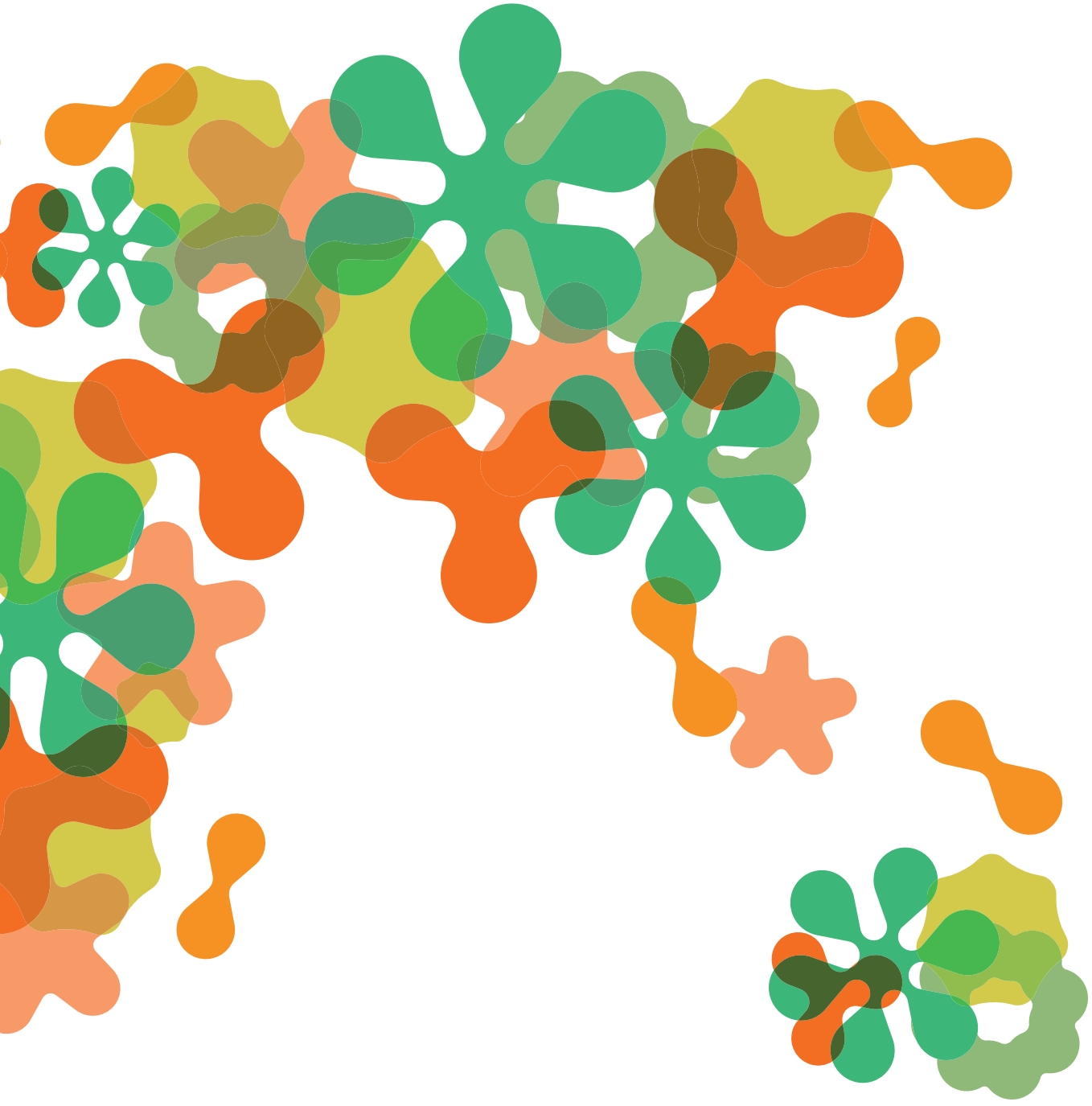
UniTo & the challenges of Industry 4.0

2017

Release September 2017

University of Torino



University
of Torino

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Foreword

This report originates from the need to gain comprehensive knowledge about the competences developed by researchers at the University of Torino in scientific domains that are crucial to address the challenges raised by the transition of the society towards the so-called Industry 4.0.

A working group has been created as of November 2016, involving several researchers affiliated to a wide array of Departments. The main aim of this working group was to provide a synthetic description of the scientific activities carried out by research teams, which show a high complementarity degree with the principles inspiring the Industry 4.0 paradigm or having high potential in supporting its successful implementation, by maximizing the returns and minimizing the social and economic costs.

The Departments involved in this enterprise were the following:

Department of Agricultural, Forest and Food Sciences

Department of Chemistry

Department of Clinical and Biological Sciences

Department of Computer Science

Department of Cultures, Politics and Society

Department of Economics and Statistics "Cognetti de Martiis"

Department of Law

Department of Life Sciences and Systems Biology

Department of Management

Department of Mathematics "Giuseppe Peano"

Department of Medical Sciences

Department of Physics

Department of Psychology

In addition, three Interdepartmental Research Centers took part to the activities of the working group:

Centre on ICTs and Innovation for the Society and Territory (ICxT)
Centre on Nanostructured Interfaces and Surfaces (NIS)
Competence Centre on Scientific Calculus (C3S)

The report intends to provide systematic evidence of the strengths of researchers at the University of Torino in the wake of the fourth industrial revolution, as well as of the opportunities for large companies, small firms and other stakeholders to establish fruitful collaborations to cope with the multifaceted nature of the transformation imposed by the new paradigm. This report has been produced by a team that collected and processed the knowledge provided by the participants at the working group.
The team is composed by:

Silvio Aime *(Vice-rector, coordinator)*
Marco Pironti *(Department of Computer Science)*
Francesco Quatraro (*Department of Economics and Statistics Cognetti de Martiis*)
Marco Zanetti (*Department of Chemistry*)
Silvia Forno and Francesca Natale (*Industrial Partnership Liason Team, Research & Third Mission Division*)
Stefania Stecca (*Communication, General Directorate*)

Contributions to the paper came from an extended group composed by:

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Department of Mathematics "Giuseppe Peano" - Laura Lea Sacerdote.

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Department of Management - Riccardo Beltramo, Pierantonio Bertero, Valter Cantino (Department of Management Director), Paola De Bernardi, Alberto Ferraris, Giuseppe Tardivo, Roberto Schiesari.

Department of Cultures, Politics and Society - Filippo Barbera, Roberto Di Monaco, Dario Padovan, Sergio Bernardino Scamuzzi, (Vice-Rector), Lia Tirabeni.

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Department of Psychology - Chiara Ghislieri.

Department of Law - Francesco Costamagna, Alberto Oddenino, Ugo Pagallo.

Department of Earth Sciences - Cesare Comina, Giuseppe Mandrone, Alessandro Pavese, Giulio Pavia.

Department of Molecular Biotechnology and Health Sciences - Silvio Aime (Vice-Rector).

Department of Life Sciences and Systems Biology - Margherita Micheletti Cremasco.

UniTo Incubator 2i3T - Giuseppe Serrao.

Research and Third Mission Division - Giuseppe Caputo.

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Preface

The challenges brought by I4.0 call for a renewed role of the University as it implies to further strengthen its deep integration over its territory to support the continuous improvement of its manufacturing system.
Tasks in educational and training programs and in the selection of research projects have to be refocussed towards the main needs of the ongoing industrial transformation.
The University will be more and more integrated in the engine of the development of its territory.
The University of Torino is keen to play this role and contribute to maintain for Turin and Piedmont their primary position in the field of manufacturing industry.
To tackle this task, a Working Group (WG) formed by delegates from several Departments has been set up with the commitment to start to make an inventory of what UniTo may contribute along the challenging avenues of I4.0. The contributions have been summarized in this document that aims at being the starting point for the development of new interdisciplinary collaborations between UniTo and the industrial system in the frame of the new horizons opened by I4.0.

Silvio Aime

1.

A full appreciation of the challenges of the Industry 4.0 paradigm

1. A full appreciation of the challenges of the Industry 4.0 paradigm

The manufacturing industry worldwide is facing constant pressure to increase productivity by reducing the utilization of raw materials and energy. Germany launched in 2011 the platform "Industrie 4.0" to tackle this challenge and to improve the competitiveness of its industries.

'Industrie 4.0' combines production methods with state-of-the-art information and communication technology (ICT). The driving force behind this development is the rapidly increasing digitalization of the economy and society.
The technological foundation is provided by intelligent, digitally networked systems that will make largely self-managing production processes possible.
In the world of 'Industrie 4.0', people, machines, equipment, logistics systems and products will communicate and cooperate with each other directly. Production and logistics processes are integrated intelligently across company boundaries to make manufacturing more efficient and flexible.

In September 2015, European Parliament issued this paradigm defining "**Industry 4.0**" as the fourth industrial revolution as develops new ways of organizing production across the entire value chain.
The Industry 4.0 factory operates according to six key principles:

- The factory is virtualized in order to simulate and monitor products, processes and the production environment in 3D
- Its systems are interoperable: they have the ability to communicate and interact with each other
- Decisions are decentralized: with cyber-physical systems taking autonomous decisions
- Analysis and decision-making take place in real-time, through continuous and instantaneous communication
- It is service-oriented: with better maintenance, and can offer new types of services
- It is modular and it rapidly adapts to changing demand conditions.

After Germany, other countries developed their own Industry 4.0 projects.
On September 21, 2016, the Italian Ministry of Economic Development, presented the "Industrial National Plan 4.0", for 2017-2020, which considers principles set out in Industry 4.0 issued by the European Parliament.
In this regard, the Italian Plan, to support Industry 4.0 developments,defines

four strategic measures:

1. **promotion of private investment in technologies**, support to research, development and innovation, promotion of investment in venture capital and start-up firms
2. **promotion of I4.0 education programs and skills development**, creation of Competence Center and Digital Innovation Hub
3. **implementation of the Ultra Broadband Plan**, and collaboration for the definition of IoT standard communication protocols
4. **adoption of public measures to ensure private investments**, support large investments in innovation; strengthen and innovate the supervision of international market.

At the outset the Industry 4.0 paradigm was almost exclusively articulated from a strict technological perspective. In the meantime, however, it became more and more evident that the transition to this new paradigm would have strongly affected the whole society. After six years from the launch of Industrie 4.0 in Germany it is clear that **constraining the "Industry 4.0" to just a technological breakthrough would be a mistake**. By involving trade associations and the unions, the German project has not fallen into this trap. The impacts on the organization of production, as well as on skills reconfiguration and disciplines cross-fertilization, are highly significant.

Industry 4.0 is a major challenge for the national production plan. However, it is not possible to accelerate the industry towards a new paradigm without this transition being in connection with society and territory. It will be necessary to develop a "4.0" environment ready to cope with the challenges posed by this transition.

While some analysts are concerned about the job displacement effects of these new technological solutions, a balanced view of the employment effects of Industry 4.0 should not neglect the fact that its introduction will generate opportunities for **new business models** that in turn could enable new jobs creation and productivity gains.

The introduction of cyber-physical based production systems will influence the human/machine interface, tasks organization and activity structures, as well as, ultimately, the overall **organization of the production process**. At the same time, the Industry 4.0 paradigm is expected to bring about major changes in labor markets – either inside or outside companies – and in the **relationships between enterprises and trade unions**.

1. Advanced additive manufacturing (AM) is one of the key factors in the development of smart production processes. However, the properties of AM parts are often inconsistent as compared to their conventional machined counterparts. This is due to a variety of factors including feedstock uniformity, microstructure evolution due to AM processing, and the overall ability of commercial AM machines to reliably form structural parts.
Without research and development into enhanced **new materials** (polymeric and metallic) specifically suited for AM will likely continue and further delay the transition from rapid prototyping to rapid manufacturing.

The high level of technology and process systems required by innovation typically involve large capital investments. **Capital budgeting and financial strategies** to support the Industry 4.0 transformation is crucial. **Tax planning** encompasses many different considerations, for example it is very important to consider measures to support innovative investments and empower skills, such as Super and Hyper amortization schemes.

The new industry will be characterized by developments of a range of new technologies such as artificial intelligence, robotics, nanotechnology and biotechnology. The resulting job displacement would likely occur in labour-intensive industries. Continuing education can cope with at least part of the unemployment problem created but also other critical social issues are connected with factory 4.0 and deserve specific analytical attention and coping strategies. **Skilled workforce** is key for the development, introduction and exploitation of the Industry 4.0 potentials. Post-graduate education and vocational training programmes provide the most appropriate environment to **human capital** that best fit with firms' requirements to effectively adopt new technological and organizational solutions.

In short, Industry 4.0 represents a radical change in the way things are designed and produced. It is based on global perspectives and involve not only all operational functions (production, supply chain, engineering, maintenance, etc.), but also the support functions (finance, human resources, and information systems). Accordingly, **academic institutions** should play the role not only of **technological pivots**, but also of **gatekeepers linking industry**, **society and territory**.

A new role of universities for innovation and local development has been largely recognized since the end of XXth century with the use of various concepts: triple elic, entrepreneurial university, community university, third mission. Industry 4.0 is a new promising chapter of this same tale.

2.

The scientific production for Industry 4.0 of the University of Torino at a glance

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2.1 Introduction

Managing the transition of socio-technical systems towards the Industry 4.0 paradigm requires the command of a wide array of skills and competences. The pluralism of disciplines represents a major strength for academic institutions, as compared to technical schools, in this perspective.
The University of Torino (acronym in the following pages: UniTo) provides an ideal and fertile environment for the development of a comprehensive set of competences functional to the Industry 4.0 paradigm, as it gathers together researchers specialized in natural sciences with those specialized in social sciences and humanities.

Though the term Industry 4.0 has been proposed only recently, it points to technological and socio-economic dynamics that have been dominating the scientific environment for many decades. A close inspection of the scientific production of researchers at UniTo in the last 20 years may provide an idea of the extent to which it is able to provide a full coverage of the relevant dimensions stressed above, and of how these competences represent a consolidated comparative advantage.

The University contribution is explored through the analysis of scientific publications of University members during the last 20 years. Publication data have been extracted from the Elsevier SciVal platform by employing specific research queries to extrapolate the scientific publications related to Industry 4.0 framework. Queries have been constructed by combining a set of competences keywords, identifying five different research areas that are interested by the transition towards the new paradigm: Agriculture, Chemistry, Computer Science, Physics and Social Sciences.

The analysis of the scientific contributions is conducted by means of four different metrics, presented in the following sections. The metrics are: i) the overall scholarly output; ii) an impact measure; iii) the degree of internationalization; iv) keyphrases calculations. The first three metrics are performance indicators that characterize the nature and the quality of the academic efforts made by UniTo members, while keyphrase analysis provides an intriguing overview of the evolution in key concepts within research fields.

2.2 Scholarly Output

Figures concerning the scholarly output provide a picture of how scientific production evolved over time. Figure 1 plots the scholarly output of our researchers in Industry 4.0 related topics during the last 20 years. The Figure shows an evident increasing trend in publications, revealing the importance these topics have gained over time. In particular, the scholarly output has grown substantially since the 2003, reaching 267 publications in 2016. In Figure 2, instead, we disentangled the contribution of each research area. A large share of all the publications comes from Chemistry and Physics studies, followed by Computer Science. However, Figure 2 shows that the research areas share a common increasing trend, though at slightly different rates, highlighting the relevance of the role played by each field.

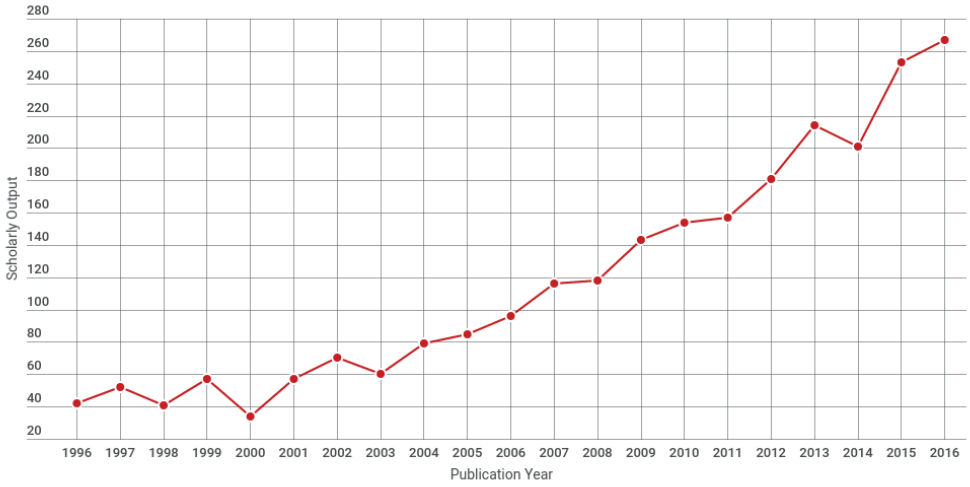

Figure 1: Numbers of Unito publications related to Industry 4.0 yearly from 1996 to 2016
Source: Own elaboration on SciVal

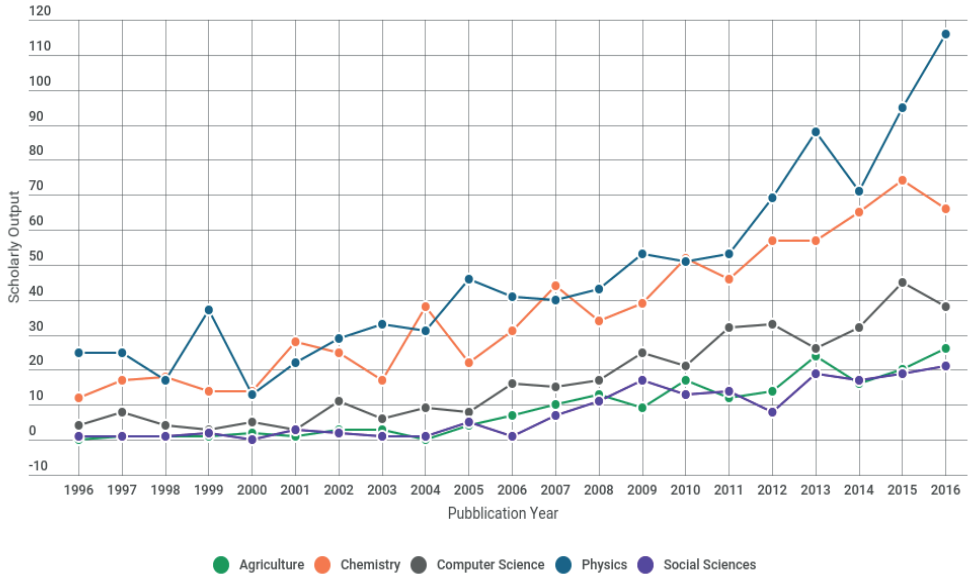

Figure 2: Number of UniTo publications related to Industry 4.0 yearly from 1996 to 2016
Source: Own elaboration on SciVal

2. 2.3 Research Impact

The metric used to evaluate the quality and the impact of publications is based on citations count. It is computed as the number of publications that have been highly cited, having reached a given threshold of forward citations. Figure 3 shows the evolution of the share of publications that are in the top 10 citation percentile. The evidence on publications quality suggests that on average about 1 out of 5 publication ranked in top 10% most cited worldwide. We can also notice that the long term tend seem to be slightly increasing, even though citation patters tend to fluctuate over time.

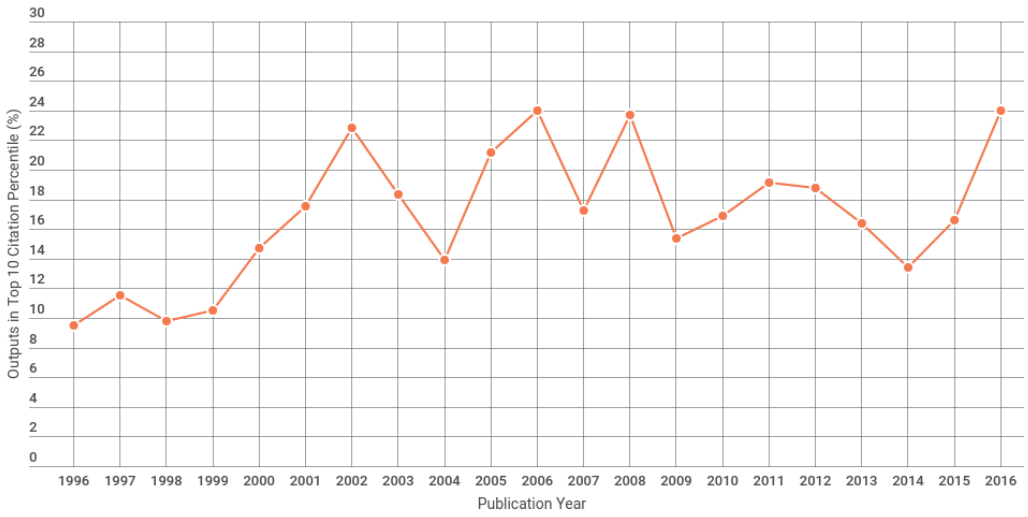

Figure 3: Share of UniTo publications related to Industry 4.0 in top 10 citation percentile expressed as a percentage, yearly from 1996 to 2016
Source: Own elaboration on SciVal

2.4 Internationalization

The interesting and promising evidence provided by the quality metric is confirmed by the data on the internationalization degree of the university publications. The extent of international collaboration is measured by counting the number of publications in which at least one co-author belongs to a foreign institution. The internationalization degree of Industry 4.0 related publications from 1996 to 2016 is shown in Figure 4. The data exhibit a pronounced increasing trend with a substantial acceleration during the last five years. It is worth noting that, comparing the number of internationally co-authored publication with the overall number of publication in Figure 1, the former are about half of the latter, indicating a strong tendency toward international collaborations. This increasing relevance of international co-authorships is also confirmed by the evidence on the research areas (Figure 5).

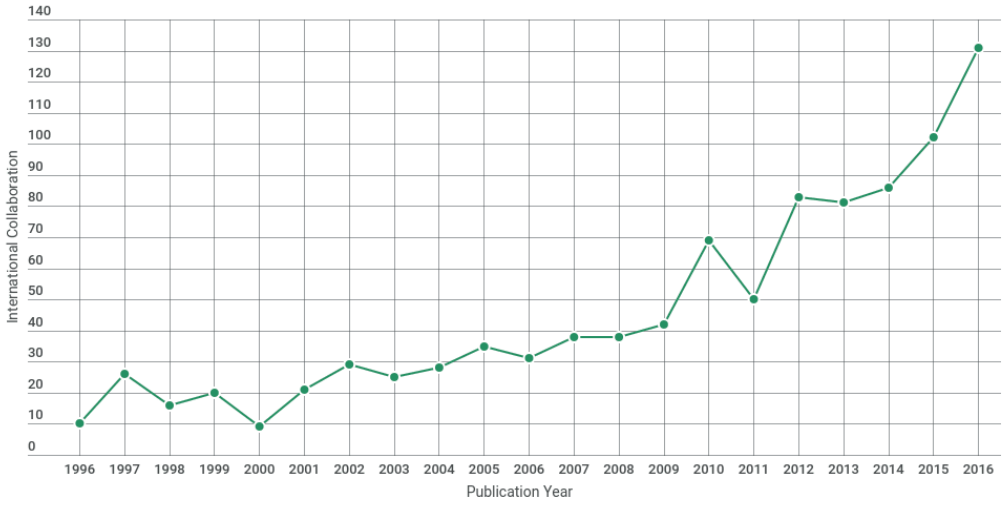

Figure 4: Number of UniTo international co-authored publications related to Industry 4.0 yearly from 1996 to 2016
Source: Own elaboration on SciVal

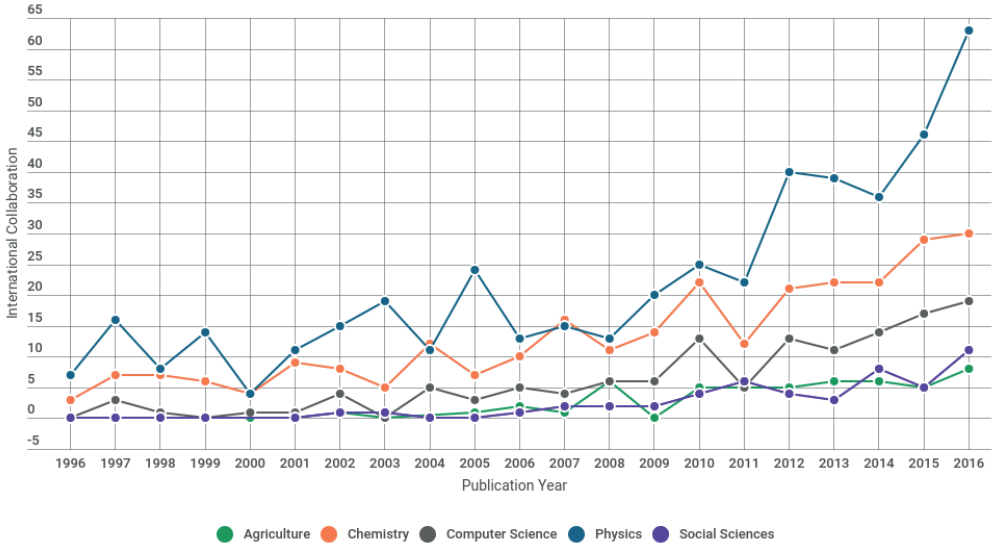

Figure 5: Number of UniTo international co-authored publications related to Industry 4.0 per research area yearly from 1996 to 2016
Source: Own elaboration on SciVal

2.5 Conclusion

The increasing number of publications, their quality, the high share of international collaborations and the distinctive keyphrase are all indicators of the strong competencies already present at UniTo. Furthermore, their evolution over time also signals encouraging positive developments in Industry 4.0 related researches in the near future.

3.

Education & Training activities for I4.0

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UniTo is committed to tackle the training challenges for licensing the highly qualified staff that is needed to cover all the stages of the innovation value chain for industry 4.0, for the forthcoming years.

Along the years, UniTo has implemented activities that are of key importance for tackling the main issues towards a full embodiment of the objectives of I4.0. In all the currently operating degree courses, UniTo provides qualified teaching in Information and Communication Technologies, supported by a diffuse network of computer teaching labs. Moreover Entrepreneurship courses are active in several domains as well as a centralized initiative in the five main macro-areas. The training activities include thematic workshops and laboratory work-up tailored for the specific field of application.
The trainees are introduced to the use of tools like IoT, Arduino, etc. as well as to get practice on 3D-printing, Advanced Additive Manufacturing procedures, preparation and characterization of new materials, nanotechnology devices and advanced software management and development. Importantly an increasing number of courses are given in English.

UniTo will progressively **optimize its educational offer** to support small and large enterprises in their path **along the I4.0 revolution** through a full involvement of competences from all the science/technology domains and the most relevant Social Sciences & Humanities (SSH) fields. We aim at using the opportunity offered by I4.0 to develop a new paradigm of collaboration with the industrial world based on an intense research collaboration and training support to boost transfer of knowledge and innovation in manufacturing industry either on the technology side or in management and business models. Much attention is and will be devoted to continuing education activities (e.g. Master courses) to support industries in their specific, managerial and entrepreneurial, challenges that I4.0 poses on their organizational transformation, business model innovation, and technology management strategies.

In particular, **apprenticeship** represents an opportunity for a continuous of training/work exchange process, through which trainees can be hired by a company and simultaneously follow a training course (first and second level degree courses, master or PhD).

In this context it is worth of mention the recent activation of Industrial PhD programs in the field of Modeling and Data Science and Innovation for the Circular Economy.

UniTo has already implemented an extensive educational and training framework in a number of core fields (Hard skills) relevant to Industry 4.0. They are:

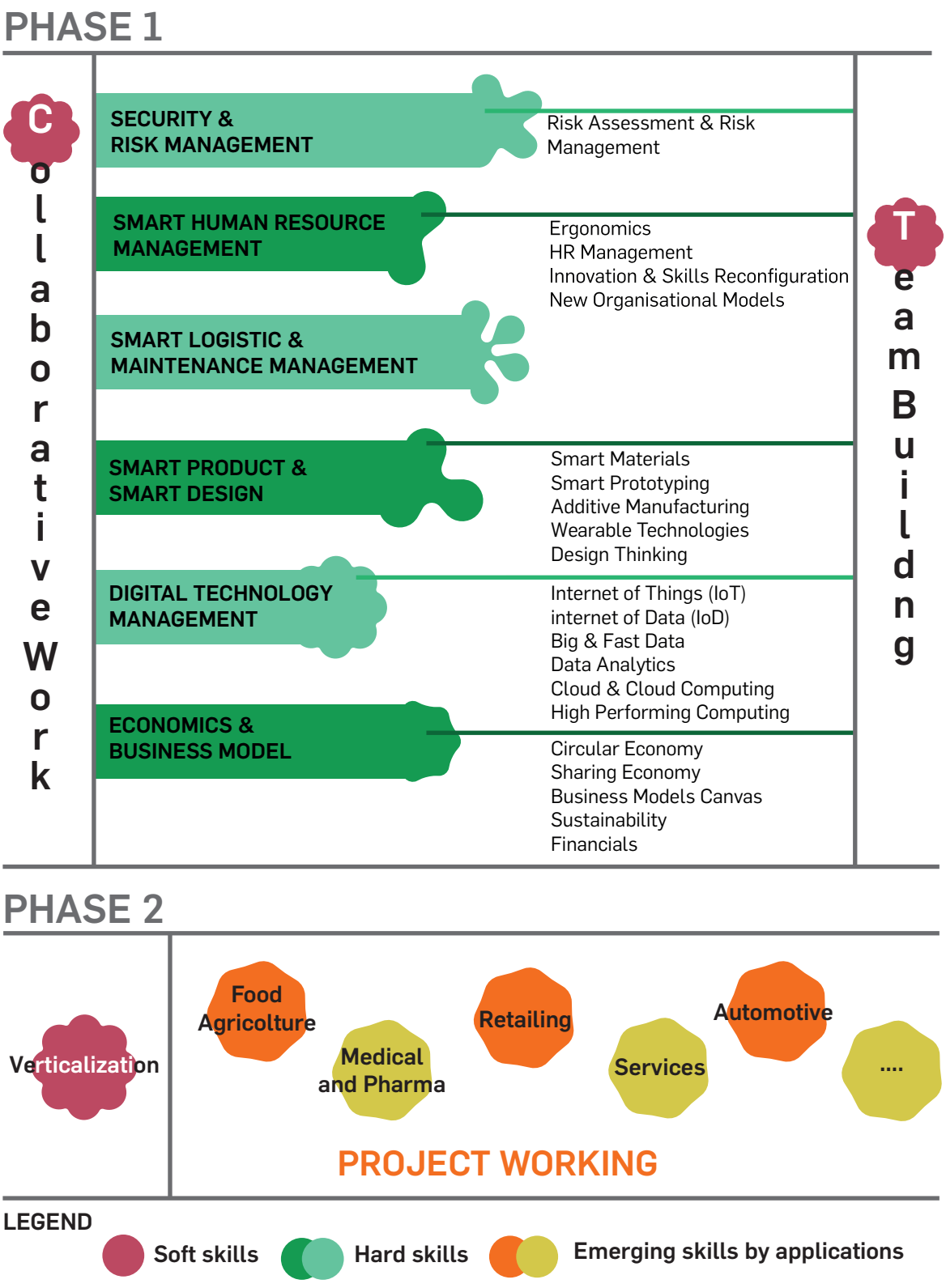
- **Economics and Business Models** (Circular economy, Sharing economy, Business Models Canvas, Sustainability and Financials)
- **Digital Technology Management** (Internet of Things IoT, Internet of Data IoD, Big & Fast Data, Data Analytics Cloud & Cloud Computing, High Performing Computing)
- **Smart Product & Smart Design** (Smart Materials, Smart Prototyping, Advanced Additive manufacturing, Wearable Technologies, Design Thinking)
- **Smart Logistic & Maintenance Management**
- **Smart Human Resource Management** (Ergonomics, HR management,innovation & Skills reconfiguration, New Organizational Models)
- **Security & Risk Management** (Risk assement & Risk Management)
- **Design and testing of innovative materials**
- **Design and testing of innovative sensors and devices.**

Furthermore, the learning process allows promoting the **development of Soft skills** related to **Team Building** abilities and **Collaborative Work competencies**.

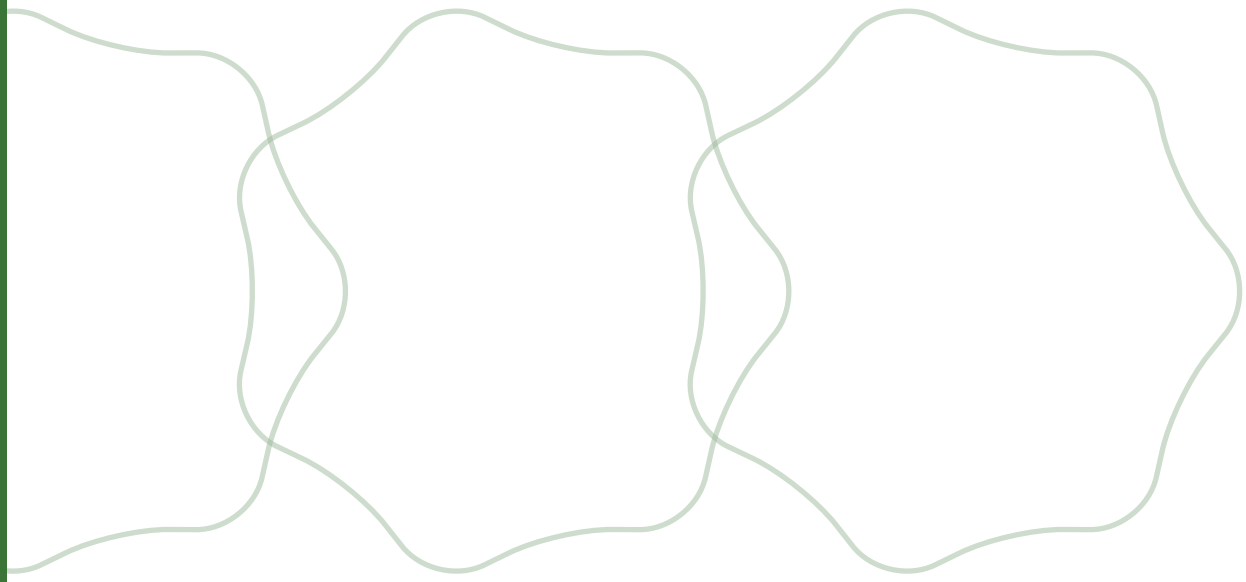
The acquisition of Hard and Soft Skills enables trainees to play important roles in the complex pathway industries have to engage to adhere the new paradigm of Industry 4.0 (whatsoever is the specific activity field, i.e. AgriFood, Medical and Pharmaceutical, Retailing, Services, Automotive, etc…).

The overall links are summarized in the flow-chart (Fig. 6).

3. Industry 4.0



The development of both Hard and Soft Skills competencies allow to trainees to empower new skills to rightly identify and perform the challenges of Industry 4.0 and shape them for specific fields (i.e. Food Agricolture, Medical and Pharmaceutical, Retailing, Services, Automotive, etc.).



4.

The University of Torino and the local innovation ecosystem in the transition to the Industry 4.0

4. The University of Torino and the local innovation ecosystem in the transition to the Industry 4.0

In view of the wide scope of challenges and opportunities that the Industry 4.0 paradigm is expected to bring about in the society, UniTo will draw upon the key strengths illustrated above to stand as a key player in the local innovation ecosystem that facilitate the transition by maximizing the benefits and minimizing the potential side effects for the stakeholders.

The role of such an interdisciplinary research institution is crucial in view of the specific features of the regional and national economy, in which the size distribution of firms is strongly skewed due to the very large share of small and medium-sized enterprises (SMEs), most of which experience serious barriers to the successful adoption of digital technologies within the organizational boundaries.

The diffuse statement concerning the Industry 4.0 mostly focuses on technological change and spread out of innovations, and how these affect firms' performances. The contribution of an academic institution in this respect concerns both the generation and the adoption of new technologies. In addition, assets' sharing represents a new opportunity to provide local actors with access to expensive scientific infrastructures and machineries, without bearing the prohibitive purchasing costs.

On the one hand, as a key player of the innovation ecosystem, UniTo is clearly committed to collaborative R&D activities and to technology transfer. Large and multinational corporations operating in the area can find in our institution a bundle of scientific and technological competences that are at the frontier of scientific research. It's a unique mix blending a wide array of fields, ensuring productive cross-fertilization and creation of novelty. UniTo will promote **joint research efforts and technological partnerships to accompany firms in the local ecosystem to the new paradigm**.

On the other hand, most of SMEs do not have the resources to carry out independent or collaborative research. In most cases they stand as potential adopters of digital technologies to move towards the new paradigm. UniTo has developed sound experience in scientific collaborations with both large corporations and SMEs, and will be acting as a relevant **node of local**

digital innovation networks linking these different types of institutional actors.

Sometimes SMEs are even hardly aware of which technological solution is better suited to make a factory 4.0 out of their production plants. A key supporting activity in this respect concerns **technological intelligence, and the identification of technological needs, gaps and solutions** that fit best with the nature of their economic activity and their prospective strategies.

Moreover, the implementation of new technological solutions within firms' organizational boundaries involves much more than the command of scientific and technological principles to govern the new equipment.
Key complementary innovations concern the organizational structure. UniTo will provide **support in the identification of the organizational layout and/or management structure that fit best the new technological configuration**.

The opportunities for firms willing to adhere to the Industry 4.0 are also related to the massive production of data, and the way these are exploited.
On the one hand, the large amount of data can be analysed to monitor and improve the efficiency of the production process, reduce the environmental impact and/or implement changes in the organizational layout. UniTo will **help firms by searching models and algorithms for big data analysis**, and for the interpretation of the results. On the other hand, data are increasingly gaining economic value. Firms will be helped in the **identification of new business models based on data production**.

Industry 4.0 is not only about technologies but also, and mostly, about people working in firms that ought to be actively engaged in the design and implementation of the new paradigm. **Human resources** will still be crucial for firms to successfully cope with the change. Because of the interplay between new technologies and people, the implementation of Industry 4.0 is likely to have an important social impact, well beyond the mere productivity gains and profitability of industrial activities. Some jobs will become obsolete, while many other will be created. The net impact can hardly be foreseen.
To maximize the social benefits, Innovation must be coupled with **skills reconfiguration, human capital accumulation and lifelong learning programmes**. These aspects are part of the main mission of an academic institution, i.e. education and training.

UniTo will act as **pivotal node of an extended network** that will involve all relevant stakeholders, **to promote the Industry 4.0 paradigm as a social**

4.

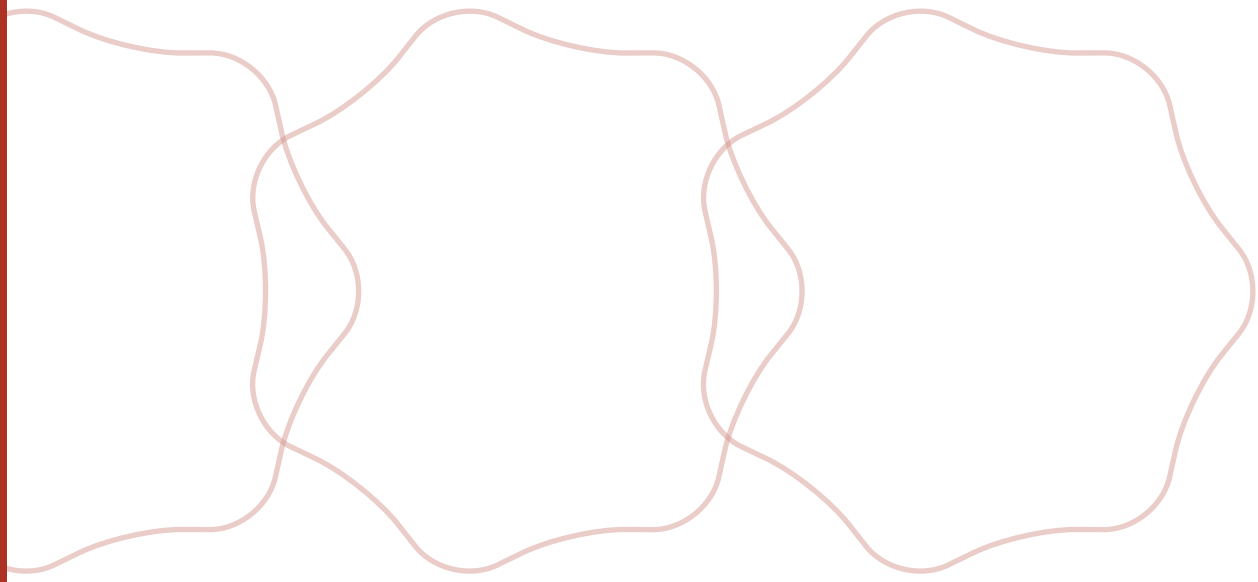
innovation, i.e. a new configuration that makes contribution to social progress. This entails increased social added value not just for workers of future smart factories, but for citizens in general.

A comprehensive approach to the Industry 4.0 will call for close interactions with public institutions and policymakers, to provide **support to decision making concerning public policies** to promote social inclusion and sustainability in the wake of the digital revolution.

UniTo provide a unique blend of heterogeneous and yet complementary fields, which have been long working on topics that are relevant for the Industry 4.0 plan. In this context, such wide coverage makes **UniTo as an ideal partner to design, implement, manage and assess firms' strategies and to promote a shared approach that maximizes social benefits**.

To this purpose, a working group of experts has been recently established within our institution, to achieve comprehensive knowledge about the activities carried out in the past years by our researchers, and the competences developed accordingly, which are directly or indirectly related to the scientific and technological fields underpinning the Industry 4.0 paradigm.

A broad survey was launched, involving all of the University Departments, asking researches to show their distinctive competences and knowledge in view of their bearing on the implementation of the paradigm. The results of this survey are synthesized in the following section. More detailed information is available on request at the address **staff.ricerca@unito.it**.



5.

An overview of the UniTo competences for the Industry 4.0

5. An overview of the UniTo competences for the Industry 4.0

Departments

5.1 Department of Chemistry

Advanced materials for I4.0

Advanced materials are developed from compounds at a molecular level through applied physics, materials science, and chemistry and may generally be considered to fall into three categories, including metals, composites and polymers, in addition to new materials, such as ceramics, carbon nanotubes, soft materials and other nanomaterials.
Advances in materials and manufacturing technologies are linked to those in computing and data management as well as by developments in connectivity. In the Department of Chemistry several research groups are currently involved in:

1. **Advanced metallurgy**. UniTo groups are leaders in the field of metallic glasses, with contributions both to the fundamental theory underlying their formation, as well as to their industrial applications. Recently, this research line has led to the development of novel nanoporous metals with peculiar chemical and spectroscopic properties.
2. **Additive metallic manufacturing (AMM)** involves rapid solidification either as selective laser and electron beam melting/deposition giving the chance of attaining enhanced solubility, refined microstructure, metastable phases representing a new paradigm for alloy design in view of resource exploitation, reduction in the use of critical materials and recycling (aspects of "green metallurgy").
3. **Polymer nanocomposites** are a very important class of material that is just recently being used in additive manufacturing. UniTo groups are leader in developing polymer nanocomposites for flame retardant and automotive applications. More recently CNT/polymer piezoresitive nanocomposites have been developed for innovative vehicle application. Newly, this research line lead to the development of nanocomposites to be employed in **3D printing**.
4. **Organic functional materials** are finding increasing applications in cutting-edge technologies such as energy production, storage and conversion, nanomedicine and biotechnology. UniTo groups are experts in the synthesis of π-conjugated molecules (with absorption and emission properties from the UV-Vis towards the NIR) and photoactive,

electroactive and conductive nanomaterials. Some of these systems are being actively investigated in sensors, photovoltaic cells, light-emitting devices and nanomedicine (i.e. optical imaging and theranostic).

5. **Adsorbent materials** represent a solution for the detection and removal of pollutants from industrial productions. The main used adsorbent materials are **activated carbons** offering a good compromise between selectivity and performances, however the production of these microporous materials does not follow principles of green chemistry. The use of sustainable **biomass precursors** is studied to reduce the carbon footprint as possible. The use of activated carbon in combination with a second more specialist adsorber could allow extension of the adsorption capacity of the overall system. **Metallic organic frameworks (MOFs)** are acknowledged to be candidates for selective toxic gas adsorption from the air and they offer the advantages to offer the possibility to be tuned to adsorb specific targets, e.g. ammonia, formaldehyde, benzene, H2S, NO or CO.

Modelling for Industry 4.0

Modern manufacturing technologies need improved products and processes.
The development of new materials, with improved properties, can be currently predicted in silico by suitable modelling techniques.
In UniTo several research groups are currently involved in the in-silico modelling of products and processes. In particular, based on the scale of modelling, the following competences in UniTo can be mentioned:

1. **Small scale simulations** are carried out at ab-initio calculations. Development of a powerful program distributed all around the world (www.crystal.unito.it). Current use of various codes available. Availability of HCP power computer for easy and fast calculations on relatively large systems.
2. **Thermodynamic and kinetics modelling**. Development of thermodynamic and kinetic database for the calculation of phase diagrams and for the simulation of phase transformations. Specific applications to metallic materials and to hydrides.
3. **Simulation of piezoelectric, dielectric, elastic, and photoelastic properties** of material relevant for industrial applications
4. **Finite Element Methods**. Software are available in the Department for the simulation of process, even at industrial scale.
5. **Life Cycle Analysis**. The application of LCA approach to energy storage systems is currently running in UniTo.

5. 5.2 Department of Physics

Advanced materials and Advanced Manufacturing Solutions for I4.0

Researchers of the Physics Department have established strong connections with industrial partners on shared research programs aimed at making progresses in both the synthesis and characterization of **innovative materials and advanced manufacturing solutions.**

A work grown in several fields: automotive applications, heat dissipation as well as space science, on space debris remediation, and high tech solutions for cancer treatment developed by the Medical Physics Group of the Department, in close collaboration with the Torino Istituto Nazionale di Fisica Nucleare (INFN).

1. In the **automotive field** are under way:
   i) thermal, structural, compositional and acoustic analysis of advanced materials for brake pads;
   ii) micrographic characterization of cast irons for exhaust manifolds;
   iii) micrographic characterization of aluminium metal alloys for cylinder heads;
   iv) advanced optical lighting systems
2. In the fields of **heat dissipation and radiation detection**, collaborations with experimental partners have been established on the development of chemical vapour deposition of artificial diamond, with the scope of taking advantage of the unique properties of this advanced material (high thermal conductivity, extreme radiation hardness)
3. **Space exploration** as well as **medical radiation therapy** require to develop **innovative detectors** capable of identifying simultaneously signals from living cells and from incident radiation and shielding systems suitable for radiation dose reduction for astronauts and patients. Those sensors are developed using **Simulation, Big Data Management**, cut-edge technology, with extremely low-power consumption, radiation hard components with real-time data processing capability, rendering them suitable for improvement in Advanced Manufacturing.

5.3 Department of Computer Science

Modelling and Data Science

Analysis and optimization frameworks to design and operate factories based on data collected from heterogeneous sources, through different tools like machine learning. Expected benefits involve higher flexibility, increased productivity with less defects, and higher competitiveness. Monitoring, modelling and analysis of manufacturing systems aim at forecasting their behaviour, and are integrated with optimization methods utilized both in the design and in the operational phase to introduce continuous improvements.

This activity provides companies with support for what concerns increasing product customization, higher demand variability (leading to fluctuations in target performance), shorter product life cycles, introduction of new technologies, more flexible manufacturing tools and higher pressure to reduce costs. It will support managers as well in taking timely decisions regarding both technical aspects (like machine reconfiguration or buffer modularity) and managerial aspects (such as allocation of machine operators and maintenance personnel).

Big Data, Analytics and Machine Learning

This field of study is at the intersection between Databases (in particular very large databases and NoSQL databases) and Data Mining/Machine learning. The activity revolves around:
i) the implementation of innovative data analysis models based on Machine Learning;
ii) the elaboration of privacy-preserving algorithms that allow the application of analytics on big data (sensor data) but at the same time preserve the privacy of the data owners (users of sensors).

Cloud computing

Dealing with ICT solutions for developing service oriented distributed and collaborative platforms, hosting IoT and business data collection and analysis services. The integration is aimed at orchestrating distributed services collaboration. This is very important for the Industry 4.0 framework because it enables a seamless integration of different production and data analysis environments including legacy systems. This allows companies to collaborate with each other in complex, distributed data flows, without changing their own SW solutions. These competences translate into supporting activities concerning:

1. **Advanced Manufactoring Solutions** (Numerous integrated sensors and standardized interfaces)
2. **Enhancement of the efficiency** (e.g., supporting real time data collection and analysis for preventive maintenance of machineries), improvement of the quality of work (by reducing, e.g., the overhead in quality certification through digitalization and automation of quality processes, or the configuration work to set up production systems).

Augmented reality

Visual data represents one of the richest form of information in our digital word. Promising avenues of development range from self-driving cars to medical applications or industrial automation. Researchers investigate how "Machine Vision", e.g. automatic inspection and analysis for process control and robot guidance, can enable changes in manufacturing production processes and environments.

5.4 Department of Mathematics

Big Data and Analytics

1. **Full evaluation of available data**
   The research team at the Department of Mathematics develop **mathematical models to analyse data and extract information** often not even imagined by their collectors.
   Any company collects data. Often, these data are not deeply studied and the management loses an important aid for its decision process. Models determined from data can improve industrial efficiency, allow comparisons between different manufacturing and automatic procedures, forecast future problems and allow selecting the best politics accounting for external conditions. Models for network may allow to understand customer satisfaction as well as to forecast the effect of new marketing policies. Here below some examples of study implied or connected to these fields:
   i) **Price modelling**
   ii) Algorithms for **Brain Computer interfaces**
   iii) Mathematical **models of networks** and their use to **forecast long term behaviour** (social networks, World Wide Web, neural networks are examples of applications)
   iv) **Optimal stopping problems** -as the study of atomic clock error-but analogous problems may arise in very different applications.

2. **Real-time decision-making support and optimization**.
   Data allow simulating different scenarios through models that

approximate the behaviour of the market. A great number of industry 4.0 goals requests the use of data and the ability to integrate different databases. However, it is important to underline that use of data without the support of mathematical models may determine "ad hoc" solution that may lose their value when something changes in the context of application. Use on models may be an important tool to attain the prescribed goals.

5.5 Department of Agricultural, Forest and Food Sciences

Advanced Manufacturing Solutions for Agricultural and Food Products

The Department of Agricultural, Forest and Food Sciences is investing large efforts in Agriculture 4.0 challenges. Many of the competences developed in this field are readily applicable to Industry 4.0 paradigm.

1. **Simulation, Robotics** and **Automation** can play a key role in the field of agriculture and food productions. These technologies can improve the quality of products, increase the productivity, introduce higher flexibility in the use of the machines, reducing the overall production costs. At the same time, they allow the reduction of the environmental impact and the possible risks for the safety and health of the operators founding applications in plant factory systems.
2. **Precision Agriculture** requires advanced agricultural machines, able to adapt in real-time their operating condition, to match, on a site-specific scale, crop/soil needs across the adoption of farm machinery, automation, optical sensors and software, through a strict collaboration between advances industries and researchers.
3. **Biobased materials** can play a key role in the field of agriculture and food productions. These materials can improve the sustainability of products, increase the shelf-life of fruits and vegetable and satisfy requests of the new consumers in terms of reduction of the environmental impact. Biobased packaging can improve both waste reduction and higher competitiveness of products thanks to innovation and sustainability.
4. **Traceability** nowadays plays a key role in any production field and, in particular, in agriculture and food productions.
   Automatic identification of products, as well as the ability of managing lots with dynamic and appropriate properties, are strategic tools to improve the efficiency of supply chains and their capability to face possible product recall. One of the key-points relies in the development of technologies for the automatic identification of items of product using radio frequency, contactless, techniques (RFID - Radio Frequency Identification).
5. **Geomatics** (Remote Sensing, Digital Photogrammetry, Satellite Positioning and Navigation, GIS) can play a key role in the field of

agriculture and food productions. One of the main task of the research group is the validation of existing remote sensing sensors, software for image processing with the explicit goal of suggesting improvement and simplifications to make them core compliant with both agronomic requirements and incomes.

6. **Crop genomics and transcriptomics** involves the production of large amounts of data, which fall within the "Big Data and Analytics", related to the topics and the guidelines of Industry 4.0.
7. **Enhanced Relationship Tools for Agriculture and Food Production** is strictly related to the topics of Industry 4.0 and Agriculture 4.0 frameworks. Advanced production processes will cause a big amount of data, closely related to the economic analysis. In the forthcoming time, will be needed to manage new Relationships, new Businesses, and new Companies Organization.

5.6 Department of Management

Horizontal / Vertical Integration

The Department researchers analyze how the company operates within the environmental system, acting in mutual relationships with its specific context, capturing constraint and opportunities for the realization of its competitive and durability successful. The research activity refers to all the stage of the company lifecycle. The shared study approach is that of functional areas. The Department is facing organizational and management changes as a critical success factors for any digital transformation program embracing, in our researches, four major areas: **aligning leadership** (e.g., digital vision, role modeling), **mobilizing** the **organization** (e.g., communication), **building capabilities** (e.g., digital skills), **supporting strategic and management decision-making processes and ensuring sustainability** (e.g., adapting KPI and incentive systems).

Moreover, digital technologies and smart manufacturing models need reshaped accounting and management information systems (e.g., planning, budgeting, reporting, forecasting and cost accounting systems), enhancing their information potentialities and their ability to support decision-making processes.

The Department can help companies to **redefine the key strategic decisions-making processes** to prepare them for these fundamental changes. It could be as part of the strategic orientation (Roadmap & Assessment), the anchoring in the organization (Change Management & Target Operating Model) or the specific design of the performance management instruments (Digital Forecasting, Digital Reporting), the researchers are on hand to exchange with companies experiences, ideas and expertise.

Moreover, the Department of Management activated on the topic of industry 4.0 collaborations with category associations such as "Unione Industriale", "Piccola

Industria" and the Chamber of Commerce of Turin. The research is carried out within an observatory namely Smart Manufacturing Piemonte (SMaPi).

In addition, the Department of Management is developing forms of collaboration with various large and small businesses on topic 4.0 in collaboration with dedicated interdepartmental centers (Labnet), other Departments (Culture, Politics and Society, Computer Science), and other University Structures (SAA School of Business Administration, Industry Group 4.0). Particularly, in co-operation with the LABNET laboratory, the Department is developing a specific business advisory and research center that aims at deepening issues 4.0: the Human & Organization 4.0 Center.

Precondition for a fully automated value chain
(from supplier to customer, from management to shop floor)

- **Food Digital Monitoring (FDM) project** is implemented in the Department of Management with the Food Digital Monitoring project. It develops the concept of "**Intelligent Factory**" through the active and passive control in Near Real Time of all the indicators of the multidimensional dashboard, that provide information on the potentially critical phases of a food process.

  This centralized monitoring system, indicated in the FDM project with the term "dashboard" (or "Smart Dashboard"), will allow Food companies to control the entire production and distribution chain by detecting any anomalies through the diagrams that represent the phases and the production facilities until you find out very quickly where the problem has occurred.

  In this type of approach, the consumer is a key element of the control system: thanks to sentiment analysis systems applied to social networks - that will serve as capillary distributed "virtual sensors"- it will also be possible to monitor emotional impact and perception of the product by the consumer. Also using the method of focus groups to taste on customer preferences and perception on technology content of new smart products.
- Industry 4.0 in Agrifood system can abilitate **digital monitoring processe-**as described above-to create a new paradigm of PAT –Process Analytics, the Internet of Things, Open Data, and Process Paradigms Big data. They will be harvested by means of technologies specially developed for the monitoring of chemical, physical and microbiological parameters, data and information throughout the production chain of sample food, raw material acquisition, transformation, finished product, distribution, reaching to the consumer. These data will be processed and returned in the form of control elements to allow capillary monitoring of the respective production process.

5. 5.7 Department of Cultures, Politics and Society

Horizontal / Vertical Integration

The department supports businesses to optimize the introduction of 4.0 technologies and to avoid the risks associated with the low involvement of human resources and organization. Two areas of research and advice are priorities.
The first area supports the competitiveness of businesses and business networks on the following themes:

- **Properly interpreting data** collected and delivered by consumers (and this requires knowledge of lifestyles, product use contexts, how they interact, etc.);
- **Design and implementation of network structures, analytical tools and learning processes** that allow to use data concerning production processes in a decentralized way, in order to facilitate continuous quality improvement, learning and self-control of work;
- **Strengthening the skills of people involved and designing motivation strategies** in order to increase collaboration in data interpretation and performance improvement;
- **Supporting the reorganization of structures and the development of appropriate leadership models**, enabling the distributed intelligence to be properly valued both in the organization, in the production chain and in collaborative networks.

The other area of research and advice concerns company's context and factors that represent the system's conditions for competitiveness and equity.
In particular, CPS research and advice are focused on the following topics:

- **Policies** for promoting and encouraging **stable cooperation between enterprises and training and research organizations**
- Training **policies** to **improve the relationship among businesses and the labour market**
- **Policies** to improve the **quality of the socio-economic environment.**

In both these areas, the CPS Department performs multidisciplinary research, using both qualitative and quantitative methods and tools suitable for handling complex archives, such as network analysis and case studies. In addition, CPS is developing forms of collaboration with various large and small businesses on topic 4.0 using labs with corporate staff, collaborations with dedicated interdepartmental centers (Labnet, ICxT), other Departments (Management,

Cognetti Economics, Computer Science, Psychology), and other University Structures (SAA School of Business Administration, Industry Group 4.0). Particularly, in co-operation with the LABNET laboratory, CPS is developing a specific business advisory and research center that aims at deepening issues 4.0: the Human & Organization 4.0 Center.
The Department hosts researchers specializing in the **sociology of organizations**, of work, of local development, and of innovation.

1. Particular attention is devoted to **operational implications** of the adoption of digital technologies to achieve a Factory 4.0, and to the changing role of managers.

2. Researchers support firms in the identification of its own approach to industry 4.0 from a cultural and organizational point of view, identifying tools and methods that may be needed to **improve the expected performance of technological innovations** and more generally corporate performance.

3. Specialized competences on the **classification of professions**, the **analysis of the quality of work and of working life**, **labour market** and **labour policies,** help a better **understanding of the critical issues** concerned with an extensive and intensive introduction of Ict in the factory 4.0 and in the local labour market and training system. Both direct and side effects of the diffusion of this innovation in the regional economy and for a local industrial policy can be appreciated and forecasted thanks to a long tradition of analysis of local development, both urban and regional, and of the social factors affecting economic and social innovation.

5.8 Department of Economics and Statistics Cognetti de Martiis

Big Data and Analytics

The Department hosts competences related to the Industry 4.0 paradigm concerning

i. labour economics and the association between '**individuals' health and the condition of workplaces** on the one hand, and
ii. big data analytics on the other hand.

The **DESPINA Big Data Lab** promotes research cooperation and exchange with scholars and universities in Italy and abroad; facilitates spillovers with companies and business partners; we support public administrations in policy formulation; and stimulates public debate and dissemination of good practices in data management and analytics.

5. 5.9 Department of Psychology and Department of Public Health

Different but complementary approaches to **security** and **wellbeing of work and working life** are developed since many years in the two departments whose activity has important connections either with private enterprises and with the public health agencies encharged by law on these two topics.
Important competences are engaged in current research and in the measures that are necessary to cope with the new problems of factory 4.0.

5.10 Department of Law

Important critical issues in the activities connected with factory 4.0 concern private, commercial, public law and the department developed specific competences ranging from the **right** of robots to big data, privacy, and industrial cybercrime, to **patents** in the ict innovation processes.

5.11 Department of Psychology

The Department hosts competences related to the Industry 4.0 paradigm concerning:

- **People assessment/evaluation/training**: softs skills profile, assessment instruments and procedures, evaluation of assessment/advancement/development practices
- **Wellbeing and work family balance**: wellbeing at work, at individual and organizational level, and its antecedents; job satisfaction; work engagement; performance evaluation; organizational climate research; practical implication to enhance people wellbeing (training, leadership/management practices); older workers.
- **Automation of industry**: human-automation interaction; people motivation in industry 4.0 era; leadership and management style, decision making processes in industry 4.0.

These activities can provide firms with support in technological innovation processes and in change management (through research-action-training practices); recruitment, selection, career development & advancement, organizational behavior training (leadership, communication, teamwork, decision making processes, ...), people management, older workers management in Industry 4.0.
Companies are expected to improve their processes of personnel placement, development and induction; foster workers wellbeing, work engagement,

people involvement and organizational commitment; reach success in innovation processes fostering the best human-workplace fit in Industry 4.0 paradigm.

5.12 SAA School of Management of University of Turin: LabNET Human & Organization 4.0

Human & Organization 4.0 is a Research-Action Laboratory part of LabNET, the Innovation Centre of SAA – School of Management of University of Turin. At the moment it integrates resources and **competences** of a **managerial**, **organizational**, **economic**, sociological, psychological nature (but is open to the contribution of other disciplines) coming from SAA, the Management Department, the Political Culture and Society Department, external expertise from companies and **consulting** firms - making them available to industry innovation processes 4.0, particularly in SMEs.

The benefits expected from industry 4.0 are conditioned not only by technological investments, but also in particular by the organizational and management capabilities of companies, both in the design phase and in the implementation and development of the change. The approach is to consider transformations of the entirety Social-Technical system of the company and not just its strictly technological component.

Human & Organization 4.0 Centre makes it available to companies several initiatives, tools and methods, dedicated to:

- **Check** their "**Managerial and Organizational Readiness**" to the transition toward innovative digitalized manufacturing models
- **Improve managerial awareness** and capability to face the change management process required, in terms of i) impact of technological innovation on the business's economic characteristics and performances, such a value generations and new emerging business models; ii) impact on leadership models and on internal process integration, supply chain integration, client involvement; iii) impact on organizational models and on the organization of work, in particular on the models of coordination, information flows, knowledge management, continuous improvement, lean production, etc.; iv) impact on people's skills and human resource management practices, in particular people's engagement, man-machine/man-data relationship, span of control, etc.
- **Accompany companies** in the process of transformation through a "Research-Intervention" framework
- Provide **training**, using the "Learning Factory" approach, in particular by increasing the management capabilities, equipping managers with

new tools and competencies and giving new skills, such as the ability to relate to more and more dematerialized work processes, to use massive data treatment, to think applying abstract models and representations of production processes

- Create **new models** of engagement and empowerment of human-resources
- Collect and **share knowledge**, through in particular an "4.0 Observatory" on the ongoing transformations in companies; 4.0 Focus groups" with companies, experts, stakeholders, business associations; Dissemination materials; Benchmarking and "Benchlearning" opportunities for companies; Comparison with international experiences.

Centers and Labs

5.13 NIS—Nanostructured Interfaces and Surfaces Interdepartmental Center

The NIS Centre is an inter-departmental Centre composed by more than 90 researchers from 5 Departments of UniTo: Chemistry Dept., Physics Dept. Drug Science and Technology Dept., Life Sciences and Systems Biology Dept. and Earth Science Dept.. NIS Centre collects competences on a variety of materials and processes relevant to the manufacturing industry with a long tradition of industrial collaborations.

The NIS Centre accomplishes **Process Intelligence Investigation**, typically aimed at identifying and understand the causes of defects and process drifts by using a combination of: process audits by interdisciplinary teams, chemical analysis, physical characterizations and environmental monitoring, literature surveys (including patents), laboratory experiments. We offer a range of physical and chemical investigation tools, together with a broad range of competences ranging from technology to medicine and the social sciences. According to our experience, this is particularly valuable in the development of the flexible production systems envisaged by Industry 4.0, where rapid evolution of products and processes requires a continuous adaptation.

The NIS Centre operates an **Electron Microscopy Laboratory** with a High Resolution TEM (Jeol, 300kV) and a Scanning Electron Microscope with microanalysis and variable pressure capability (Leica Stereoscan). The laboratory is also equipped with several optical microscopes, including confocal microscopes for biological samples. The microscopes are managed as a facility on an Open Access basis, open also to external users from academia and industries. A wide range of competences in the microscopy of metals, polymers, glasses & ceramics and biological samples is available.

5.14 C3S – Competence Center on Scientific Calculus

High-Performance Computing (HPC) and Edge Computing aim at achieving a common goal by way of many computing devices, tightly or loosely coupled, respectively. HPC is specifically focused on solving absolute computing performance (w.r.t. execution time or problem size), whereas Edge (similarly to Internet-of-Things) is focused on moving computation near to data sources in a distributed network.

HPC is an enabling platform for several Industry 4.0 drivers. HPC techniques are needed in all cases an improvement of the latency, the throughput of computing makes it possible to achieve results with a better quality or to process larger data sets turning them into knowledge. Edge computing supports device sensorization and complement it with adaptive and autonomic control of single devices and their pipelines, which in turn is enable predictive maintenance, optimisation of production plans and process, feedback-based control of processes. Directly involved drivers are: Simulation, Advanced Manufacturing, Additive Manufacturing, Cloud, and Big Data Analytics.

In engineering and science **simulations**, HPC can be used to improve the quality of the result and therefore to reduce the number of physical prototypes and time-to-market. **Advanced** and **additive manufacturing**, may also benefit from both HPC and Edge: HPC is the technology to simulate structural properties of material and to optimise the process itself and forecast production time, cost and optimise it against dynamically changing constraints. Edge computing is the key technology to collect sensors data and to provide manufacturing facilities with adaptive (autonomic) control and coordination on large manufacturing pipelines. This also might enable the consolidation of the control and coordination aggregates (e.g. pipeline) of many manufacturing facilities enabling predictive maintenance, maintainability and robustness.

5.15 Agroinnova

The **Agroinnova Competence Center** operates in the field of basic and applied research, knowledge transfer and technology transfer, lifelong learning and communication in the agri-environmental and agri-food sectors. Researcher at Agroinnova developed **Advanced Technologies for Food Digital Monitoring** and for **Food Safety and Security** suitable for Industry 4.0. Managing crop biosecurity and impacts caused by climate changes requires the adoption of advanced solutions, constituted by decision-making

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support and optimization tools, optimized real-time data from intelligent systems integrated by sensors. Advanced manufacturing technologies can be implemented by integrating **nanotechnology-based sensors**, advanced methods based on DNA extraction (such as LAMP and **Lab-on-chip**) for detection of microorganisms and abiotic contaminants in ingredients and foods, standardised interfaces monitoring food production and processing.

5.16 Corporate Finance Lab

The high level of technology and process systems required by the Industry 4.0 typically involve large capital investments. The initial purchases of machinery necessary for production, as well as the eventual technological replacements or upgrades of that machinery means that manufacturing businesses have to engage in continuous investments. Manufacturing businesses, therefore, need to consider the long-term goals and expenses related to these capital investments, considering the correct financial structure. Project evaluation is actually an integral part of the complete manufacturing strategy.

Corporate Finance Lab for I4.0 supports the entire **capital budgeting process**. Capital budgeting can also include investments in other types of intangible assets (software, patents, know how, etc.). As a result, the choice of financial channels (Private Debt/Equity, VC, etc.) to support the Industry 4.0 transformation is crucial.

In order to boost productivity, accelerate technological upgrading, stimulate private investments and Increase private expenditure in R&D, the Lab considers as an important part of a financial plan Tax planning, to reduce tax liability and ensuring **tax efficiency**.

Tax planning encompasses many different considerations, including the timing of income, purchases and other expenditures. For example, it is very important to consider measures to support innovative investments and empower skills, such as: Super and Hyper amortisation schemes, tax credits on R&D and on profits from intangible and patented assets (for example the National plan “Industria 4.0” of the Italian Government).

5.17 ICxT—Innovation Center for Territory

ICxT (Innovation Center for Territory) is a multidisciplinary research centre raised by the cooperation of several Departments of UniTo: Computer Science, Sociology, Law, Psychology, Economics and Management, Statistics, Mathematics and Statistics, Chemistry, Biology.

The Center develops research to address the major challenges posed by the Industry 4.0 in collaboration with enterprises. In this respect, the interdisciplinary research team is active in **two dedicated Labs**: Smart Factory on the one hand, and **Smart City and Circular Economy** on the other hand.

The aim of the centre is supporting projects until they reach the market. ICxT has structured the industrialization process creating links with enterprises in order to industrialize, manufacture, distribute and sell the final solution in an Industrial Ecosystem of Innovation in which the companies could communicate and cooperate iteratively and interactively by sharing relationships, ideas and knowledge, by adhering to the potentialities of technological development.

Starting from an open data and artificial intelligence platform, the digital transformation that accompanies the conversion of the enterprise's production and engineering systems aim to exploit new technological development in order to create a self-adaptive, open, and self-motivated business model, more properly namely "Self-Tuning Open Reengineering Model" (STORM), able to support the development of a new lean, smart, innovative and versatile organization that likewise replicates within the firm the conditions of innovation co-development and value co-creation according with the paradigm of Industry 4.0. The implementation of cyber-physical systems along the entire value chain and the digital transformation of products and processes, is regarded as a significant agent of change in our current industrial system which support a customer-driven build-to-order business model.

The activities of the Center are based on:

i. **Crafting lab**, where prototypes are created and organizations can test innovative technologies
ii. **Contamination lab**, where companies and University co-work and collaborate using a multidisciplinary approach
iii. **Living labs** where companies can test their projects and proofs of concept.

On the basis of new technologies and innovative product/service solution, the Center identifies a cluster of SME as potential user that can test and re-define the effective outputs ready-to-sell.
The ambition is realize an ecosystem able to involve researchers, enterprises (supply and user side), students, institutions and other players of the territory focused on Industry 4.0.
Special emphasis will be placed on engaging SMEs by providing simple, clear and transparent mechanisms of accessing to the labs, build up and

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management the challenge/projects, using new technologies machine inside the ICXT Lab and be supported in the industrialization project . This infrastructure will accelerate the development of emerging industries, which will boost industrial competitiveness and underpin future economic growth, jobs, and progress towards a resource-efficient economy.

Moreover, thanks to the interdisciplinary nature of the ICxT Lab, researchers can support firms in many different respects, like providing technological intelligence services; technological outlook, identification of current trends and anticipation of future development; identification and anticipation of market trends, and analysis of customers' attitudes towards novelties. Support can also be provided to policymakers, by analysing changing patterns of local technological specialization to help the design of local technological and industrial policies.

Collaborations with industries

All the competences outlined have been developed in the field of scholarly studies and research collaborations with **regional, national and international enterprises, of different sizes**.
The University activities on Industry 4.0 are a result of numerous direct research contracts and joint-projects with SMEs and major multinationals, aimed at spreading innovation through technologies, patterns, know how, business and organization models, according to new market trends.

The University activities on Industry 4.0 are a result of numerous direct research contracts and joint-projects with SMEs and major multinationals, aimed at spreading innovation through technologies, patterns, know how, business and organization models, according to new market trends.

Over 100 companies have active collaborations with the University on Industry 4.0 research topics. Within this company network, most represented industrial sectors are:

- IT-Digital technology (25%)
- Metal-mechanical and engineering (14%)
- Agro industry (14%)
- Energy&Environment (10%)
- Electronics (7%)
- Aersopace (6%).

Industrial relations on Industry 4.0 are not only limited to regional level, as 32% of industries are located outside Piedmont.

How to connect with the University of Torino?

Contact the Industrial Partnership Liason Team

The Industrial Partnership Liason Team is the main university "entry point" for a company, with a proactive role in developing and stimulating collaboration, ensuring smooth and timely implementation of the activities.

The team works in connection with a Scientific team of the University, different in composition, according to the specific research topics and composed by experienced faculty staff, identified to connect with the company on project-based activities.

The action plan of the liason team can be resumed as:

- To **prioritize company interest areas** and **match them** with University most performing research areas
- To identify **ideal company participants**, stakeholders
- To **schedule specific activities** involving interactions with faculty researchers, labs and centers
- To **provide ongoing assessment**, advice on next steps.

The Liaison Officer advocates company's research agenda on the campus and favours face to face meetings with faculty staff as:

- **meeting** with the **Rector**
- **interdepartimental meetings** on specific topics
- **introduction session with startups** of the Business Incubator 2I3T and on patents university portfolio
- introduction **session on one-day private research workshop**
- **secondment of company staff** at University laboratories
- use of **University laboratories**
- introduction to **local industrial suppliers**.

Contacts: **staff.ricerca@unito.it**

6.

General information on UniTo and on added values from an exchange with industrial enterprises

6. General information on UniTo and on added values from an exchange with industrial enterprises

6.1 General information

With over 67,000 students and more than 3,900 academic and administrative staff, the **University of Torino** in north-west Italy is one of the country's largest and most prestigious universities.
The University, founded in 1404, provides quality higher **education and research** opportunities; many UniTo graduates have achieved international renown.

Today, the University of Torino offers over 150 undergraduate and postgraduate degree courses in almost every field of study. A growing number of courses are taught in English, and Italian language tuition is available for incoming students.

The University's 27 **departments** offer excellent opportunities for Italian and non-Italian academic staff; 4 doctoral schools provide 29 doctoral programmes.

International and local funding programmes, both public and private, support the University's commitment to innovation and research.

UniTo is extremely aware of its role in the local community, and promotes knowledge transfer to firms through patent licensing and spin-offs, respecting economic, social and **environmental sustainability**.
Over 3,800 international students and more than 600 agreements with other universities worldwide enhance UniTo's international dimension.

Over 3,800 international students and more than 600 agreements with other universities worldwide enhance **UniTo**'s international dimension.

Students and academic staff can make use of 40 libraries with over 2 million books, the Botanical Garden, and a number of university museums; university accommodation, university canteens, and sports facilities are well situated. Torino is a **lively, people-oriented city,** and boasts a wide variety of cultural resources: historic buildings, world-class museums and

galleries, and numerous exhibitions and fairs. The city's parks and 2 rivers together with the nearby mountains and lakes provide a great leisure environment.

6.2 Gains to industrial enterprises from an exchange with UniTo

- **Developing new technologies** and **confronting new markets**, taking profit of UniTo's world wide applied research experience
- **Productivity gains** and **business innovation**
- **Reducing** duplication of firms' **R&D investment**
- Supporting the **exploitation of scale economies** in R&D
- Supporting **access of industrial firms** (and SME specifically) **to R&D** capabilities in lab
- Supporting the creation of a **common technological vision** within industry that can guide R&D investment and related investments by public and private entities
- **Access to specific EU Funds** for industrial research
- **Creation and development of human capital**, increased performance of employees and collaborators, better quality of jobs, positive externalities for local economy

6.3 Gains to UniTo from an exchange with industrial enterprises

- Developing **direct knowledge on needs of new technologies** and new markets of the local economy
- Improving the ability to conduct research and experiments with **direct input from industry and firms**
- Facilitating and **accelerating the transfer of research** results from university to industry
- **Increased financial resources** for research and teaching
- Enabling **larger scale research projects**
- **Spillover effects research-teaching**: topics for research that are relevant to industry and provide up to date input for teaching
- Diversified **funding for research** assistant, doctoral and postdoctoral students
- Inputs for **continuous education programs**
- Better **knowledge of critical issues** for the organization of labour , the employment , the policies for local development.

In short >>

Why exchange with the University of Torino?

A reliable institution with a centennial history, a large dimension, a differentiated and innovative offer of research and teaching, a sense of responsibility for the local community, short distance locations.

Why exchange with enterprises and local enterprises?

Economic, social and environmental responsibility of university in the global competitiveness of the local economy.

6.

7 reasons for choosing UniTo

1. **Reliability** A long-standing, well-established institution, with over 67,000 students and 3,900 academic and administrative staff: a reliable partner for international teaching and research programmes

2. **Tradition** One of Italy's oldest, largest, and most prestigious universities: many famous alumni in its 600 years of existence

3. **Innovation** A modern approach, renovated infrastructure, innovative courses and research programmes: a forward-looking institution

4. **Teaching** A great range of undergraduate and postgraduate degree courses, as well as Italian language tuitions for foreigners: many options, enabling students to find their future path

5. **Research** High quality PhD courses, funded projects, fellowships in a wide range of subject areas: carrying out research and transferring knowledge to the community

6. **Internationalisation** Over 600 international partner universities worldwide, 34 bi-national degree courses, PhD programmes with other countries: a European and international campus

7. **Responsibility** Clear awareness on the University's part of its social responsibilities and of the importance of economic, social, and environmental sustainability: a community-minded Institution

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