Science and Nutrition, Vol. 53, No. 7, pp. 682-693.

OECD. (2020), “COVID-19 and global food systems. OECD policy responses to Coronavirus (COVID-19)”, Paris: OECD, http://www.oecd.org/coronavirus/policy-responses/covid-19-and-global-food-systems-aeb1434b/ (accessed 12 August 2021).

Opejin, A.K., Aggarwal, R.M., White, D.D., Jones, J.L., Maciejewski, R., Mascaro, G. and Sarjoughian, H.S. (2020), “A bibliometric analysis of food-energy-water nexus literature”, Sustainability, Vol. 12, No. 3, 1112.

Parida, V., Westerberg, M., & Frishammar, J. (2012). Inbound open innovation activities in high-tech SMEs: the impact on innovation performance. Journal Of Small Business Management, Vol. 50, No. 2, pp. 283-309.

Pellegrini, L., Lazzarotti, V. and Manzini, R. (2014), “Open innovation in the food and drink industry”, Journal of Agricultural & Food Industrial Organization, Vol. 12, No. 1, pp. 75-94.

Petroni, G., Venturini, K. and Verbano, C. (2012), “Open innovation and new issues in R&D organization and personnel management”, International Journal of Human Resource Management, Vol. 23, No. 1, pp. 147-173.

Randhawa, K., Wilden, R. and Hohberger, J. (2016), “A bibliometric review of open innovation: setting a research agenda”, Journal of Product Innovation Management, Vol. 33, No. 6, pp.750-772.

Rao, N.C., Sutradhar, R. and Reardon, T. (2017), “Disruptive innovations in food value chains and small farmers in India”, Indian Journal of Agricultural Economics, Vol. 72, No. 1, pp. 24-48.

Richie, H. and Rose, M. (2020), “Agricultural production: our world in data”, https://ourworldindata.org/agricultural-production#cereals (accessed 12 August 2021).

Saguy, I.S. (2011), “Paradigm shifts in academia and the food industry required to meet innovation challenges”, Trends in Food Science and Technology, Vol. 22, No. 9, pp. 467-475.

Santoro, G., Vrontis, D. and Pastore, A. (2017), “External knowledge sourcing and new product development: evidence from the Italian food and beverage industry”, British Food Journal, Vol. 119, No. 11, pp. 2373-2387.

Sarkar, S. and Costa, A.I.A. (2008), “Dynamics of open innovation in the food industry”, Trends in Food Science and Technology, Vol. 19, No. 11, pp. 574-580.

Schröder, M. J., & McEachern, M. G. (2004). “Consumer value conflicts surrounding ethical food purchase decisions: a focus on animal welfare”, International Journal of Consumer Studies, Vol. 28, No.2, pp.168-177.

Secinaro, S. and Calandra, D. (2020), “Halal food: Structured literature review and research agenda”, British Food Journal, Vol. 123, No. 1, pp. 225-243.

Seyfettinoğlu, Ü.K. (2016), “Analysis of relationships between firm performance and open innovation strategies and stages in the Turkish food and beverage industry”, New Medit, Vol. 15, No. 1, pp. 42-52.

Siedlok, F., Smart, P. and Gupta, A. (2010), “Convergence and reorientation via open innovation: the emergence of nutraceuticals”, Technology Analysis and Strategic Management, Vol. 22, No. 5, pp. 571-592.
Stead, S.M. (2019), “Using systems thinking and open innovation to strengthen aquaculture policy for the United Nations Sustainable Development Goals”, Journal of Fish Biology, Vol. 94, No. 6, pp. 837-844.
Tang, O. and Musa, S.N. (2011), “Identifying risk issues and research advancements in supply chain risk management” International Journal of Production Economics, Vol. 133, No. 1, pp. 25-34.
Tardivo, G., Thrassou, A., Viassone, M. and Serravalle, F. (2017), “Value co-creation in the beverage and food industry”, British Food Journal, Vol. 119, No. 11, pp. 2359-2372.
Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research policy, Vol. 15 No. 6, pp. 285-305.
Traill, W. B., & Meulenberg, M. (2002). “Innovation in the food industry.” Agribusiness: An International Journal, Vol. 18, No. 1, pp.1-21.
Traitler, H., Watzke, H.J. and Saguy, I.S. (2011), “Reinventing R&D in an Open Innovation Ecosystem”, Journal of Food Science, Vol. 76, No. 2, pp. R62-R68.
Triguero, A., Fernández, S. and Sáez-Martinez, F.J. (2018), “Inbound open innovative strategies and eco-innovation in the Spanish food and beverage industry”, Sustainable Production and Consumption, Vol. 15, pp. 49-64.
United Nations. (2017), Sustainable Development Goals. Food and Agriculture Organization of the United Nations, http://www.fao.org/sustainable-development-goals/goals/goal-3/en/ (accessed 12 August 2021).
Van Eck, N.J., Waltman, L., Dekker, R. and van den Berg, J. (2010), “A comparison of two techniques for bibliometric mapping: multidimensional scaling and VOS”, Journal of the American Society for Information Science and Technology, Vol. 61, No. 12, pp. 2405-2416.
Van Oorschot, J.A., Hofman, E. and Halman, J.I. (2018), “A bibliometric review of the innovation adoption literature”, Technological Forecasting and Social Change, Vol. 134, pp. 1-21.
Vlačić, E., Dabić, M., & Božac, M. G. (2020), “The relevance of absorptive capacity in firms’ innovation strategies measured via bibliometric analysis”, Journal of Corporate Governance, Insurance, and Risk Management, Vol. 7, No. 1, pp. 1-14.
Vila-Lopez, N. and Küster-Boluda, I. (2020), “A bibliometric analysis on packaging research: towards sustainable and healthy packages”, British Food Journal, Vol. 123, No. 2, pp. 684-701.
Vrontis, D., Bresciani, S., & Giacosa, E. (2016). “Tradition and innovation in Italian wine family businesses.” British Food Journal.
West, J., & Bogers, M. (2014). “Leveraging external sources of innovation: a review of research on open innovation”. Journal of Product Innovation Management, Vol. 31, No.4, pp. 814-831.
Wambu, E. W., Fu, H. Z., & Ho, Y. S. (2017). “Characteristics and trends in global tea research: a Science Citation Index Expanded-based analysis.” International Journal of Food Science & Technology, Vol. 52, No.3, pp. 644-651.
Wiener-Bronner, D. (2020, 15 April), “Why dairy farmers across America are dumping their milk”, CNN Business, https://edition.cnn.com/2020/04/15/business/milk-dumping-coronavirus/index.html, (accessed 12 August 2021).
Wolfert, J., Verdouw, C.N., Verloop, C.M. and Beulens, A.J.M. (2010), “Organizing information integration in agri-food: a method based on a service-oriented architecture and living lab approach”, Computers and Electronics in Agriculture, Vol. 70, No. 2, pp. 389-405.
World Economic Forum, 2018. Innovation with a purpose: The role of technology innovation in accelerating food systems transformation. World Economic Forum viewed 31

March 2021, <http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf>.

Yan, E. and Ding, Y. (2012), “Scholarly network similarities: how bibliographic coupling networks, citation networks, co-citation networks, topical networks, coauthorship networks, and coword networks relate to each other”, Journal of the American Society for Information Science and Technology, Vol. 63, No. 7, pp. 1313-1326.

Zeba, G., Dabić, M., Čičak, M., Daim, T. and Yalcin, H. (2021), “Technology mining: artificial intelligence in manufacturing”, Technological Forecasting and Social Change, Vol. 171, 120971.

Zilberman, D., Lu, L. and Reardon, T. (2019), “Innovation-induced food supply chain design”, Food Policy, 83, pp. 289-297.

Part IV:

The first OpenInnoTrain Summer School

12 Exploring how to plan and manage the impact of research: the first OpenInnoTrain Summer School

Anne-Laure Mention, Avni Misra, Massimo Menichinelli, Ahmad Alaassar, Pauline Rasera

1 Introduction

Three Summer Schools, targeting early-stage researchers, are foreseen over the four years of the OpenInnoTrain project. The first edition of the OpenInnoTrain Summer School, held in 2021, focused on teaching researchers at different levels of their research careers about the importance of research impact in both academia and industry and the ways in which this impact can be delivered at different stages of their research[1]. This first OpenInnoTrain Summer School aimed at providing an understanding of the established research pathways for conducting and delivering impactful research and familiarizing with the tools and techniques required for generating impact through research. This Summer School was run as a pilot programme, supported by extensive participation and engagement from researchers across the globe. The participants were a mix of industry practitioners and researchers from different levels of the academic ladder.

2 Objectives

Researchers at different phases of their careers generate valuable contributions and insightful ideas through an extensive process that includes the scoping, ideation, mapping, and engagement stages. At each stage, the research process provides opportunities for creating impact; however, most researchers find it challenging to identify the right tools and techniques for creating impact efficiently.

The OpenInnoTrain Summer School 2021 aimed to assist participants in achieving their individual and professional research goals, such as:

1. Developing ideas with potential impact.
2. Publishing research outputs through various platforms.

[1] https://www.openinnotrain.eu/download/media-release-09/

3. Implementing tactics that allow developing a highly visible research profile within industry and academia.

The participants were taken through a 5-day journey of creating impact and were taught how to implement effective methods to generate impactful outcomes through research ideas. The approach can also be applied in reverse where the participants are taught to strategize plans to develop impact- competent research ideas. After a week of intensive training and fruitful exchanges, the participants have developed a thorough knowledge of a step-by-step approach to generate impact both in industry and academia at each stage of the research process.

3 Framework

Research contributes to the economy, society, environment, or culture, beyond the contribution to academic research itself: this the definition of research impact adopted in the OpenInnoTrain Summer School 2021. The impact process is the method through which researchers can potentially generate impact during different stages of their research. As generating impact has become an essential pursuit for researchers and research institutions, several frameworks provided by different bodies of research worldwide suggest a process-based approach through which they encourage the researchers to generate impact through research. This is the case of CSIRO[2], Centre for Applied Disability Research (CADR)[3] (Australia), and Institute for Work & Health[4] (USA). This also highlights that the impact process is capable of being flexible and that different perspectives can be applied to view impact and its implementation from different lenses.

The programme of OpenInnoTrain Summer School 2021 was designed keeping in mind the basic deliverables of the impact process and aligning with the established knowledge. A framework suitable to a broader array of audiences was developed following five stages – scoping, identification, mapping, engagement, and tracking (Table 1).

Table 1 The five stages of the impact programme – scoping, identification, mapping, engaging, and tracking.

DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Scoping future areas of research	**Identify** the reach, significance, collaborations	**Map** the timeline, stakeholders, process requirements	**Engage** for generating impact	**Tracking** outcomes using impact measurement tools

[2] https://www.csiro.au/en/
[3] https://web.archive.org/web/20200919083638/http://www.cadr.org.au/
[4] https://www.iwh.on.ca/

What is the current need? Future research and industry trends Ideate the problem – New knowledge gaps Seek common interests and needs Framing the desired impact – short-term, mid-term long-term	Establish research goals Identity types of input and output activities Identify the beneficiaries of the outcome Identify the methods, tools, and techniques	Outline the stages involved Mapping of required activities, resources, and their source Map the partnerships & audience Map different impact outcomes	Identify the roadmap for deliverables Strategizing engagement approaches Customising content for engagement Identifying the role of stakeholders / beneficiaries during engagement	Plan a tracking approach Implementing metrics for evaluation Identifying areas for improvement Improvising strategies that work through iterations Broadening the impact

4 Methodology

The programme of OpenInnoTrain first Summer School was delivered using a mix of lectures, discussions, and interactive sessions. The content was designed using a range of theoretical frameworks, industry examples, case studies, panel discussions, canvas-based approaches, special presentations from industry and academic speakers, pitch sessions and open Q&A sessions. The participants were encouraged to work individually and in groups for learning the implementation of various impact activities.

Case studies were selected based on a thorough consultation process between the organising team, including review of relevant universities, companies, research content websites and reports, and input from professional staff, industry experts and academics. Theoretical frameworks were based on research papers from published authors in the field of research translation, impact creations, value creation, industry engagement and commercialisation. Panel discussions involved speakers with the expertise in the field of research context evaluations, ideation, brainstorming, research engagement, impact tracking and impact road mapping. Academics and practitioners with several years of experience conducted panels which allowed open Q&A with participants generating an immersive learning experience.

A step-by-step canvas-based approach was employed in teaching strategic decision making for developing a well mapped impact process for individual research projects. The canvas sessions were delivered by experienced academics with industry backgrounds and follow-up engagement sessions were conducted along with a Q&A session.

Pitch sessions were organised by group within a limited timeframe, designed to motivate the participants to present their research ideas and aligning steps of their customised impact journeys based on a combination of tools and project management approaches. The pitches were judged by a panel including a mix of an academic and industry personnel to provide an iterative feedback to the participants for improvement.

5 Key learnings

By participating in the OpenInnoTrain Summer School 2021, participants benefited by:

1. Learning how to ideate impactful research ideas.
2. Learning to scope opportunities in the industry to collaborate for successful implementation.
3. Learning engagement pathways for developing university-industry collaborations.
4. Learning to apply tools and techniques to track the output of research impact and strategies future approaches.
5. Learning how to pitch your ideas and using a canvas approach to design your pitches.

Target audience:

1. PhD Researchers at any stage
2. Post-doctoral Researchers
3. Academics
4. Industry Fellows
5. Research Professionals
6. STEM and non-STEM disciplines

6 The journey of impact

6.1 Day 1 – Scoping

The programme started with the introduction of 74 participants from different time zones. The first lecture, delivered by Prof. Anne-Laure Mention, aimed at explaining the meaning and importance of impact and led to the first open engagement session from the audience. The discussion evolved into interesting ideas and identification of personal and professional impact barriers related to the understanding and awareness regarding research impact.

Following the inclination of the audience's mindset, an impact assessment workshop was conducted to further help the participants to identify their individual understanding of impact, and to which extend they have generated impact through their existing work. In furtherance, an interactive lecture by Prof. Anne-Laure Mention and Dr. Avni Misra explained the impact process and its link with identification of the research context. The participants were exposed to the concept of mission-led research and its relevance in the global context.

The participants were then made to work collaboratively on a research context comparison framework to develop their research ideas for their impact journeys programme using Miro[5], under the guidance of Dr. Massimo Menichinelli. The day was finally concluded with a lecture delivered on pitch delivery by Dr. Avni Misra and Dr. Ahmad Alaassar, preparing the participants for the pitching sessions in the next four days.

Table 2 Learning objectives of Day 1 of the OpenInnoTrain Summer School 2021

Key Sessions	**Learning Objectives**
What is impactful research, avenues, and Success stories	To understand the meaning and reasons of impact of research and the types of impact of research.
Impact Assessment Workshop	To identify the need for creating impact through research. To be able to self-assess the impact the research is generating and identify the opportunities for generating research impact through new avenues.
Research Impact Context and Process	How to identify the research area based on specific research agendas and identify the criteria for selecting impactful research contexts To evaluate research contexts based on the need of the stakeholders Understand the stages of the research impact process
Pitch Perfect and Delivery	To be able to design a research pitch for different audience and understand the key criteria for structuring the pitch delivery To be able to deliver a pitch to a diverse audience.

[5] https://miro.com/

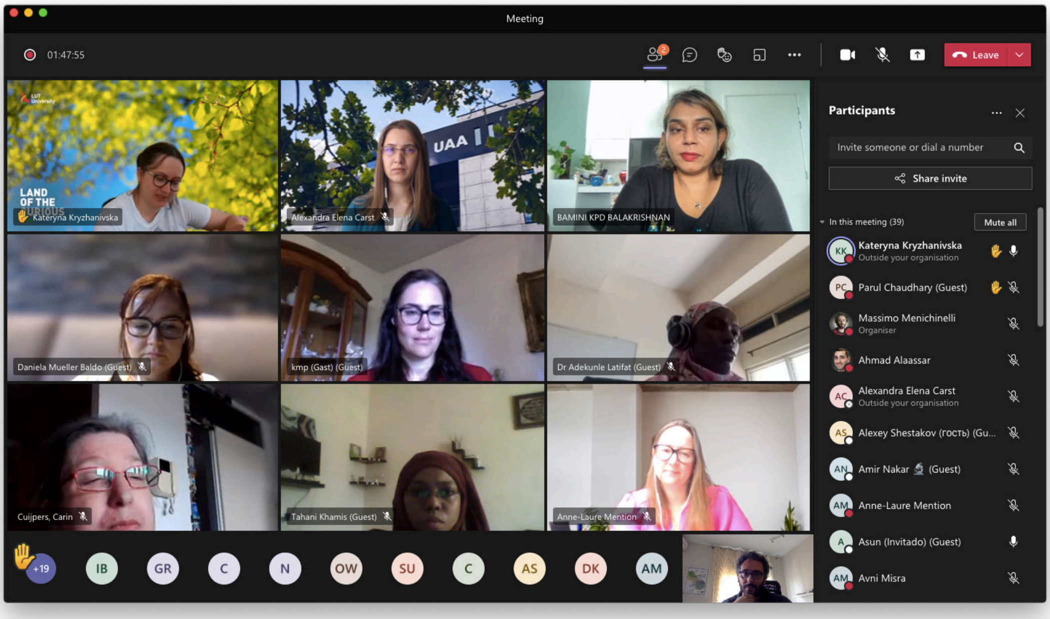


Figure 1 Discussion during Day 1 of the OpenInnoTrain Summer School 2021

6.2 Day 2 – Identification

On the second day of the programme, after a recap of the scoping activities, the first session was articulated by research context and identification experts Prof. Mona Enell-Nilsson & Prof. Tauno Kekäle from the University of Vaasa. The session touched upon the key criteria for evaluating research context, which the audience specifically researchers at the early stages found particularly engaging, as it assisted them in evaluating the research ideas based on industry, government, and academic criteria.

To further explain the relevance of different stakeholders, Dr. Menichinelli presented the audience with a thorough understanding of the voice of the stakeholders and how it can be integrated in developing impactful research projects with a design approach. The participants were then inspired to ideate their project based on the criteria using industry-level ideation techniques based on a lecture delivered by the ideation and brainstorming expert, Jordi Ràfols Fernández from Innoget[6] (largest online Open Innovation Networks). Based on the learnings from this session, the participants were immersed in the first canvas development process using the Lean Research Canvas, which focuses on developing a broad overview of the research project that the participants were keen on pursuing during this programme. This was done using a group Miro session facilitated by Dr. Misra and Dr. Menichinelli. The day concluded with the participants developing some initial ideas and preparing for the first pitch on day three using the Lean Research

[6] https://www.innoget.com/

Canvas. At the end of the session, participants split in ten working groups to develop a pitch based on their own research canvas. The session was highly engaging and discussion oriented. The participants were constantly provided feedback by the faculty and prepared for the pitch to industry panel for day three.

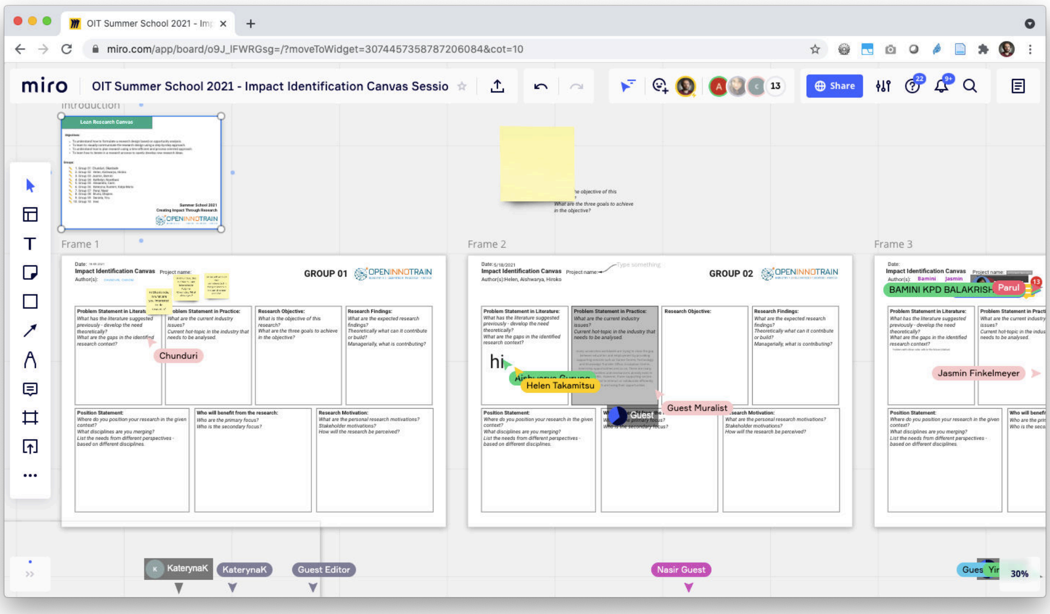


Figure 2 Interactive Session in Miro

Table 3 Learning objectives of Day 2 of the OpenInnoTrain Summer School 2021

Key Sessions	**Learning Objectives**
Research Problem and Context Identification	To understand the assessment criteria for selecting new research areas. and the application of new tools and techniques for evaluating new research agendas
Integrating the Voices of the Stakeholders	To understand the needs of the stakeholders and integrate the learnings into process of research opportunity identification. To be able to design the research solution to cater to the needs of the stakeholders for developing the right type of impact.
Introduction to ideation and screening approach and Idea Brainstorming session	To understand the ideation process for designing a methodological research approach. To understand the tools and techniques required for ideating new research problems based on real market opportunities.

Lean Research Canvas – Discussion and Relevance	To understand how to formulate a research design based on opportunity analysis and to visually communicate the research design using a step-by-step approach. To understand how to plan research using a time efficient and process-oriented approach and to iterate in a research process to openly develop new research ideas.

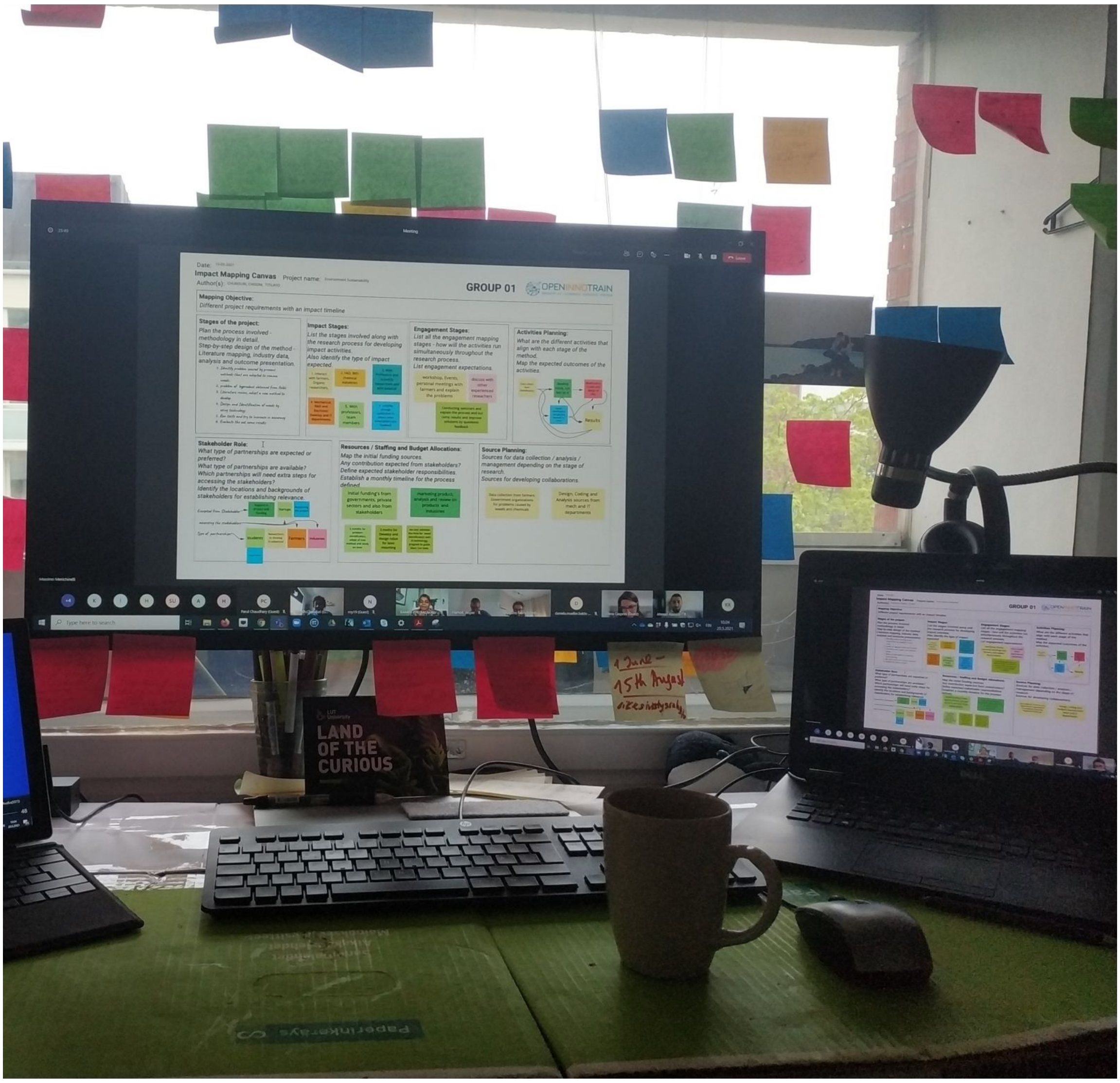


Figure 3 Lean Research Canvas pitch session.

6.3 Day 3 – Mapping

Day three kickstarted with a quick recap and then a captivating pitch session, where the ten collaborative research groups presented their research canvases live using an online platform to the academic and industry expert - Prof. Anne-Laure Mention & Dr. Krish Sankaran. The participants were inspired to receive the motivating feedback on their ideas.

One key component of day three was to introduce the concept of value creation by developing university-industry collaborations. This interactive session delivered by Prof. Anne-Laure Mention and Dr. Ahmad Alaassar emphasised on instigating the thinking of the participants to map their research processes in alignment with their impact and engagement journeys. Participants were guided to map the processes keeping in mind the value that needs to be delivered to the diverse range of stakeholders to meet their expectations and to also to apply a balanced perspective from a researcher perspective in congruence with industry expectations.

Day three was a more action-oriented session as the aim was to allow participants to reflect on the feedback and to strategically plan the next stages of their impact journeys. The participants were introduced to the second canvas of the impact process: the Impact Mapping Canvas. The canvas was designed using a project management perspective to help the participants to map the required resources, stakeholders, stages, and risks involved in the research impact process. This canvas was linked to the previously discussed Lean Research Canvas to show the interdependent relationship between research and impact. The last few hours of the day were dedicated to facilitation of the mapping canvas by Dr. Misra and Dr. Menichinelli to prepare the mapping pitches for day four.

Table 4 Learning objectives of Day 3 of the OpenInnoTrain Summer School 2021

Key Sessions	Learning Objectives
Lean Research Canvas Pitch	To deliver a pitch to a diverse audience involving academics and industry personnel and obtain iterative feedback from experts in the field, to improve the research design. To explain the research design precisely using a time effective approach.
Research Impact for Creating Value	To understand how to create value through stakeholder collaborations and to align the research objectives with stakeholder objectives to deliver innovative outcomes. Learning to maintain a research identify while creating value for the stakeholders.
Impact Mapping Canvas -Introduction and Design	Learning to apply a step-by-step approach to deliver value at all stages of the research process and understanding the tools and techniques to identify stakeholder perception of value and creating a value-based solution. Learn to assess research projects for the value evaluation.

6.4 Day 4 – Engagement

The second to last stage of the impact process is engagement. This stage is linked to impact mapping and the researchers were pushed to think creatively about the type of impact, stakeholders, channels, content, and delivery aspects of the research. The session was applying a marketing and stakeholder management perspective to teach the participants to enhance visibility and promotion of their research projects using diverse platforms and customised stakeholder engagement designs. The day started with a quick recap of the mapping stages and a pitch by the ten working groups on the design of their impact canvases to Dr. Jesper Harholt (Senior Scientist at Carlsberg Research Laboratory) & Dr. Elena Casprini (Senior Researcher at Department of Business and Law, University of Siena). The participants received valuable feedback from the experts and the combination of the STEM and non-STEM panel assured appropriate distinction of feedback across the ten projects. To further assist the participants in translating the feedback into their engagement design, Prof. Anne-Laure Mention and Dr. Avni Misra delivered a lecture on multi-stage research engagement process which introduced the participants to a new way of looking a research communication and stakeholder involvement.

This was followed by an individual engagement assessment session using a self-assessment template to allow the participants to assess their individual engagement capabilities and understand their strengths and weaknesses for research collaborations within their groups and other stakeholders. The discussion revealed an assorted range of assessment levels among the participants which motivated them to learn more about the engagement process and its relevance. This was further complemented by a discussion-based session delivered by Dr. Ahmad Alaassar focusing identifying the toolkits for better management of internal and external stakeholder engagement. Towards the end the participants were introduced to the Engagement Canvas and another technique for delivering an engagement pitch – the engagement narrative which was delivered by Dr. Misra and facilitated by Dr. Menichinelli. The participants were then left to work in groups using Miro to prepare for their engagement narratives to pitch to the industry expert on the final day of the impact programme.

Table 5 Learning objectives of Day 4 of the OpenInnoTrain Summer School 2021

Key Sessions	Learning Objectives
Impact Map Canvas Pitch	How to conduct and contribute to a moderated conversation about creating value for and with stakeholders and to design and deliver a pitch to convince the involved stakeholder regarding overall research value. How to iterate based on peer feedback using a diverse audience perspective.

Framework for Aligning Research Process to Engagement – Multi-Stage approach	To develop roadmaps for research engagement to collaborate with different stakeholder and understand different strategies and design for developing a research engagement plan. Learning to develop customised content for engaging different stakeholders showcasing the benefits for engagement. Identifying the risks associated with stakeholder engagement.
Toolkit for internal and external stakeholder engagement	To identify different communication and delivery techniques for stakeholder engagement. To understand how to design a consistent message with a customised benefit offering for stakeholder engagement.
Impact Engagement Canvas & Narrative – Design	Learning to apply a step-by-step approach to engage stakeholders in the research process. Understanding the tools, techniques, and reasons for planning the stakeholder engagement. Learn to understand and present engagement through a narrative

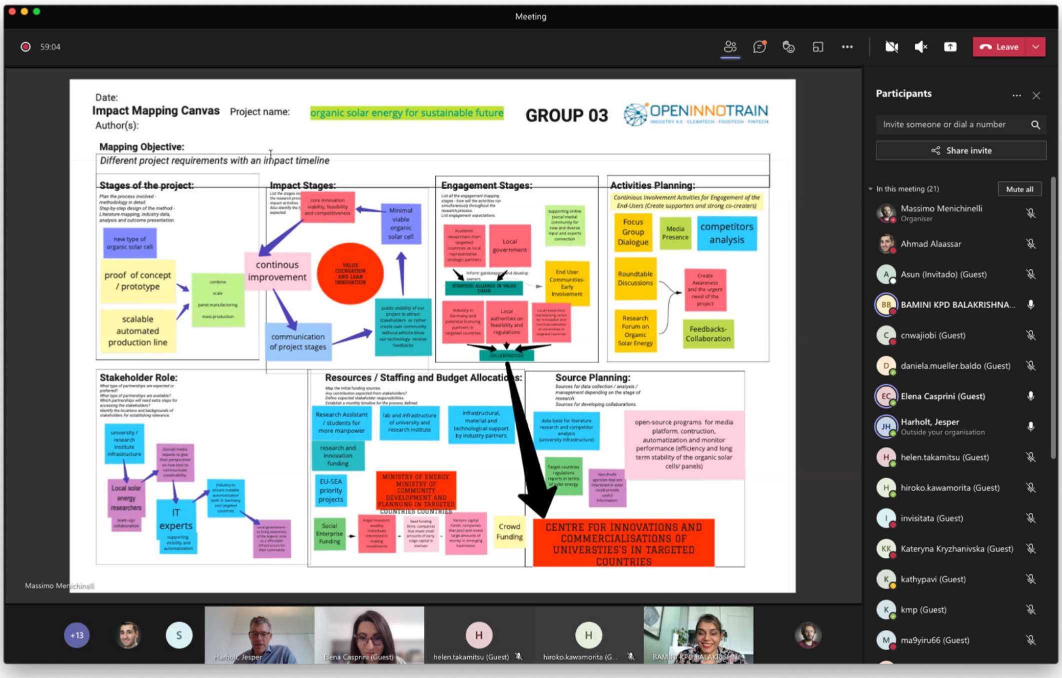


Figure 4 Pitch session of an Impact Mapping Canvas

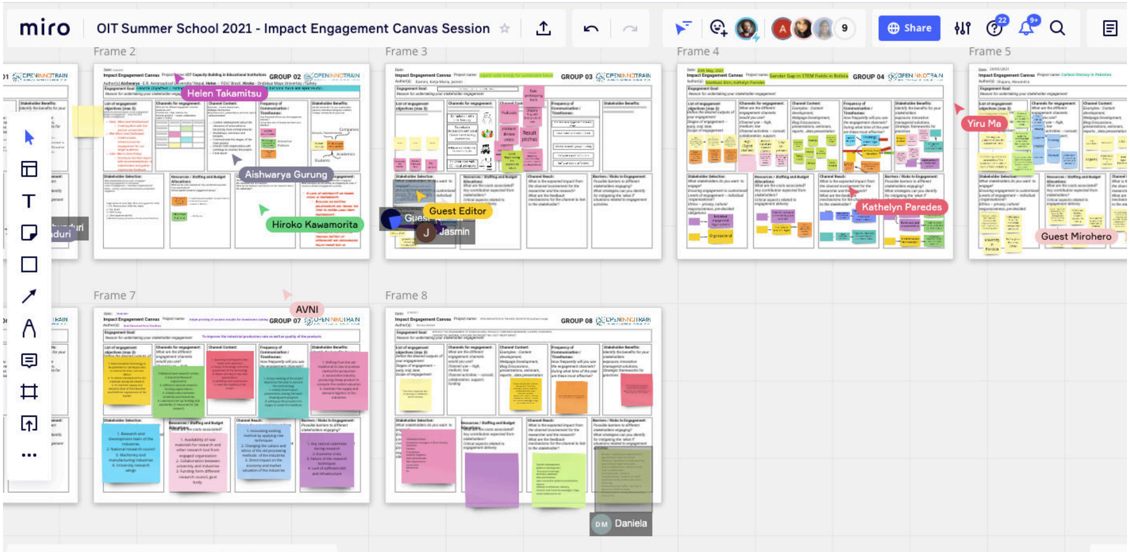


Figure 5 Interactive Session on Miro

6.5 Day 5 – Impact tracking

The final day revolved around impact tracking. Several existing impact processes predominantly consider impact generation activities until the stage of engagement; however, the Summer School programme went a step beyond the usual and developed a session that trained researchers to track the impact of their research to then formulate improvised impact strategies.

Starting with a quick recap of day four, the theoretical underpinnings and the industry-based relevance of impact tracking was introduced by Dr. Avni Misra in a morning lecture. The participants had then the opportunity to prepare their narratives and pitch them to Bruno Woeran, an experienced industry expert, the head of research management & technology transfer for Paracelsus Private Medical University. The pitches were well directed towards engagement and participants received thorough feedback from their presentations.

To improvise on their strategies, the participants explored the Impact Tracking Canvas delivered by Dr. Avni Misra focusing on the development of a tracking plan by identifying the metrics essential for measuring the success of the previously designed engagement strategies. The participants were introduced to the concepts of impact dashboards, altimetric and quantitative and qualitative metrics.

To further build upon their journey of developing research impact, the last session of the programme delivered by Prof. Anne-Laure Mention, Prof. Tor Helge Aas (Research professor at NORCE Norwegian Research Centre AS and University of Agder) and Dr. Ahmad Alaasar was linked to the role of research impact in employability and the future strategic road mapping of impact. The open Q&A and a highly exuberant networking session wrapped the Summer School. Certification and comments were provided to the participants and a follow-up survey was conducted to obtain the feedback from the participants.

Table 6 Learning objectives of Day 5 of the OpenInnoTrain Summer School 2021

Key Sessions	Learning Objectives
Impact Tracking Canvas - Introduction	How to measure the success of an engagement strategy using different metrics. How to design a tracking approach based on metrics for measuring the engagement outputs. Develop skills in tracking, evaluating and faster implementation of research impact
Engagement Canvas Pitch	To deliver a pitch to a diverse audience involving academics and industry personnel. To obtain iterative feedback from experts in the field, to improve the research design. To explain an engagement strategy using different metrics
Impact Tracking Canvas	Learning to apply a step-by-step approach to plan, measure and report the impact of the research and the outcome of engagement of research. Understanding the tools, techniques, and reasons for tracking the impact of research.
Road mapping the Research impact	How to map the future of your research for generating continuous impact. How to align the research with continuously evolving mindsets of academic and industry stakeholders. To identify new areas of opportunities and new research arenas.

6.6 The future program

The OpenInnoTrain first Summer School was intended as a flagship project to experiment with the level of engagement and traction that the programme achieves. Based on the feedback received from the participants and the organising team, it is expected that research with impact Summer School will be a continuously running programme across different phases of the OpenInnoTrain project with potential applications and further developments even outside the project. For example, future directions of the programme could include:

- *Modularisation*: develop individual micro courses based on the different sessions delivered across the research impact programme.
- *Customisation*: the research impact programme can be customised to deliver knowledge regarding impact generation to target research and researchers working on specific research focus area and priorities or at different academic levels within different disciplines. Shortened versions can be delivered in the form of collaborative seminars and workshops for industry fellows and researchers working together to develop different value outcomes.
- *Train the trainer*: develop customised Summer School courses for researchers across the consortium, integrating them with the existing offer. This will empower consortium partners and participants in the Summer School Courses in taking leading roles in running the research impact programme with contextualisation to their local environment and cohorts.

The importance of innovation through university-industry cooperation has rarely been more acute than it is today. Over the last 18 months of COVID-19 pandemic, we have experienced unprecedented circumstances in our lifetime that have demonstrated the critical role of knowledge creation and transmission across industries and disciplines. Identifying, developing and scaling-up breakthrough technologies, and converting them into incremental, radical or disruptive innovations that are widely accepted by, and available to beneficiaries, users, customers and communities is of paramount importance. However, turning research outputs into novelties for the benefits of wider society seldom occurs spontaneously. Numerous mechanisms – such as stakeholder engagement and co-creation processes – can assist in creating framework conditions to foster the development and adoption of novelties that address current and future societal needs. The European funded OpenInnoTrain project precisely aims to explore those mechanisms, across four specific contemporary settings, so to as equip researchers and practitioners with actionable knowledge to support their research and innovation journeys. As we cross the 2-year mark of the project, the intent of this book is to provide glimpses on OpenInnoTrain's current reflections and achievements with a variety of illustrations featuring activities across the consortium and beyond.

This research has received funding from the Horizon 2020 Programme of the European Union within the OpenInnoTrain project under grant agreement n° 823971. The content of this publication does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the publication lies entirely with the author(s).

ISBN 978-1-922016-75-1

9 781922 016751