INBOTS

Inclusive Robotics for a better Society

# WHITE PAPER

# INTERACTIVE ROBOTICS MARKET ANALYSES & SUPPORT FOR SMEs

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# INBOTS

Inclusive Robotics for a better Society

# Contents

1. Executive Summary ........ 5
2. Motivation ........ 7
3. Interviews with entrepreneurs ........ 9
   1. Data collection ........ 9
   2. Summary of interviews ........ 11
4. Interactive Robotics companies overview ........ 16
   1. KPIs identification ........ 16
   2. Data collection ........ 20
   3. Data analysis- summary of the results ........ 23
   4. INBOTS website - interactive visualization ........ 43
5. Intellectual Property Rights in Interactive Robotics ........ 46
   1. Tools to support IPR for SMEs ........ 46
   2. Results of the survey on IPR ........ 49
6. Business models and exploitation strategies ........ 55
   1. Business models overview ........ 55
   2. Identification of technological assets ........ 63
   3. Best practices & Success stories ........ 64
7. Fundraising strategies and business fora ........ 70
   1. Private funding strategies ........ 70
   2. Taxation and incentives for Research, Development and Innovation affecting Robotics: a review of scientific literature and State Aid cases ........ 74
   3. Public funding opportunities ........ 80
8. Summary of the white paper ........ 96
9. Annexes ........ 99

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

Versioning and Contribution History

| Version | Date | Modified by | Modification reason |
|---|---|---|---|
| v.1 | 2021.03.02 | R. Conti | Initial version |
| v1.1 | 2021.03.08 | R. Conti | Modified version according to partners’ feedback |
| v1.2 | 2021.03.31 | R. Conti | Final version according to the internal INBOTS peer review process |
| v1.3 | 2021.04.16 | R. Conti | Added final section related to taxation |
| v1.4 | 2022.03.08 | R. Conti | Updated sections 5-6-7 according to reviewers’ comments |

*This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 780073*

# 1. Executive Summary

The White Paper aims at providing an overview of the companies working in specific sectors of Interactive Robotics[1] (IR), showing trends and different approaches to non-technical aspects such as (i) identification of challenges and barriers in the specific market, (ii) selection of the proper business model and fundraising techniques (considering both public and private funding opportunities) to guarantee the company self-sustainability and (iii) management of Intellectual Property Rights aspects.

Being Interactive Robotics, a wide and heterogeneous robotic field, the analysis carried out within this document has been limited to only four specific sectors (taking into account the prior market knowledge of some INBOTS partners working in those IR fields):

- Wearable Robotics, such as exoskeleton and robotic prosthetic companies (WRs), considered in three different application domains, i.e. healthcare, industrial and consumer.
- Humanoids, focusing on humanoids for service robotics (HUMs), considered in three different application domains, i.e. healthcare, industrial and consumer.
- Industrial Collaborative Robots (IndCOBOTs), considered in the industrial application domain.
- Surgical Collaborative Robots (SurgCOBOTs), considered in the healthcare application domain.

It is worth mentioning that some activities of the document have been carried out in close collaboration with the "COST ACTION 16116 - Wearable Robots for Augmentation, Assistance or Substitution of Human Motor Functions" to extend the visibility of this work in the whole robotics community and to collect feedback for interviews.

The overview of the companies working in the considered fields shows an exciting, lively environment where a lot of new companies has been created in the last decade. According to interviews with founders of companies, it is evident that these fields present a lot of opportunities with great potentialities, but they are, at the same time, really challenging, not only in terms of technological aspects, but in terms of market barriers. Indeed, many founders of companies highlighted the presence of a lot of market barriers to the adoption of these new technologies that are slowing down the real development of markets, such as the lack of clear normative framework or limited stake-holders acceptance in using new products. Therefore, to have a successful company in one of these fields, it is not sufficient to find a clever way to solve real problems of customers, it is extremely important to have a robust business model to take into account all the additional activities that are time and money consuming, such as certification or dissemination/training activities to convince stakeholders.

Being the purpose of the document is to present an overview of the considered IR fields not relying only on qualitative aspects gathered in the interviews, a method able to evaluate the evolution of the above-mentioned interactive robotics sectors has been defined. Therefore, the white paper presents the developed method, the data collection issues and the results in terms of specific KPIs. The list of the final KPIs used for the overall analysis of the IR fields is the following:

I. New businesses created in a sustainable manner.
II. Number of FTE/company size.
III. Total companies per location/geographical distribution.
IV. Number of R&D projects.
V. Change in the number of patents.

[1] In IR, robots are conceived to perform their intended tasks in close proximity with humans, cooperating with them both physically and cognitively, in the same workspace.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

VI. Change in the total number of R&D collaboration.

The results analysis highlights that some analogies can be found for all the sectors: it is really evident by the analysis carried out in the document that (i) identification of the business model to guarantee self-sustainability is fundamental, and (ii) public funding is, at the moment, crucial for the start-up phase of many companies working in these sectors. Tools provided by the EC such as the SME tool in Horizon 2020 or the EIC Accelerator in Horizon Europe 2021-2027, are considered effective tools to build solid and innovative companies.

Another important aspect shown in the results analysis is the limited use of IP tools for protecting core technologies of companies: it is worth noting that for SMEs this aspect is mainly due to higher cost and an under estimation of the resource needed to manage it. Therefore, a part of the document is dedicated to provide a summary of tools to support the protection of the intellectual properties.

To support the identification of business models for innovative companies, a comprehensive overview of the main economic aspects related to the creation and the growing of an innovative start-up company has been provided. The white paper provides a method for identifying the proper business model as well as analysing the main funding opportunities currently available in the field (both private and public ones). In addition to that, it has been elaborated a quick guide to identify a recommended business model based on the different characteristics of a company, that is expected to help SMEs when approaching the market.

Finally, it has been proposed a summary of available funding resources (private and public) and tax reduction strategies. Being public funding a very relevant aspect for the growing of the IR field, different public funding opportunities for Robotics in the EU are detailed, covering the latest Research and Innovation Framework Programmes (H2020, Horizon Europe) and the next funding programme, i.e. Next Generation EU. The main areas of research are presented as well as the Robotics-related funding topics and calls. Within this section, it is also presented a study of the impact of public funding at a European level on Interactive Robotics with a specific section focused on investigating the relationship between public funding and the development of SMEs in the field of Interactive Robotics. This section ends showing the future trends on Public Funding and European Policies and identifying the main barriers and gaps to be solved and the future direction that robotics will take in the upcoming years.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 2. Motivation

As outlined in the executive summary, primary objectives of the final white paper are to promote entrepreneurship in the field of interactive robotics and to provide non-technical support to small and medium enterprises (SMEs).

To meet this goal and foster new robotic enterprises in a scalable fashion, we decided to generate a white paper:

- to synthesize the experience and insight of entrepreneurs, to highlight the main obstacles they've faced and the strategies they've employed to succeed in the interactive robotics market;
- to provide an overview of the market in four IR fields in terms of number of companies, companies classification, country, patents and public funding;
- to describe the main Intellectual Property Right (IPR) aspects for protecting the IP of the company (which is in most of the cases the real added value of the company)
- to identify the main business models that a SME could adopt to find its self-sustainability, considering both private and public funding opportunities.

Being the INBOTS consortium, a heterogeneous group of private and public entities working in different fields of the interactive robotics such as wearable robotics, humanoids, collaborative robots, etc.., it has been agreed to get benefit by the prior market knowledge of INBOTS partners focusing the analysis on four specific IR fields:

- Wearable Robotics, such as exoskeleton and robotic prosthetic companies (WRs)
- Humanoids, focusing on humanoids for service robotics (HUMs)
- Industrial Collaborative Robots (IndCOBOTs)
- Surgical Collaborative Robots (SurgCOBOTs)

More specifically, for WRs are intended robots that are physically connected to human body and that exchange mechanical power to the wearers like exoskeletons and robotic prostheses (considering the manufacturing, healthcare and consumer domains). For HUMs are intended legged or wheeled robots that are designed primarily to interact with people in various settings (such as retailing, hospitality, education, health care, entertainment, etc...), built to mimic human motion and interaction in various ways, both with people and with the environment (it's domain of application is mainly consumer). For IndCOBOTs, they are considered all the industrial robotic arms that collaborate with operators in the same operative workspace (mainly considering manufacturing domain). Finally, for SurgCOBOTs are intended robots that work in the surgical field (for the healthcare domain).

To provide a map of the document to the readers, the document is structured in five sections that are briefly described hereafter:

Section 3 focuses on interviews carried out with entrepreneurs of companies, highlighting the structure of the interview followed, the main different approaches to the company problems and a summary reporting analogies and barriers found.

Section 4 provides an overview of the market, outlining the companies that currently work in the considered fields. Numerical data found on companies' websites or database searches are presented in terms of KPIs to show an overview of the market. In this section will be presented also the systematic method followed to gather data, the data collection issues identified in the database analysis and an overview of the databases used. The challenges related to the collection of the data necessary for the calculation of all the KPIs has been presented dividing the KPIs in three different categories according to the challenge encountered in their calculation (data collection issues, time

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

consuming, no collection issues). The section concludes presenting the results for the considered fields in terms of specific KPIs and showing a description of the interactive material available on the INBOTS website to complement results shown.

Section 5 is related to IPR aspects adopted in the robotics field; indeed, to get an overview of the IPRs landscape an exploratory survey was conducted. Results are shown within this section, outlining different strategies and solutions to manage intellectual properties.

Section 6 outlines business models that can be adopted by SMEs, showing pros and cons of different approaches and a quick guide to select the most appropriate one according to the characteristics of the company.

Section 7 goes deeply on describing the fund-raising tools and opportunities identifiable in the public sector, including the latest Research and Innovation Framework Programmes (H2020, Horizon Europe) and the next big funding programme Next Generation EU. This part concludes presenting a study of the impact of public funding at a European level on Interactive Robotics with a specific section focused on investigating the relationship between public funding and the development of SMEs in the field of Interactive Robotics. Finally the future trends on Public Funding and European Policies is presented and analysed, identifying the main barriers and gaps to be solved and the future direction that robotics will take in the upcoming years.

Section 8 concludes the document with key information elaborated in the document.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 3. Interviews with entrepreneurs

This section aims at reporting experience and perspectives about the main challenges and barriers dealt with entrepreneurs during first years of activity of their start-up companies that often could discourage new robotics entrepreneurs in the field of Interactive Robotics (IRs).

Therefore, the following sub-sections have been conceived for new robotics entrepreneurs willing to create their own business as well as for people working in well-established companies that are interested in understanding the dynamics in this emerging robotics field, i.e. IRs.

## 1. Data collection

As already mentioned in the introduction of the White Paper, in this document four different branches of the IRs have been considered: wearable robots (WRs), humanoids (HUMs), industrial collaborative robots (IndCOBOTS) and surgical robots (SurgCOBOTs), trying to cover most of the domain applications of the market.

In the "Preliminary White Paper" document, released in June 2019, the focus was only on wearable robots and humanoids companies, collecting in total 8 interviews to CEOs, former CEOs, founders, etc… Analyzing in detail the feedback provided by those people, three main classes of business barriers have been identified:

- Economic barriers, including the accurate identification of the real needs of the target market, access to funding, and various legal services such as those related to intellectual property;
- Personnel challenges, of gaining access to experienced collaborators, and of assembling a talented team with a suitable spectrum of multi-disciplinary expertise;
- Market entry barriers to overcome among end-users, including educating the target market about the capabilities and benefits of interactive robotic technologies.

The approach for collecting these stories is to perform interviews with founders/longtime members of the staff. Some interviews have been made in collaboration with the COST Action project (CA16116 - Wearable Robots for Augmentation, Assistance or Substitution of Human Motor Functions, https://wearablerobots.eu/).

Due to the relatively low number of interviews collected in the first part of the project, it has been agreed to follow two parallel strategies for increasing the number of interviews: (i) direct contact, more precise but time consuming, as already carried out in the first part of the project and (ii) online survey, less precise but more efficient.

It is important to mention that for the purpose of the interview, some exclusion criteria have been defined to filter out non-eligible companies from the total list of companies, created by the INBOTS partners following the collection method explained in Section 4. Indeed, as shown in Figure 4, step 2 provided the "table of companies" working in the considered field that has been used for extracting the list of founders to be contacted directly or to be contacted through the survey. Due to the purpose of the interview, two eligibility criteria have been adopted: (i) consider only SME and (ii) consider only European companies. These two criteria have been introduced to identify the most appropriate companies where the feedback provided by the interviewed would have been really valuable in terms of experience and perspective.

Below in the table, it has been reported the total number of companies contacted in the four different branches:

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

*Table 1: table of contacted companies among the whole extended list of companies*

| | Acronym of the IR field | Contacted (eligible/total) | Negative feedback | Positive feedback |
|---|---|---|---|---|
| **Wearable robots** | WRs | 25/43 | 16 | 9 |
| **Humanoids** | HUMs | 12/27 | 10 | 2 |
| **Industrial Collaborative robots** | IndCOBOTs | 11/42 | 8 | 3[2] |
| **Surgical collaborative robots** | SurgCOBOTs | 5/8 | 1 | 4 |
| **Total interviews** | | | | 18 |

The interview/survey consists of 8 questions, trying to describe challenges and barriers that the entrepreneurs faced with:

- Who you are? Please describe briefly yourself.
- Which was your role in the company at the beginning and what is your role now?
- What was your vision of your company at the beginning and how this vision changed during the years?
- Would you define three milestones in the growing of the company?
- Which kind of barriers did you find? Please define the most critical ones.
- What was/is the role of the academia in the creation and growing of the company?
- Which is the most critical element for the growing of a company in our sector?
- Which is the biggest opportunity for a company in our sector?

It is important to mention that these interviews/survey results have been collected during the whole INBOTS project duration (i.e. 3 years), therefore, some of them could be not representative of the current situation. In the additional material, it is possible to find the transcriptions of all the interviews, including the year of execution.

All the interviews are publicly available in the INBOTS website: http://inbots.eu/contributing-to-inbots/support-to-smes/.

[2] Within the IndCOBOTs field, an additional interview has been collected related to the Autonomous Grounded Vehicles company (i.e. ATLAS robot) that the reader can find in the INBOTS website additional material.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

*Table 2: list of interviews collected in the whole project duration, organised in terms of IR field, foundation year, n° of employees, year of interview.*

| Interview with... | Role | Company | Foundation Year | IR fields | N° of employees | Year of interview |
|---|---|---|---|---|---|---|
| Francesco Ferro | CEO | PAL Robotics | 2004 | HUM | 11-50 | 2018 |
| Frank Anjeaux | President and CTO | AXYN Robotique | 2014 | HUM | 1-10 | 2020 |
| Nicola Vitiello | Co-Founder | IUVO | 2015 | WR | 11-50 | 2018 |
| Jody Saglia | Co-Founder | Movendo | 2016 | WR | 11-50 | 2018 |
| Hugh Gills | Vice-President | Touch Bionics | 2005 | WR | 51-100 | 2018 |
| Jaime Duarte | CEO | MyoSwiss | 2016 | WR | 11-50 | 2020 |
| Elena Garcia | CEO-Co-founder | Marsi-bionics | 2013 | WR | 11-50 | 2019 |
| Serge Grygorowicz | CEO-Co-founder | RB3D | 2001 | WR | 11-50 | 2020 |
| Boudewijn Wisse | Co-founder-CEO | Laevo | 2013 | WR | 11-50 | 2019 |
| Guido Gioioso | Co-founder-CEO | WEART | 2018 | WR | 1-10 | 2019 |
| Ole Olsen | CMO | Hy5 Pro | 2015 | WR | 11-50 | 2020 |
| Hansruedi Früh | Founder – CEO | F&P robotics | 2014 | IndCOBOTs | 11-50 | 2020 |
| Georg Glasewald | Sales responsible | YUANDA robotics | 2017 | IndCOBOTs | 11-50 | 2020 |
| Enrico Iversen | CEO | OnRobot | 2018 | IndCOBOTs | 101-150 | 2020 |
| Jorge Presa | CEO | Cyber Surgery | 2017 | SurgCOBOTs | N/A | 2020 |
| Aritz Lazkoz | Co-founder and General Manager | Deneb medical | 2014 | SurgCOBOTs | 1-10 | 2020 |
| Michael Friedich | CEO | Distalmotion | 2012 | SurgCOBOTs | 1-10 | 2020 |
| Fernando Mateo | CEO | Kirubotics Surgical | 2020 | SurgCOBOTs | 1-10 | 2021 |

# 2. Summary of interviews

This section aimed at collecting and making available experiences from entrepreneurs in the Interactive Robotics field. These interviews highlighted the main challenges and barriers present in an emerging field as well as showing the degree of connection with the academic world., Collecting this kind of information has been challenging due to limited availability of companies founders or CEOs; however, in this final version of the white paper a total of 18 interviews have been gathered and analysed.

As already explained in the introduction, the analysis has been made on four sub-fields of interactive robotics: (i) Wearable Robots companies, (ii) Humanoid service robotics companies, (iii) Industrial Collaborative Robots and (iv) Surgical Collaborative Robots. These four subfields have been selected due to the prior knowledge of some partners of the INBOTS consortium. The list of companies contacted was created by the internal know-how of the INBOTS consortium which present more than twenty partners coming from the industrial and academic worlds and the data gathered through an extensive database search (e.g. CrunchBase, CORDIS, etc..).

Different companies met different difficulties depending on the size, on the level of complexity, etc., but it is interesting that some common aspects can be highlighted in terms of opportunities and milestones:

- All founders identify the TEAM as one of the main pillars towards a a successful story;
- Access to talented people with know-how in interactive robotics is very challenging;
- Ageing of the population creates opportunities for interactive robotics applications like humanoids, WRs, rehabilitative robots, etc.;
- The role of academia is considered as a fertilization tool for new technologies (e.g. start-up companies, European projects, etc.);
- Fundraising issues and/or identifying the right business model;
- Having a well-motivated team with a business-oriented mindset is fundamental;
- Acceptance of new technologies by stakeholders (such as user, clinicians, etc..) is one of the main challenges.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

An overview of the main barriers and critical elements highlighted in each interview is presented in Table 3. It has been reported also the foundation year and the n° of employees to contextualize as much as possible the replies to the questions: indeed, for a start-up company founded one year ago with 3-4 employees, the problems could be different with respect to a well-established company with 30-40 employees.

*Table 3: summary of the barriers and most critical elements provided in each interview.*

| Interview with… | Foundation Year | IR fields | N° of employees | Barriers | Most critical element for the growing of a company |
|---|---|---|---|---|---|
| Francesco Ferro (CEO, PAL Robotics) | 2004 | HUM | 11-50 | Industrial mindset<br>Certification process<br>Technological aspects | Finding motivated and experienced team members |
| Frank Anjeaux (President and CTO, Axyn Robotique) | 2014 | HUM | 1-10 | Funding issues<br>Acceptance of new technologies by end-users | Self-sustainability of the company |
| Nicola Vitiello (co-founder, IUVO) | 2015 | WR | 11-50 | Technological aspects<br>Identifying the right business model | Finding motivated and experienced team members |
| Jody Saglia (co-founder, Movendo technologies) | 2016 | WR | 11-50 | Industrial mindset<br>Cultural barriers in the adoption of new technologies | Identifying the proper users' needs |
| Hugh Gills (vice-president, Touch Bionics) | 2005 | WR | 51-100 | Self-sustainability of the company<br>Certification process<br>Commercial barriers | Organization of the company |
| Jaime Duarte (CEO, MyoSwiss) | 2016 | WR | 11-50 | Industrial mindset | Cultural barriers in the adoption of new technologies |
| Elena Garcia (CEO and co-founder, Marsi-bionics) | 2013 | WR | 11-50 | Funding issues<br>Certification process<br>Cultural barriers in the adoption of new technologies | Funding issues |
| Serge Grygorowicz (CEO and co-founder, RB3D) | 2001 | WR | 11-50 | Funding issues<br>Cultural barriers in the adoption of new technologies | Cultural barriers in the adoption of new technologies |
| Boudewijn Wisse (CEO and co-founder, Laevo) | 2013 | WR | 11-50 | Acceptance of new technologies by end-users<br>Organization of the company | Acceptance of new technologies by end-users |
| Guido Gioioso (CEO and co-founder, WEART) | 2018 | WR | 1-10 | Funding issues | Acceptance of new technologies by end-users |
| Ole Olsen (SMO, Hy5Pro) | 2015 | WR | 11-50 | Funding issues<br>Acceptance of new technologies by end-users | Identifying the proper users' needs |
| Hansruedi Früh (CEO and founder, F&P Robotics) | 2014 | IndCOBOTs | 11-50 | Funding issues<br>Industrial mindset<br>quality management | Acceptance of new technologies by end-users |
| Georg Glasewald (Sales responsible, YUANDA robotics) | 2017 | IndCOBOTs | 11-50 | Certification process | Finding motivated and experienced team members |
| Enrico Iversen (CEO, OnRobot) | 2018 | IndCOBOTs | 101-150 | Company organization<br>Finding motivated and experienced team members | Finding motivated and experienced team members |
| Jorge Presa (CEO, CyberSurgery) | 2017 | SurgCOBOTs | 11-50 | Certification process<br>Finding motivated and experienced team<br>Funding issues | Finding motivated and experienced team members |
| Aritz Lazkoz (General Manager and co-founder, Deneb medical) | 2014 | SurgCOBOTs | 1-10 | Funding issues<br>Finding motivated and experienced team members | Identifying the proper business model |
| Michael Friedich (CEO, Distalmotion) | 2012 | SurgCOBOTs | 51-100 | Identifying the right business model<br>Price of the device | Finding motivated and experienced team members |
| Fernando Mateo (CEO, Kirubotics Surgical) | 2020 | SurgCOBOTs | 1-10 | Similar patents to the proposed technology<br>Identifying the right business model | Identifying the proper business model |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

Analysing the interviews shown before in aggregated manner, it is worth noting that it is possible to identify three main aspects that are highlighted as the "Most critical element in the growing of a company": (i) team business-oriented and well motivated, (ii) acceptance of new technologies by stakeholders and (iii) fundraising issues and/or identification of the proper business model.

In Figure 1, the shares of the different aspects are shown, as extracted from interviews, and it is quite surprising that the economic aspects (explicitly mentioned as the most important barrier in Figure 3) seem to be less important compared to the other two aspects.

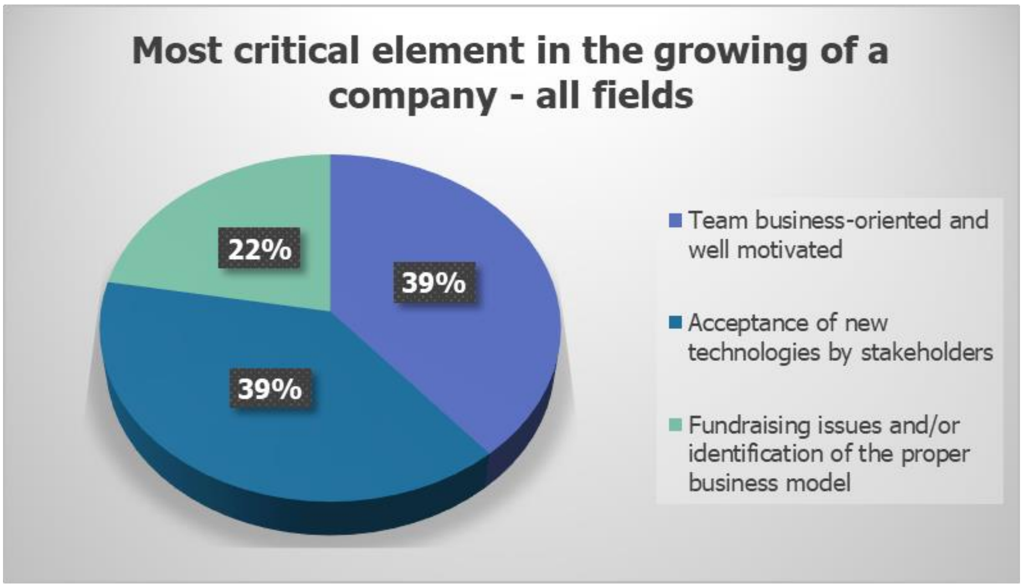



*Figure 1: Pie-chart showing the most critical aspects in the growing of a company and their share.*

Trying to identify the most critical aspect between these latter two points, the most represented group (i.e. WR field with 9 interviews) has been analysed independently from the rest to identify how these three aspects are ranked in this field.

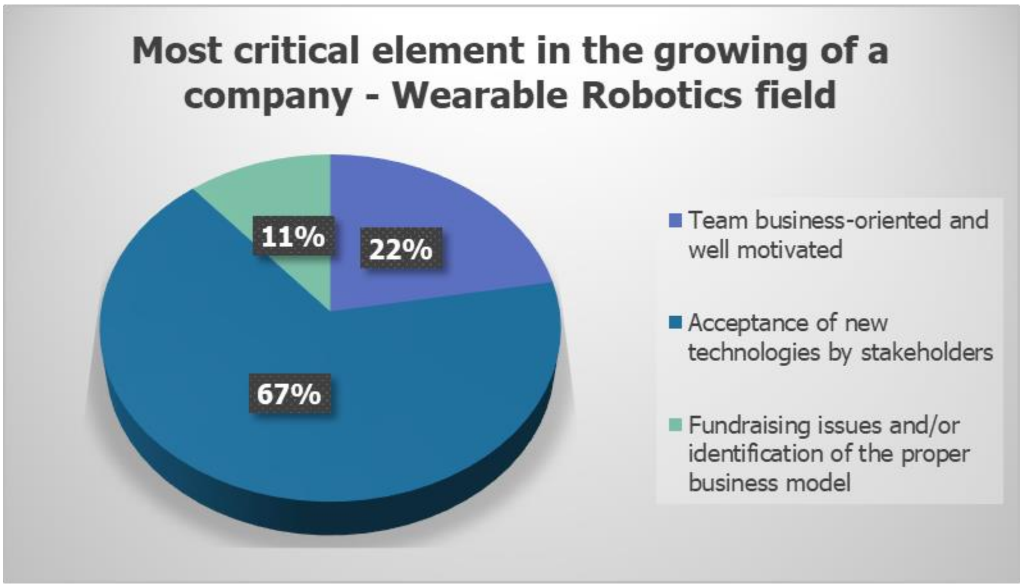



*Figure 2: Pie-chart showing the most critical aspects in the growing of a company and their share focusing only on the Wearable Robotics field.*

It is evident that "acceptance of new technologies" is considered the most critical factor, especially because it is something that an entrepreneur cannot directly control. Indeed, while managing the working team to be well motivated and with an industrial mindset or identifying the proper business

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

model, are aspects that an entrepreneur can control, the acceptance of new technologies is more related to the stakeholders-side where customers could be reticent in adopting new technologies. To influence this, an entrepreneur must try to understand the proper needs of the stakeholders and meet them in an efficient manner, guaranteeing at the same time, workshops and training programs to go through their mental inertia.

Figure 3 presents an overview of the “barriers to the creation of SME companies”, sorted in terms of number of occurrences (i.e. x-axis) collected during each interview (Table 3).

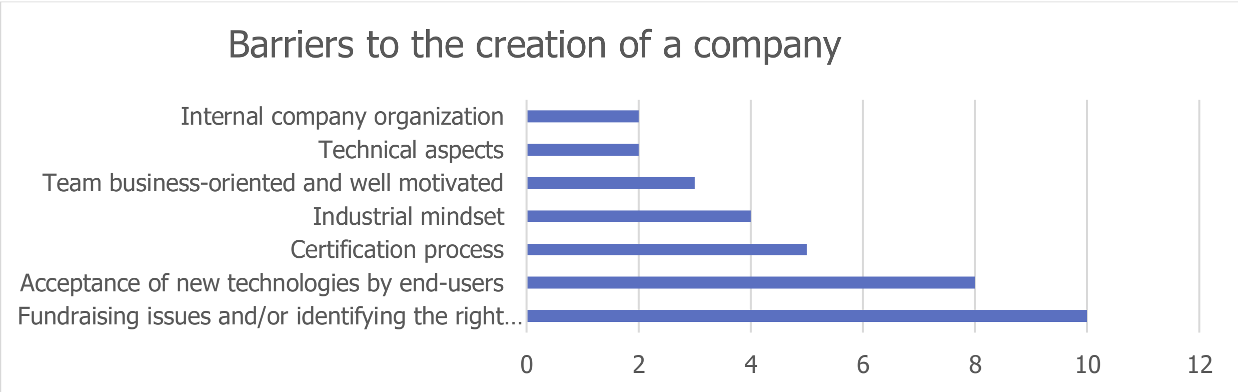



*Figure 3: bar-plots representing the ranking of the main "barriers to the creation of a company" highlighted by interviewees.*

It is worth noting that the top-two barriers are mentioned as the most critical elements, but in this case, the most voted was the “Fundraising issues and/or identification of the proper business model” barrier. This is explainable because this aspect is transversal to all the stages of growing of a company and it is the fundamental one to guarantee self-sustainability of the company. However, again here, the “Acceptance of new technologies by stakeholders” is in the second position confirming how this aspect is vital for a this kind of companies. Indeed, in more than one interview, this aspect has been described for a company such as the needs of providing a lot of additional services aimed at supporting the acceptance of the proposed technology, like technical support, training sessions and preparation of the device. Another aspect really critical for companies working in the healthcare sector, is that the acceptance of new technologies is referred to multiple stakeholders (e.g, final end-users, healthcare providers and even payers). As already mentioned above, focusing on the main barriers described by entrepreneurs, different interesting points have been identified which are not only of the company side or of the customer/product side such as the acceptance or the certification process.

In Table 4 are reported in a tabular way, the main feedbacks provided by interviewees to overcome main barriers for the creation/growing of a SME, that could provide inspiration to new and well-affirmed entrepreneurs.

*This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 780073*

*Table 4: "barrier-proposed solution" table extracted by all the interview collected during these three years.*

| Barrier | Description | Solutions adopted by entrepreneurs |
|---|---|---|
| Business model | The main barrier for the creation of a new company, especially in the innovative field, is finding the proper business model to guarantee self-sustainability. Different business models can be adopted according to the type of product or service that you want to provide (e.g. business angels, shareholders, etc..) and having a clear knowledge about pro and cons of different models is fundamental (for more detail, see Section 4 about business models). In addition to this, it is important to have a clear vision of the commercial part of the company and the added values of the company compared to competitors. | • Present the real added value of your technology to investors in a structured way.<br>• Understand the needs of your target groups.<br>• Use the proper business model according to your level of technology readiness.<br>• Use public funding opportunities to support your self-sustainability |
| Market entry barriers | There are a lot of market entry barriers in the adoption of new technologies. In particular, for technologies that are in close proximity with humans and that interacts physically and cognitively with different environments and different situations, customers could be scared about commercial products. In addition, in some interviews some experts highlighted that final stakeholders presented a mental inertia in adopting new technologies to solve problems: people tend to maintain the same mental scheme to reduce the cognitive effort of using a new solution. | • Try to have early adopters of your technology to be accepted/recognized internationally.<br>• Understand the needs of your target groups.<br>• Provide additional services to your technology such as specific training, workshops with end-users.<br>• Collaborate with top teams to get appropriate feedbacks to overcome market entry barriers. |
| Standardization/certification | Being interactive robotics a new branch of the traditional robotics, there is a clear lack of standardization and certification aspects. Policy makers do not provide clear information about the requirements and about standards. | • Do not underestimate this phase. Consider in your business-plan an adequate phase for the certification of your application in terms of timing and economic resources |
| Mindset of the entrepreneur | In some cases, innovative companies are former spin-off of universities and founders are usually people that come from the academic world. | • If you are a spin-off company, integrate your working team with more business-oriented mindset people. |
| | | • Focus the development of your product on the specific customers' needs and not only on the technological aspects |

# 4.Interactive Robotics companies overview

This section aims at providing an overview of the companies working in the considered Interactive Robotics fields (Wearable Robotics, Humanoids, Industrial Collaborative Robots and Surgical Collaborative Robots) providing Key Performance Indicators (KPIs) to analyse the trends of the market. The identification of suitable KPIs, publicly available and aligned with the objectives of the project has been really challenging and it is explained in detail in the following paragraphs. In addition to that, in this section it is provided the description of the method followed to collect the data needed for the KPIs calculation.

## 1. KPIs identification

The goal of this section is to define KPIs and evaluate the evolution of the interactive robotics sector according to the information we have collected.

Focusing on the scope of the document, the following points that will help defining a list of KPIs necessary to describe the sector have been extracted:

1. Strengthen collaboration between robotics communities
   - 1.1. Creation of business models
   - 1.2. Increased awareness of current robotics by the general public
2. Lower non-technical market barriers to robotics market readiness and take-up
   - 2.1. Diffusion of robotics technology into daily lives
   - 2.2. Accelerate robotics acceptance
3. Increase the uptake of robotics by entrepreneurs and end users
   - 3.1. Increase awareness of the benefits of robotics by entrepreneurs and end-users
4. Increase public and private investment interest in robotics technology for all stages of company formation and growth
   - 4.1. Develop activities supporting SMEs and entrepreneurship

Considering the impacts and challenges listed, the determination of some performance indicators that can be used to measure the white paper's goals is needed. These measures must ensure that the desired impacts of the project are being met/worked towards. These goals can be separated into 4 categories based on the aspect of the project they focus on.

*Table 5: goals categories related to the INBOTS project objectives*

| **Project Goals (What should be measurable with KPIs)** | |
|---|---|
| 1. Business models and entrepreneurship<br>• To track the creation of viable business models/plans<br>• To monitor the development of activities supporting SMEs and entrepreneurship<br>2. Industry mindset, teams and training<br>• To gauge the transformation to a business mindset of entrepreneurs<br>• To establish and improve multidisciplinary teams<br>3. General aspects<br>• To track the overall evolution of | 4. Cooperation<br>• To monitor cooperation levels between political stakeholders<br>○ via the inclusion of partners with extensive expertise in regulatory and standardisation aspects<br>• To gauge the communication between partners and dissemination of the information that is spread to both the robotic and general community<br>○ via the dissemination and communication strategies<br>• To track R&D collaboration and |

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073

| | |
|---|---|
| the interactive robotics sector<br>● To promote responsible research and innovation (RRI)<br>● To track funding for SMEs<br>● To monitor the use and prices of legal services<br>● To monitor industry innovation | improvement |

While the previous goals are related to the overall objective of the project, it is important to focus on the ones related to the analysis of the business models and entrepreneurship, even though all of them are relevant to get a complete view of the sector.

## Definition of desired KPIs

This chapter discusses the possible KPIs that can be used to evaluate the growth of the industry considering also their link to the project goals. They are based on the WP1 partners' considerations, and on surveys and analysis conducted during the project, through the data that have been collected for the tackled sectors, in the four Interactive Robotics fields previously listed (wearable robotics, humanoids, industrial collaborative robots and surgical collaborative robots).

In the charts below the list of KPI is presented: in particular, its definition and calculation, its link to the strategy of the project, its trend data (what increases/decreases in the statistics), the area of relevance to the project, the timeframe for which the KPI would be measured and if they are referred to a specific company or to the whole sector.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

*Table 6: KPI list including their description, how their linked to the strategy, the possible trend data, the area of relevance, the proposed time frame and if they are applicable to the single company or to the whole sector.*

| KPI | Definition and calculation | Link to Strategy | Trend Data | Area of relevance | Time frame | Company/ whole sector |
|---|---|---|---|---|---|---|
| 1. Turnover per year | Calculate the amount of money generated in a year and compare its growth with previous year | Tracking the changes in turnover per year allows to witness the growth of the industry | Increasing turnover from period to period would indicate that the market is growing | Illustrates both industry and SME growth | Measured yearly | Each company |
| 2. Market share | A company's market share represents the portion of a market controlled by a particular company and can be calculated by dividing the company's turnover by the total turnover in the market | Knowing a company's market share is useful to measure the growth of a given company in the industry, which can be useful for benchmarking purposes | Growth in market share indicates success for the individual company | SME growth and can be used for industry benchmarking | Measured yearly | Sector |
| 3. Change in number of patents (x,%) | Looking either at the total change or the percentage change in the number of patents being registered in the field of interactive robotics | Knowing how the number of patents changes on a yearly or quarterly basis can help demonstrate growth in innovation | An increase in the number of patents being registered would indicate a growth in innovation in the field of IR | Track innovation in the industry | Measured every 5 years (According to USPTO it takes roughly 22 months from start to finish to get a patent, so measuring yearly might not be reasonable) | Both |
| 4. Change in number of products (x,%) | Looking either at the total change or the percentage change in the number of products being introduced in the field of IR | Understanding the change in the number of products can be beneficial as it allows to measure increases or decreases in demand | An increase in the number of products would indicate a growth in the consumer base, as companies would not launch products for which there was no demand or before having created demand. | Diffusion of robotics technology. Changing mindsets as increase in demand denotes a larger acceptance of robotics. | Measured yearly | Both |
| 5. Change in R&D projects (x,%) | Looking either at the total change or the percentage change in the number of projects being financed by the EU or US (even though the suitability of calls can influence this KPI). | Knowing how the funding of R&D is changing is useful for measuring innovation in the industry as the idea behind the funding is to remove barriers to innovation (acc. European Commission) | An increase in R&D funding would demonstrate the advancement or improvement of technology in the IR industry | Track innovation in the industry | Measured yearly | Both |
| 6. Change in number of FTE (x,%)/company size | Looking either at the total change or the percentage change in the number of employees | The change in number of employees can illustrate growth in the productivity of a company or industry. | Growth in the number of employees signals growth for the company or sector as typically the more employees you have the more output you can produce | Growth in the industry, interest in robotics | Measured yearly | Each company |
| 7. Total companies per location/geographical distribution | The total number of companies in a certain region (e.g., Southern Europe) | Illustrate the locations experiencing the most growth in the robotics industries thereby allowing to determine if the goal of monitoring industry expansion is being met | A growth in this statistic for any given region would illustrate an increase in the expansion of the industry. This could be a result of highly talented individuals in the region, tax benefits, etc. | It allows to track the physical expansion of the industry and increase in SMEs | Measured every 5-10 years | Sector |
| 8. Website traffic | Total number of visitors to company websites | Allows us to monitor the dissemination of information and gauge the interest levels in robotics | The higher the number of visitors to the website the more interest has been generated | Dissemination of information | Measured monthly | Each company |
| 9. Funding per region | Total number of funded R&D projects in each region. Allows prospective entrepreneurs to see where the most funding can be obtained | This KPI can be useful in determining where necessary funding can be obtained or, at an earlier stage, be used to determine where to set up a business. This KPI can be also cross-checked with the KPI number 7 about geographical distribution. | An increase in the amount of funding in a given region would be a positive sign that that country wants to promote entrepreneurial activities and innovative projects. | Track funding for SMEs | Measured yearly | Sector |
| 10. Number of new businesses successfully created | The total amount of start-ups in the IR sector that make it at least 5 years | By tracking the number of start-ups that make it at least 5 years, it is possible to determine whether or not their business models are viable | An increase in the number of successful start-ups would indicate an increase in successful business models | Creation of viable business models and plans | Measured every 10 years so that each company created will have sufficient time to grow (if we only did 5 years then companies starting in year 2 wouldn't have time to grow) | Both |
| 11. Number of R&D projects being funded by the EU, USA, and other sources | The total number of projects being funded by different organizations or governing bodies | Knowing where funding for various projects is coming from is beneficial for new robotics firms looking for money to conduct research | Witnessing an increase in overall R&D funding from any region/group leads to an increase in financing available in said region | This KPI tracks financing options for entrepreneurs and SMEs | Measured yearly | Both |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

## KPIs collection challenges

This subsection contains general considerations, which will summarize any challenges or obstacles that have been faced in the implementation of the KPIs. There are three categories that all KPIs fall into in terms of feasibility. These three categories are: data collection issues, time consuming, and no collection issue.

### A. Data Collection Issues

The first grouping, 'data collection issues', refers to those KPIs that may prove difficult to gather the necessary data to obtain a large, diverse sample that can be used for the industry. They are worth monitoring, especially for a company on an individual basis, but the data that these KPIs use may be closely guarded. It is worth noting that not all the KPIs in this section encounter the same data collection issues. While some need financial information, others just require information that, while less closely guarded, is difficult for one company or small organization to monitor industry wide.

*Table 7: list of KPIs with data collection issues*

| Data Collection Issues |
|---|
| • Market share<br>• Change in number of FTE<br>• Website traffic<br>• Turnover per year |

### B. Time Consuming

The KPIs that fall into the 'time consuming' section are those which, while feasible for one company or organization to measure by themselves, would require a significant amount of time to collect all the necessary data. They could be time consuming for a number of reasons. Some have a large quantity of information that needs to be uncovered and others just need to find information that, despite being public information, can be difficult to find. The unifying factor in this group is that, for all KPIs, they would be more efficiently carried out by a diverse consortium but can certainly be carried out by one company alone. For the first three oof the four KPIs in this category, an automatic approach based in structured databases (such as CORDIS, NSF and Fedrep) has been applied.

*Table 8: list of KPIs time consuming*

| Time Consuming |
|---|
| • Change in R&D projects<br>• Number of R&D projects being funded by the EU, USA, and other sources<br>• Funding per region<br>• Change in number of products |

### C. No Collection Issue

The KPIs that fall into this category share the characteristic of being neither particularly time consuming or difficult to achieve. Therefore, these are very feasible for an individual company or organization looking to get snapshots of the industry to do because the information to track the KPIs is by no means a secret and would not take an exceptional amount of time to gather.

*Table 9: list of KPIs with no collection issues*

| No Collection Issue |
|---|
| • Change in the number of patents |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

- Total companies per location
- Number of new businesses successfully created

Even though is stated that the whole list of the 11 KPIs is necessary to evaluate the evolution of the interactive robotics industry, due to the data collection issues explained above, not all them have been collected (in the following sections the methodology for the data collection is detailed, explaining the approach used and the results obtained). The final list of KPIs used to evaluate the dynamic of the sector is, then, the following:

I. New businesses created in a sustainable manner
II. Number of FTE/company size
III. Total companies per location/geographical distribution
IV. Number of R&D projects
V. Change in the number of patents
VI. Change in the total number of R&D collaboration

## 2. Data collection

Finding economic data of companies is not trivial, especially considering only open sources data and data availability for micro or SMEs. Specific and expensive reports are usually adopted by the companies to carry out extensive market analysis. In this section, an approach based on (i) prior knowledge of INBOTS partners and (ii) data available on open-access websites is proposed.

The proposed method consists of four steps, shown in Figure 4:

- Step1 - companies identification: it provides the input for the successive steps defining an overview of the companies working in the considered sector. This step follows a two-ways approach where the partners are involved in providing keywords identifying the considered field and, at the same time, proposing names of well-known companies, competitors, etc… The output of this phase is the extended list of companies. More Information on this table can be found in the annex section in the INBOTS website.
- Step 2 – KPI data collection – table of companies: in this step the company data such headquarter location, foundation year, founders, CEO and n° of employees are collected through (i) data provided by partners and (ii) integrating missing data through online resources. Input of this phase is the extended list of companies. The output is the table of companies that has been used for identifying the founders to contact for collecting interviews and showing the IR companies overview metrics.
- Step 3 – KPI data collection – table of R&D projects: this step provides a list of R&D projects, considering both European and US databases, by analysing three different databases: R&D databases of the European Commission CORDIS, the Federal RePORTER (FedRep) and the National Science Foundation (NSF). Input of this phase is the extended list of companies and the output is the table of R&D projects, to extract “track funding for SME-large companies” metrics. The table of R&D collaborations provides a list of R&D collaborations considering as input for the research the data coming from CORDIS analysis. Input of this phase is the extended list of companies and the output is the table of R&D collaborations, useful to extract the “track R&D collaborations” metrics
- Step 4 – KPI data collection – table of patents: this step provides a list of patents, using the DEPATISnet database considering keywords for the DB research the name of the companies (collected in the extended list of companies). The output is the table of patents to extract “monitor industry innovation” metrics.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

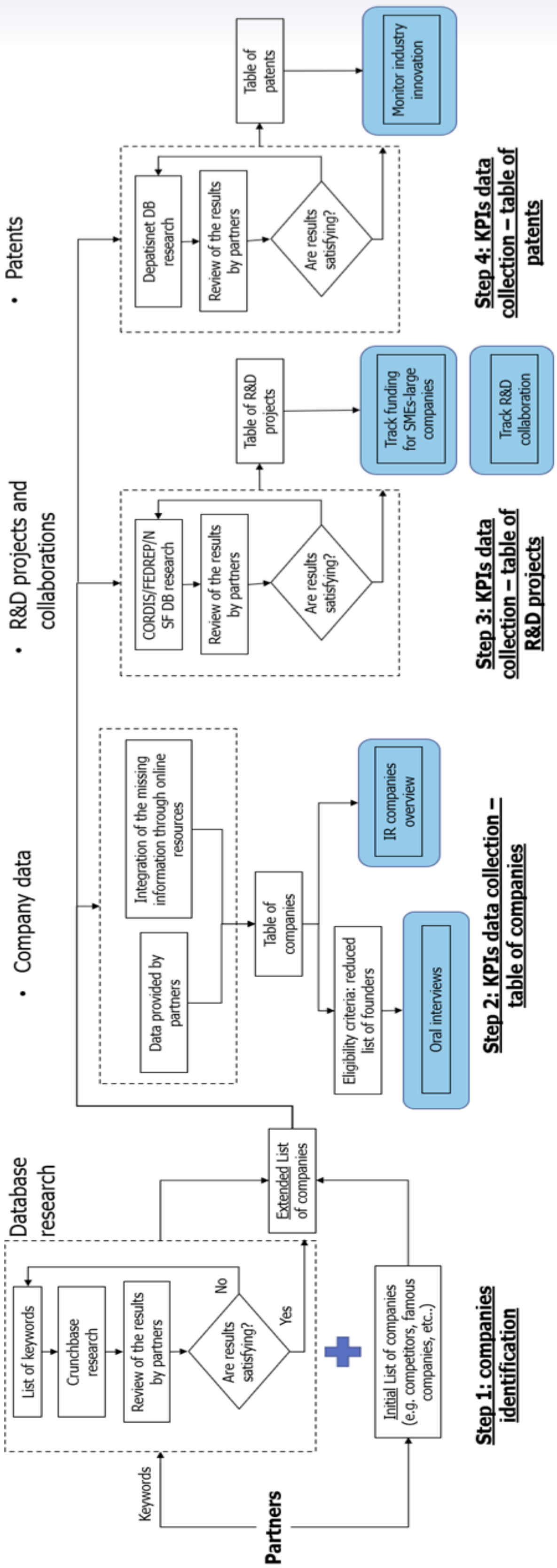



*Figure 4:* *data collection method used in the company overview chapter. Step 1 provided the extended list of companies that has been used to have an overview of the companies working in the considered field. Step 2 filled the table of companies through the prior knowledge of INBOTS partners and an integration of the missing information through online resources. Steps 3-4, through an iterative database research method, provided respectively the "table of R&D projects" and the "table of patents" for all the companies shown in the extended list of companies.*

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

As described above, the extended list of companies has been obtained by following a two-ways approach where the initial list of companies provided by partners working in these sectors has been integrated with a more extensive database research carried out on crunchbase. This latter part has been successively validated by partners, checking the database analysis results. In this way, it has been possible to provide a larger overview to the reader.

The table of companies consists of the following data collected for each company:

- foundation date of the company;
- founders;
- CEO;
- number of employees.

The data for filling this table has been collected through extensive desk research considering online web sources, company websites, specific websites, etc… This table has been used as input for the list of founders that have contacted for getting an interview (see Section 3).

In the table of R&D projects, it has been collected all the R&D projects funded in the last twenty years for each company of the "list of companies". Main data extracted from CORDIS, Fedrep and NSF databases are the funding received, n° of projects active/ended, etc…The table of R&D collaborations has been an extension of the table of R&D projects since in this case the focus was more on the interaction aspects of the different companies working in these sectors.

Table of patents has been created by considering patents applications and patents filed by each company of the "list of companies". The main data was extracted from the DEPATISnet[3] database of the German Patent and Trademark Office (DPMA). Here the analysis has required more attention to avoid duplicates and to consider only patents/patent applications referred to IR fields. For this latter point, it has been agreed that some of the patent analyses have been carried out only on SMEs because large companies provided too many data to extract from the database, i.e. many patent applications in brought range of business segments, many of them additionally outside interactive robotics.

## Database overview:

The following paragraph is going to give an overview over a generic set of databases that can be used for the examination of the Interactive robotics market and funding landscape. The databases that have been used for identifying research projects in the area of service robotics were the database of the National Science Foundation (NSF)[4], the Federal RePORTER (FedRep)[5] and the Cordis[6] database. To identify companies which are active in the field of robotics the crunchbase database has been used. All the databases are accessible over the web with a browser-based graphical frontend.

The Fedrep database (260 000 projects in total) and the NSF database (70 000 projects in total) both cover US national projects including rich data like a project description (4000 characters) and information on the grant received by each institution active in the project. Fedrep is to some extent a meta-database covering projects by different national bodies on US federal level including, at least partially, NSF. Nevertheless, the information available for each project is somewhat more

[3] DEPATISnet offers a free of charge, online search in the electronic document archive of the DPMA. It contains more than 100 million patent publications from all over the world.
[4] The National Science Foundation (NSF) is an independent agency of the United States government, that supports fundamental research and education in all the non-medical fields of science and engineering. https://www.nsf.gov/funding/
[5] The Federal RePORTER is a collaborative searchable database of scientific awards from agencies. This database promotes transparency and engages the public, the research community, and agencies to describe federal science research investments and provide empirical data for science policy. Users can search across multiple fields in both the Smart Search and Advanced Search functions-including across agencies or fiscal years, by the award's project leader, or by a text search of a project's title, terms, or abstracts. https://federalreporter.nih.gov/
[6] CORDIS stands for COmmunity Research and Development Information Service. It is the European Commission's primary public repository and portal to disseminate information on all EU-funded research projects. https://cordis.europa.eu/projects/de

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073

comprehensive in the NSF database. This is why NSF is included in the following discussion. Both of the databases are relevant in the context of (interactive) robotics. For Fedrep around 2000 projects or 0.8 % of the projects with a connection to robotics have been identified. For NSF the number of projects is slightly higher, 2700, making up for 3.9 % taking into account that the database consists only of a portion of the size of Fedrep. The relevance of NSF is thus much higher for research related to robotics.

The CORDIS database is the database for European research programmes conducted by the European Commission. It covers 40 000 projects in total stemming from the research and innovation agendas under FP7 and Horizon 2020. The information on each project is comparable to the projects in the NSF database with a slightly shorter project description ranging around 2000 characters. This difference might sound trivial at first glance. But if sophisticated queries with word-vectors in contrast to basic key-word searches are conducted the number of characters to characterize the content of a project is essential. The more text for each project is available, the more precise the results tend to be. Around 1000 projects in the CORDIS database have been identified to be relevant for the field of (service-) robotics which results in 2.5 % of the whole database. With this amount the CORDIS database ranges in between NSF and Fedrep.

*Table 10: Database overview used for the R&D projects*

| | Fedrep | NSF | CORDIS |
|---|---|---|---|
| **Number of research projects** | 260.000 | 70.000 | 40.000 |
| **Number of robotics projects** | 2.000 | 2.700 | 1.000 |
| **Share of robotics projects** | 0,8 % | 3,9 % | 2,5 % |
| **Number of characters in project description** | 4.000 | 4.000 | 2.000 |
| **Language** | English | English | English |

Crunchbase database[7] is a highly dynamic database that is updated on a regular basis and lists over 730 000 private and public companies. Crunchbase offers extensive data for each company ranging from investments and funding information, founding members and individuals in leadership positions, mergers and acquisitions, geographical locations, employee count to a short description of the activities of the company. The last criterion has been used to identify whether the company is potentially relevant for the field of robotics. Unfortunately, the quality of the data varies from company to company. This is particularly relevant for the geolocations. However, the short description for each company is surprisingly complete and thus qualifies for a database search. What makes the data from crunchbase particularly valuable for market analyses is the tracking of acquisitions, meaning that one company is acquired by another. The number of companies that are relevant in the field of robotics ranges around 2200. To have a qualitative look at each company the number of 2200 companies that are roughly associated with robotics had to be reduced severely by specifying search terms. As described in the step 1 of the proposed method, Crunchbase has been used only to extend the analysis over the prior knowledge of the partners and their data have been checked manually to verify their consistency with the considered IR fields.

# 3. Data analysis- summary of the results

In this section are shown the main results extracted by the data analysis carried out in official databases (such as CORDIS and Fedrep) and providing an overview of the current situation of the

[7] www.crunchbase.com

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

companies working in the considered interactive robotics fields, i.e. Wearable Robots (WR), Humanoid service robots (HUM), Industrial collaborative robots (IndCOBOTs) and Surgical collaborative robots (SurgCOBOTs). The motivation for showing aggregated results is to highlight common factors that belong to all fields and differences that are specifics for each sector.

In Table 11 are reported the main KPIs able to describe the different goals of this analysis that are: (i) IR companies overview, (ii) Track funding for SME-Large companies, (iii) Monitor industry innovation and (iv) Track R&D collaboration. These goals as explained in the previous section have been transformed in quantitative metrics, i.e. KPIs in order to assess the evolution of the fields.

*Table 11: detailed description of KPIs, according to the INBOTS project goal*

| Detailed description of KPIs | | |
|---|---|---|
| **KPI** | **Goal** | **Data shown in the section** |
| New businesses created in a sustainable manner | Interactive Robotics companies overview | Foundation year |
| Company size | Interactive Robotics companies overview | N° of employees |
| Geographical distribution of the companies | Interactive Robotics companies overview | Location of the headquarter |
| Number of R&D projects being funded by the EU, USA, and/or other sources | Track funding for SMEs-large companies | N° of projects per company<br>Funding received per company<br>Most active countries<br>Funding received during the years |
| Change in the number of patents applications (x,%) | Monitor industry innovation | Share of the companies with patent applications<br>Most protected countries<br>Trend along the years of the patent applications<br>Most adopted IPC classes<br>Share of the patent applications compared to patented files<br>Correlation between patents and R&D projects |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

| | | |
|---|---|---|
| Change in total number of R&D collaboration between stakeholders | Track R&D collaboration | Social network analysis<br>(i.e. betweenness centrality, node degree) |

The data analysis carried out for extracting these aggregated KPIs has produced a larger data set that can be viewed via the INBOTS website in an aggregated, interactive way in the Tableau™ section, to allow the reader to delve deeper into the results of the analysis.

As mentioned in section 1, the starting point for the analysis of the four IR fields has been the Table of companies provided by different partners of the INBOTS consortium working in those sectors. Therefore, for the comparative analysis they have been considered:

- 44 companies in the field of wearable robots (WRs);
- 27 companies in the field of humanoid service robotics (HUMs);
- 40 companies in the field of industrial collaborative robots (IndCOBOTs)
- 9 companies in the field of surgical collaborative robots (SurgCOBOTs).

The list of all companies considered can be found in the INBOTS website.

## Interactive Robotics companies overview

In this section, they are shown the results of the analysis considering the first goal of the table. Figure 5 and Figure 6 summarize respectively the company share in the four fields and the distribution of company sizes. It is interesting that despite of the recent creation of the WR field, the total number of companies is comparable to the IndCOBOTs field that is more consolidated. This is evident from the company size analysis where most of the IndCOBOTs companies are large companies (n° of employees > 249) rather than WR companies that most of them are small companies (10<n° of employees<49). The different company size between them is also related to the fact that most of the IndCOBOTs companies work not only in the Interactive Robotics field but also in the traditional industrial robotics one. The n° of companies working in the SurgCOBOTs field is the lowest one and this is most likely due to the huge market barriers in certification and authorizations needed to have collaborative robots working in surgical applications. However, considering the company size distribution, it is evident that in this latter field there are a few big players while most of the companies are small. Also, the HUM field is dominated by small and medium companies that shows that the HUM field is still growing without any real big players. In figure 3, they are reported the foundation year of each company divided per robotic fields. It is quite evident that IndCOBOTs confirms its consolidated market having most of the companies founded before 2000, while for the other three fields the real creation of markets is between 2000 and 2005 (being the first ones founded in those years).

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

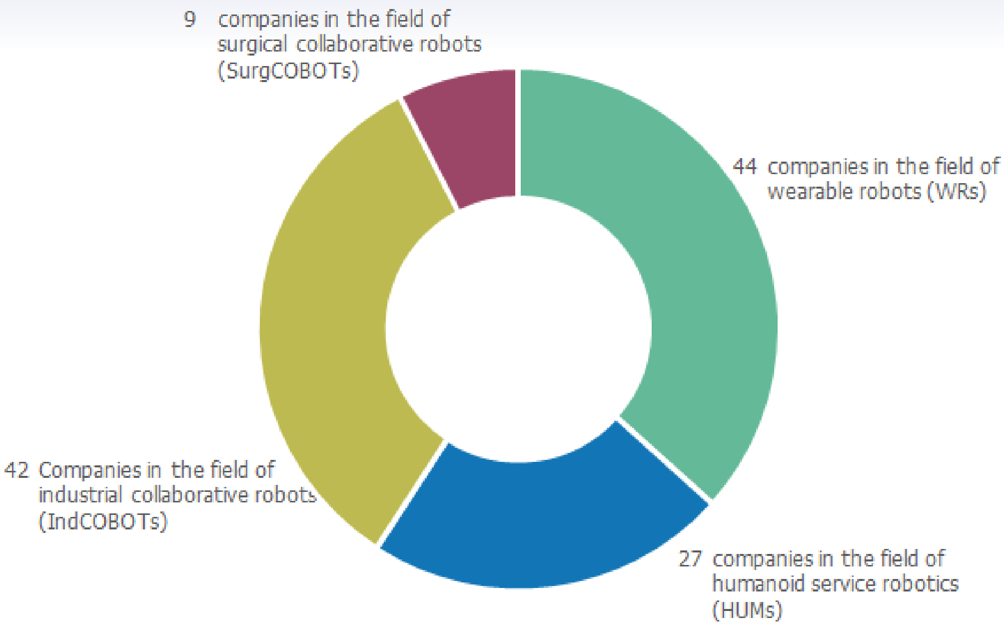



*Figure 5: Company share of 4 interactive robotic fields based on the Table of Companies (data source: data from desk research, illustration: VDI/VDE -IT)*

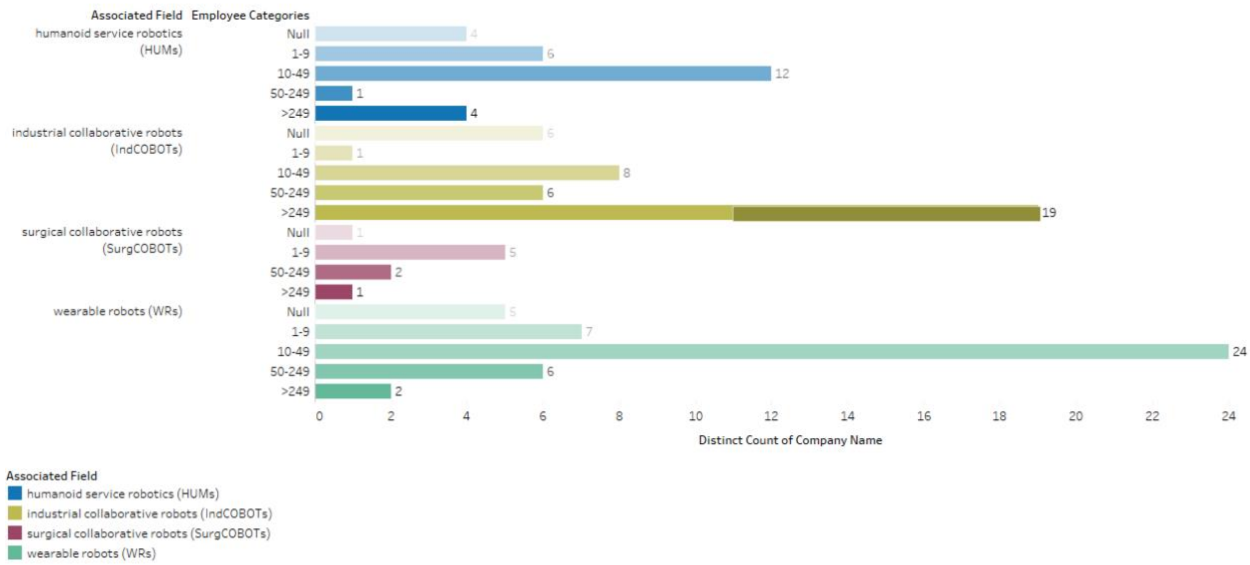



*Figure 6: Company share of company sizes in the 4 interactive robotic fields. Null data represent companies where the number of employees is missing (data source: data from desk research, illustration: VDI/VDE -IT IT with Tableau Desktop™))*

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073

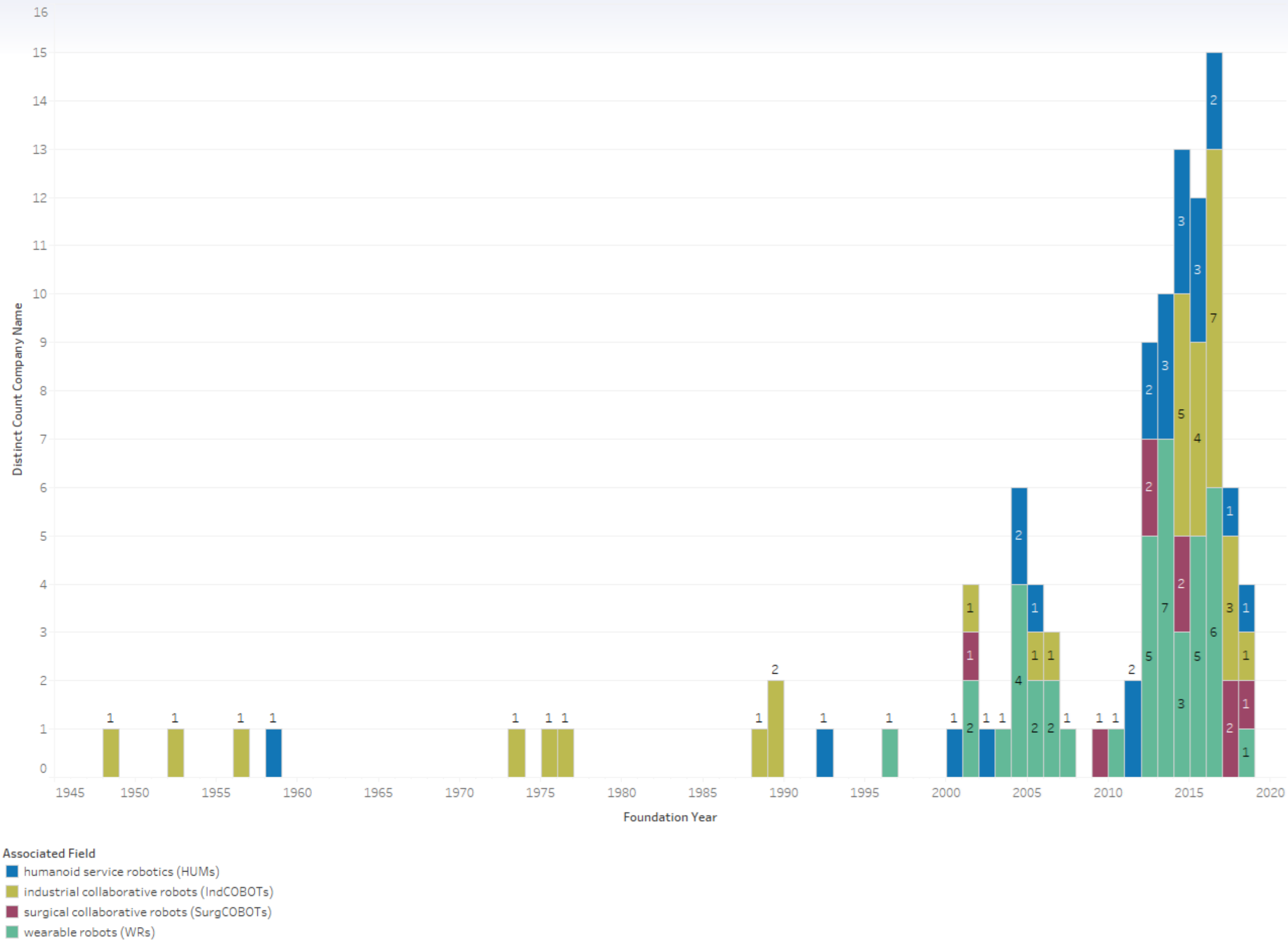
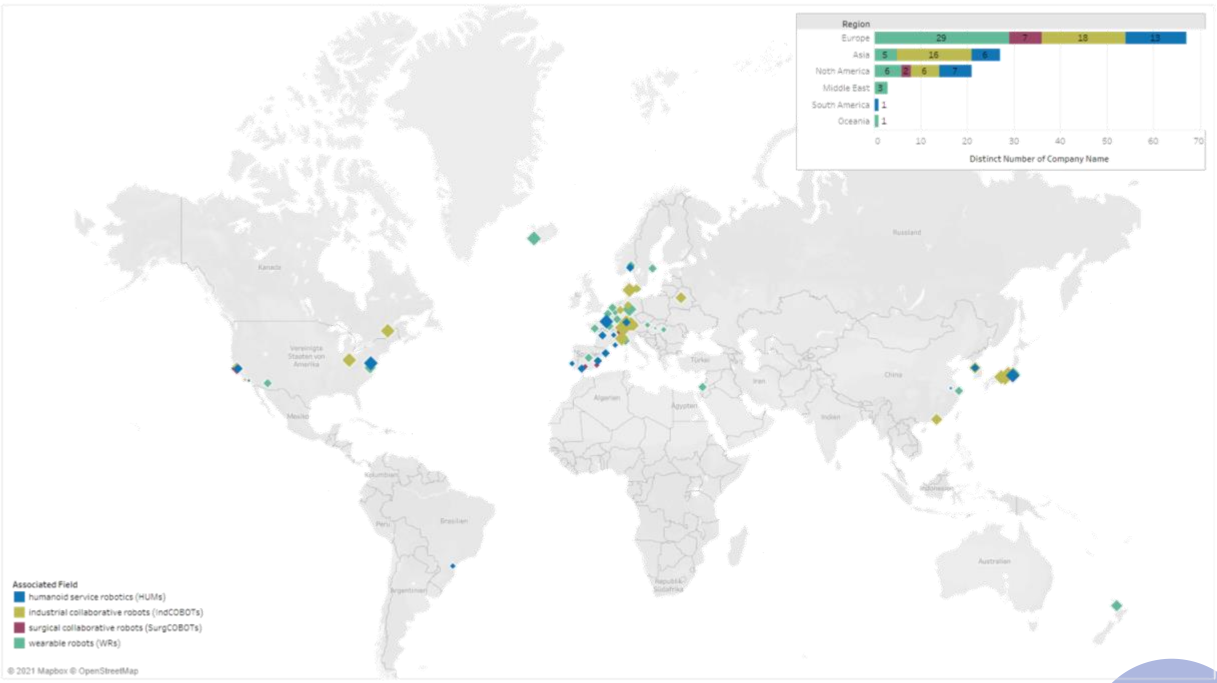



*Figure 7: Foundation years of the individual companies in the four interactive robotic fields. (data source: data from desk research, illustration: VDI/VDE -IT with Tableau Desktop™)*

Figure 8 provides a worldwide overview of the regional distribution of the headquarter locations for the considered companies in the 4 associated interactive robotic fields. The bar-plot shows the number of companies for each region.




*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

*Figure 8: Overview of the headquarter locations of all companies considered in the four interactive robotic fields and its regional distribution. (data source: data from desk research, illustration: VDI/VDE – IT with Tableau Desktop™)*

## Track funding for SMEs-large companies

This section aims at identifying the how much is important public funding for SMEs-large companies in the IR field. To give an overview of the involvement of the companies in funded research, three public available databases have been used: CORDIS, NSF and FedRep databases. It is worth mentioning that due to known gaps in these databases, e.g., late entries and other possible errors, the database analysis only can show tendencies of the actual developments.

The companies previously collected through various searches, discussions with experts, research in databases and interviews were queried in the described databases with the help of a specific search strategy. In particular, the corresponding combinations of company names were formed. The extracted database entries were then supplemented with additional, compiled information, processed and then analysed using Tableau Prep and Tableau Desktop®.

A detailed overview of the number and duration of projects over time can be viewed on the INBOTS website. Figure 9 shows the different funding volumes over time according to the starting date and corresponding call identifier of the projects for CORDIS data exemplarily, due to the only few cases for NSF and FedRep.

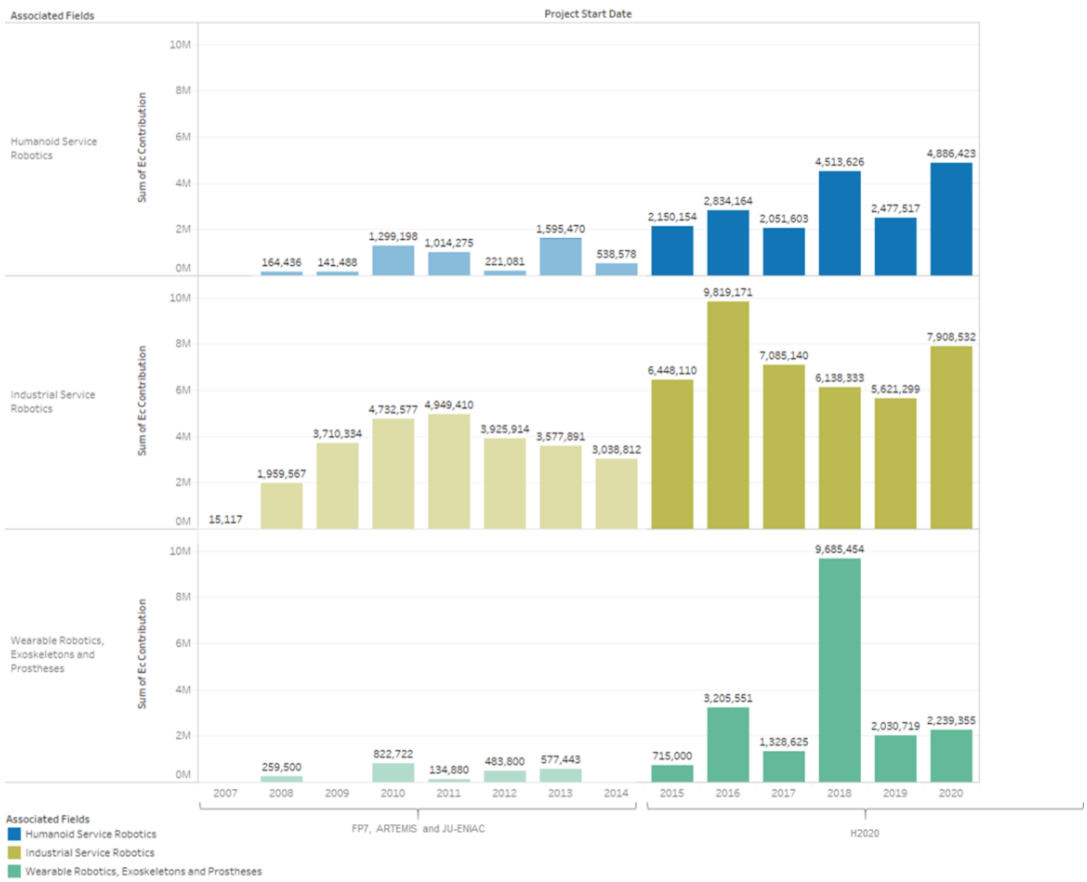



*Figure 9: Funding volumes over time according to the start date of the projects in the IRs for CORDIS data (data source: Cordis database, illustration: VDI/VDE – IT with Tableau Desktop™)*

Figure 10 shows the share of the companies using EU R&D funding compared to the total n° of companies for each IR field to investigate the question of "how many companies are more active in EU funding?". It is interesting to highlight that the most active fields are WRs and IndCOBOTs, while HUMs have a lower percentage and SurgCOBOTs are not participating to public funding opportunities.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

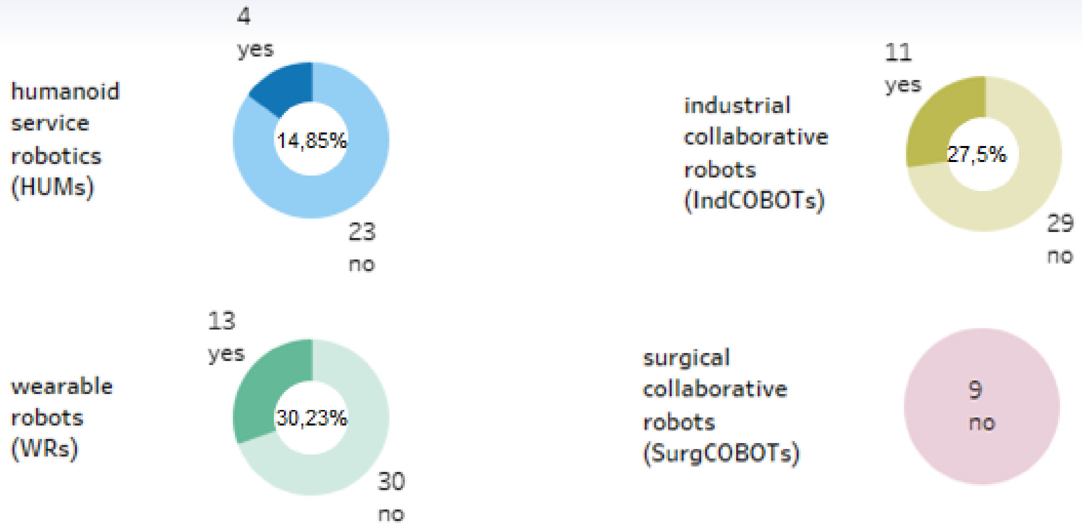



*Figure 10: Share of companies using EU and US R&D funding for each service robotic fields. (data source: data from CORDIS, NSF and FedRep databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

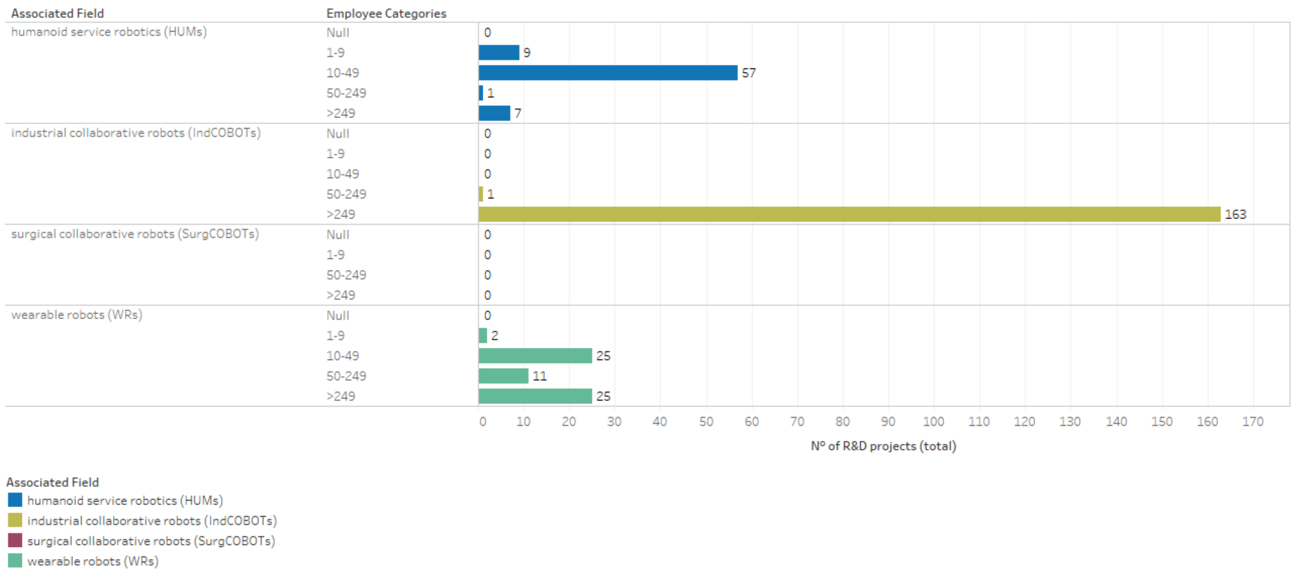
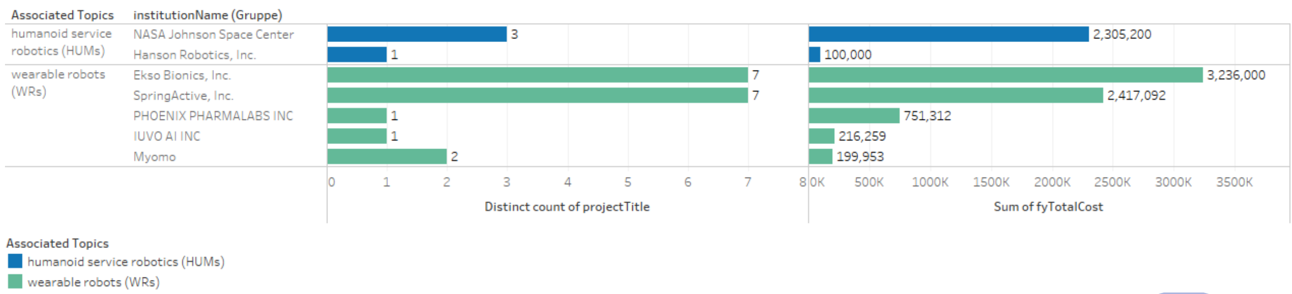


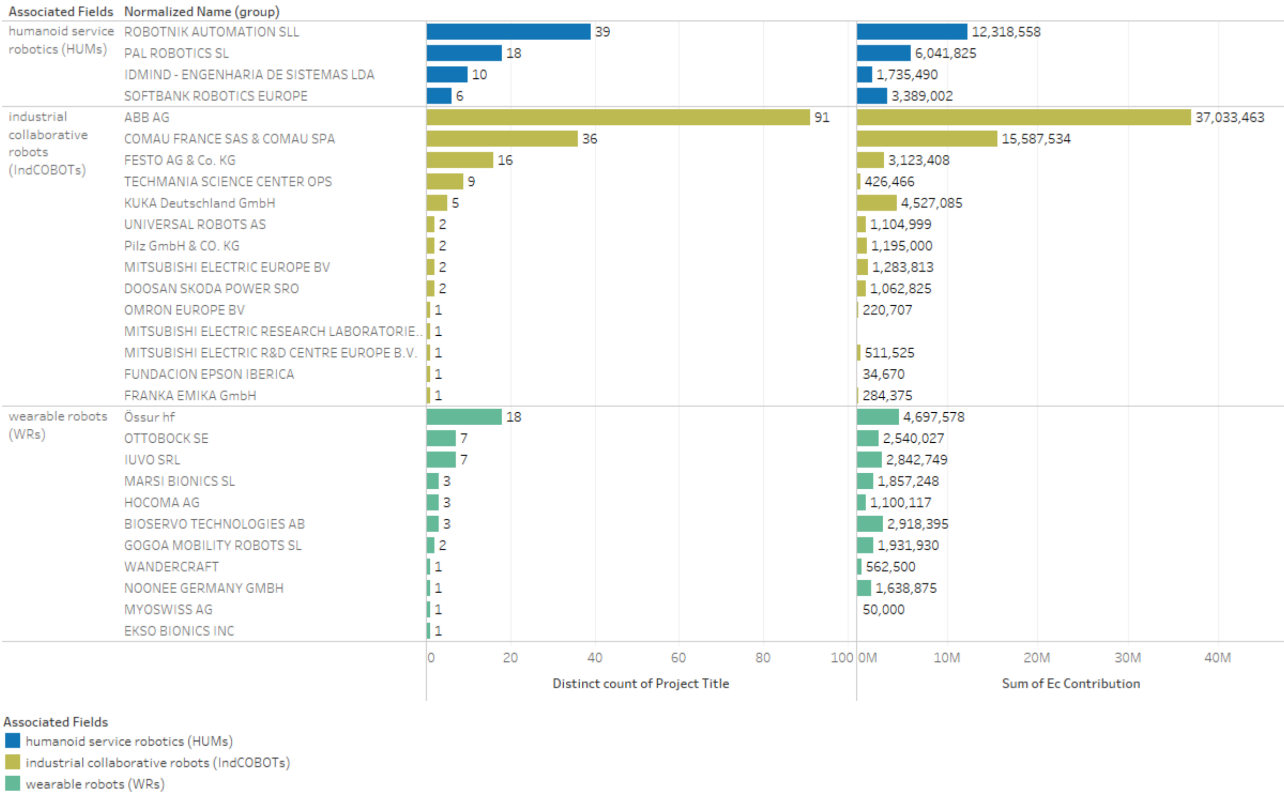

*Figure 11: Bar-plots representing the distribution of using R&D project according to the size of the company (data source: data from CORDIS, NSF and FedRep databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

Figure 11 shows the distribution of the R&D projects among the four fields, according to the company size. It is worth noting that in the HUM field is prevalent the use of R&D projects for small enterprises with only one project with a medium enterprise. Despite in the WR field, small enterprises represent the majority of the companies, in this figure, it is evident that also large companies are usually involved in R&D projects.




*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

*Figure 12 summarizes identified funded research projects in EU in the time range 2008-2023 (considering the starting date of the projects) and funded research projects in the US between 1996 and 2019 (according to the NSF database). SurgCOBOTs are not represented due to the limited numbers of companies found.*



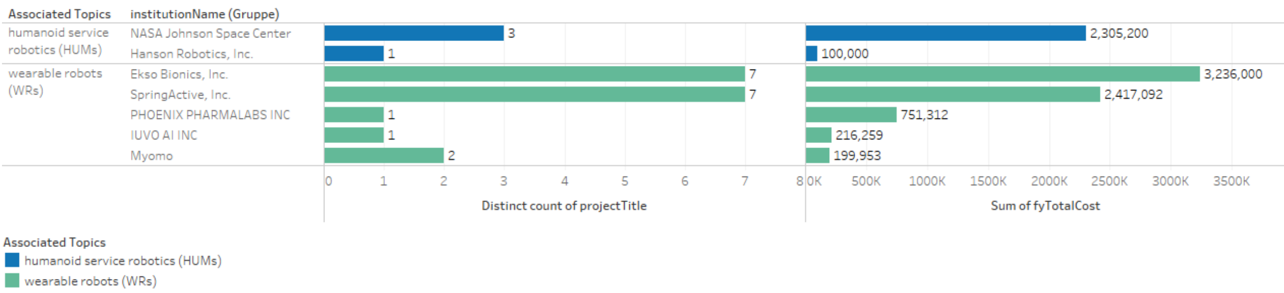




*Figure 12: Number of funded research projects and funding budget for EU and US projects (data source: CORDIS, NSF and FedRep databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

It is interesting to see the most active players in the IndCOBOTs and WR fields are large companies, while in the HUMs field are small enterprises. For WRs field, it is necessary to go down until the third position to find a small enterprise while for IndCOBOTs, the are not small or medium companies in the list.

It is important to highlight that most of the companies working in the IndCOBOTs field are large enterprises. In Figure 13, it is shown a line plot listing both the n° of projects ("Distinct count of project title") and the funding received ("Sum of EC contribution") in the time range 2007-2020 divided per countries. Through this line plots it is possible to identify the most active countries and the trends of funding for each IR field. It is evident that for IndCOBOTs the trend of funding is quite constant in the considered time-range while for WRs and HUMs the situation is constantly growing with a peak in 2018, both in terms of n° of projects and funding received. In HUM, there is a predominance of Spanish companies (confirmed also in Figure 14) while for IndCOBOTs the top three countries are Sweden, Italy and Germany. In WR field, Spain is again the most funded country and in second position, Iceland. It is also interesting to see from Figure 14, that WR field is the less funded field.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*


*Figure 13: Number of EU projects and funding budget by country (data source: CORDIS database, illustration: VDI/VDE - IT with Tableau Desktop™)*

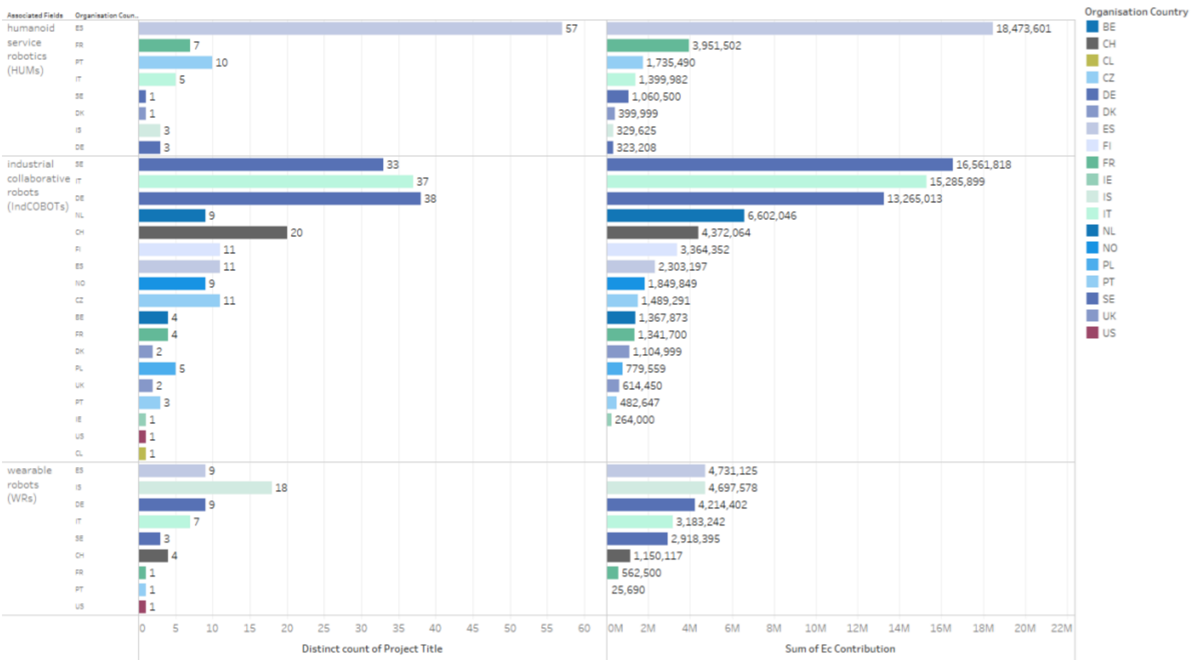



*Figure 14: Number of EU projects and funding budget by country (data source: CORDIS database, illustration: VDI/VDE - IT with Tableau Desktop™)*

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

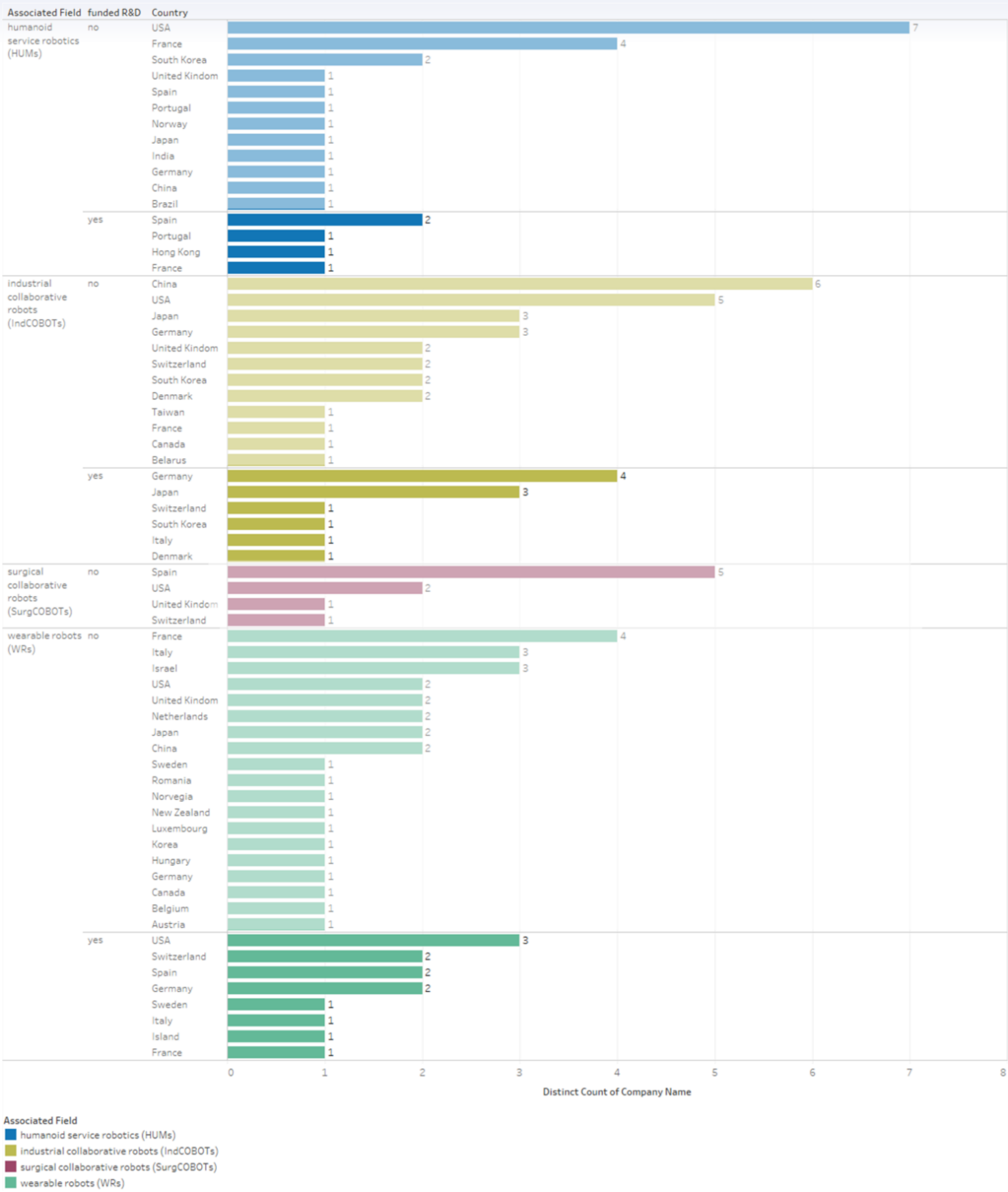



*Figure 15: Number of companies using EU and US R&D funding for each country in each interactive robotic fields. (data source: data from CORDIS, NSF and FedRep databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

Figure 15 shows funded companies with their headquarter locations involved in projects funded by the EU. For US companies involved in R&D projects funded by NSF and FedRep, it has been agreed to not represent the trend due to the small numbers of projects found (all the information is anyway available in the INBOTS website).

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

## Monitor industry innovation

This section aims at monitoring the industry innovation and an indirect way of doing that is to monitor the trend of patents created by the IR companies. Due to the nature of the DEPATISnet database analysis, that is not intended to be a patent analysis, it is important to focus the attention on the possible trends highlighted in the next figures, depicting an overview of different approaches to the innovation. For the analysis, the patent applications of all national and international (e.g. at WIPO and EPO) patent office's available via DEPATISnet were included.

In addition to that, it is important to underline that some of the figures shown below will present results only for small and medium enterprises. Indeed, in some specific cases, being interested only in patents related to interactive robotics technologies, large companies have been excluded having patents that could be out of the scope. Some large companies in the IndCOBOTs field have been excluded a priori having more than ten thousand patent applications such as ABB, Doosan, EPSON Robots, Fanuc, Festo, Hanwha Precision Machinery, Mitsubishi Electric, and Omron.

Figure 16 shows the share of the companies with patent applications, including large companies. Figure 17 shows the same share only considering small and medium enterprises. It is worth noting that percentages are changing minimally, highlighting the fact that being innovative fields with large opportunities, companies are motivated in protecting their core technologies from competitors.

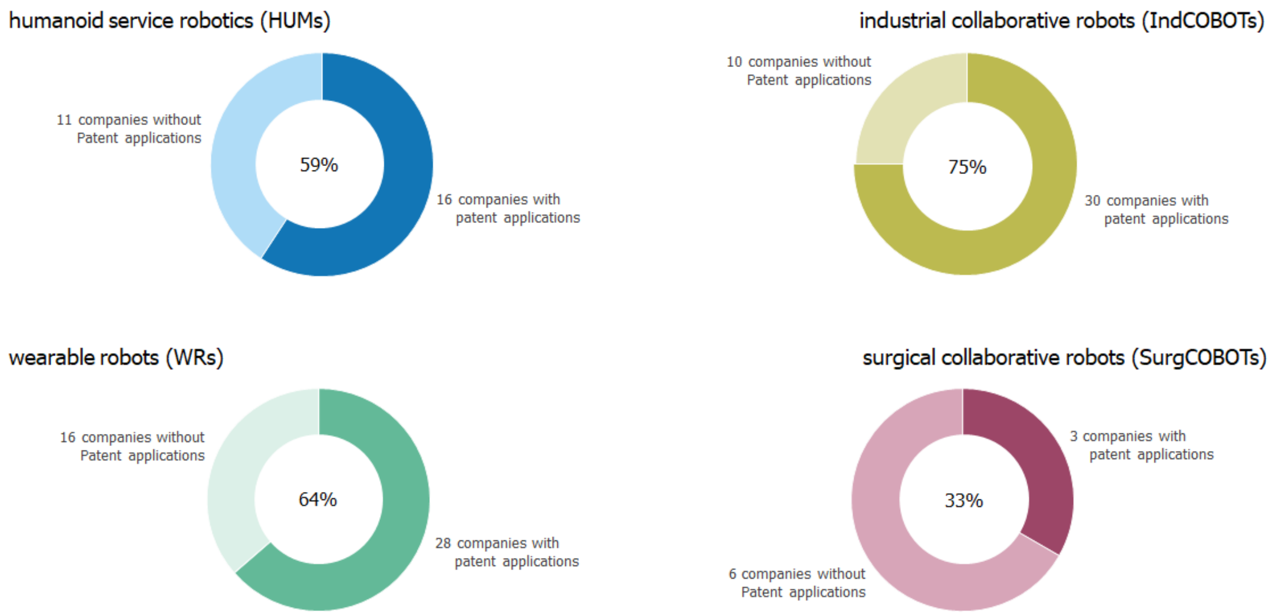



*Figure 16: Share of companies with patent applications in each interactive robotic field. (data source: data from DPMA database, illustration: VDI/VDE -IT with Tableau Desktop™)*

It is also evident that there are different IP strategies followed by companies, since considering results of Figure 17, almost 50% of the companies are not yet patenting their technologies.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

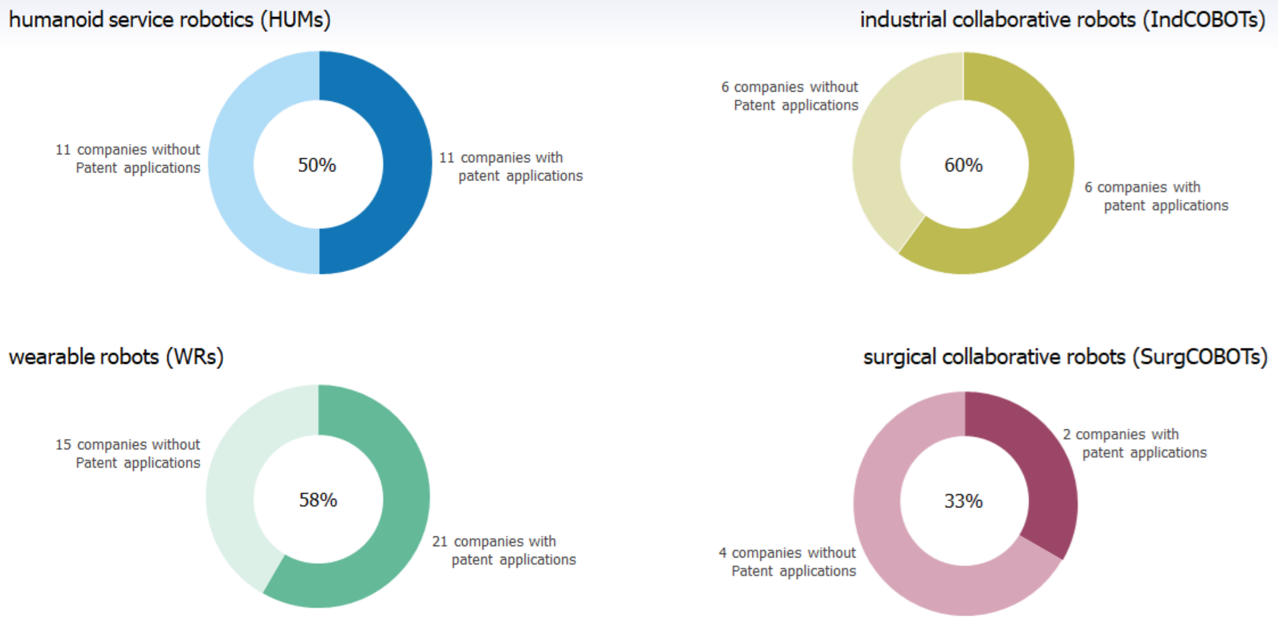



*Figure 17: Share of companies with patent applications in small and medium enterprises in each interactive robotic field. (data source: data from DEPATISnet database, illustration: VDI/VDE -IT with Tableau Desktop™)*

Figure 18 shows the trends for the four IR fields of the patent applications, considering only SMEs, over time. This plot highlights the growing trend in protection core technologies, started nearly in 2015.

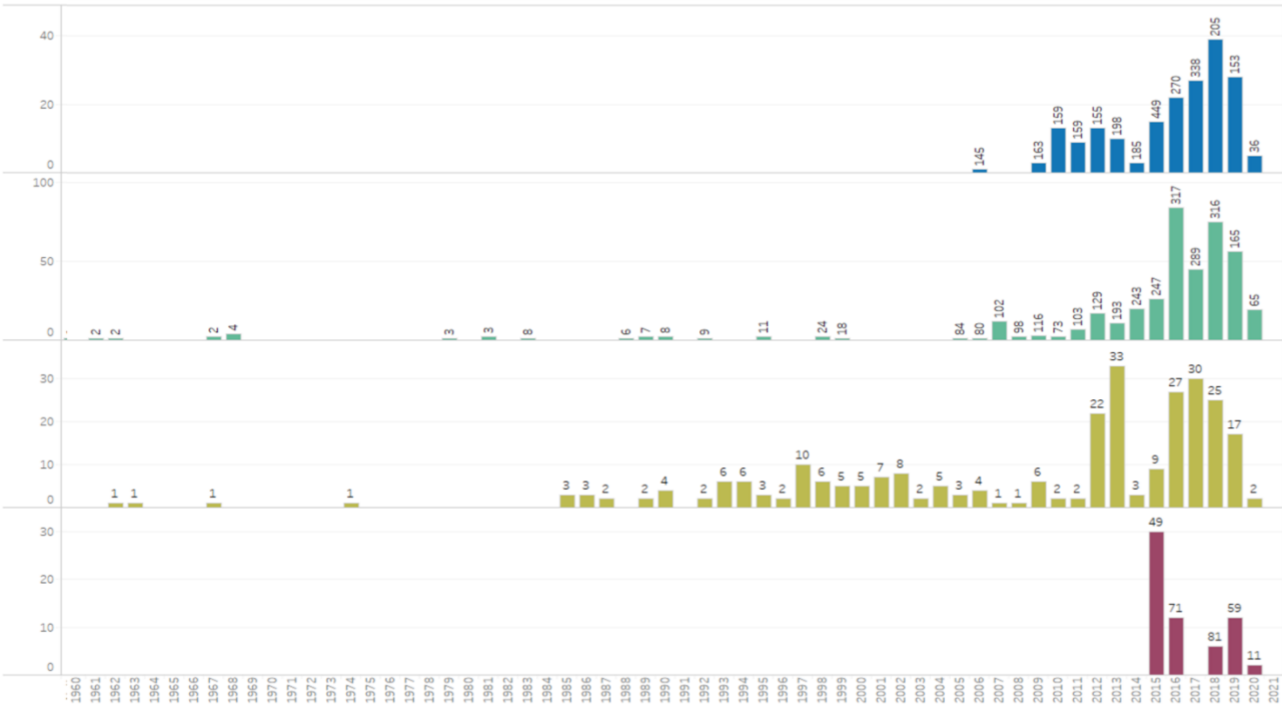


*Figure 18: Number of patent applications over time in the four fields only considering SMEs. (data source: data from DEPATISnet databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

To identify the main countries where companies file their patent applications first, it has been agreed to focus only on SMEs. Figure 19-Figure 20-Figure 21-Figure 22 show the distribution of the patents applications worldwide for all the four fields of SMEs, using the gradient of colour to highlight the top applied patent offices. In addition, also EPO (EP i.e. European patents) and WIPO (WO i.e. World patents) patent applications have been considered. Due to the relative low numbers, it is reasonable

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

to affirm that SMEs are reluctant to protect their technologies worldwide, due to the high cost of patenting.

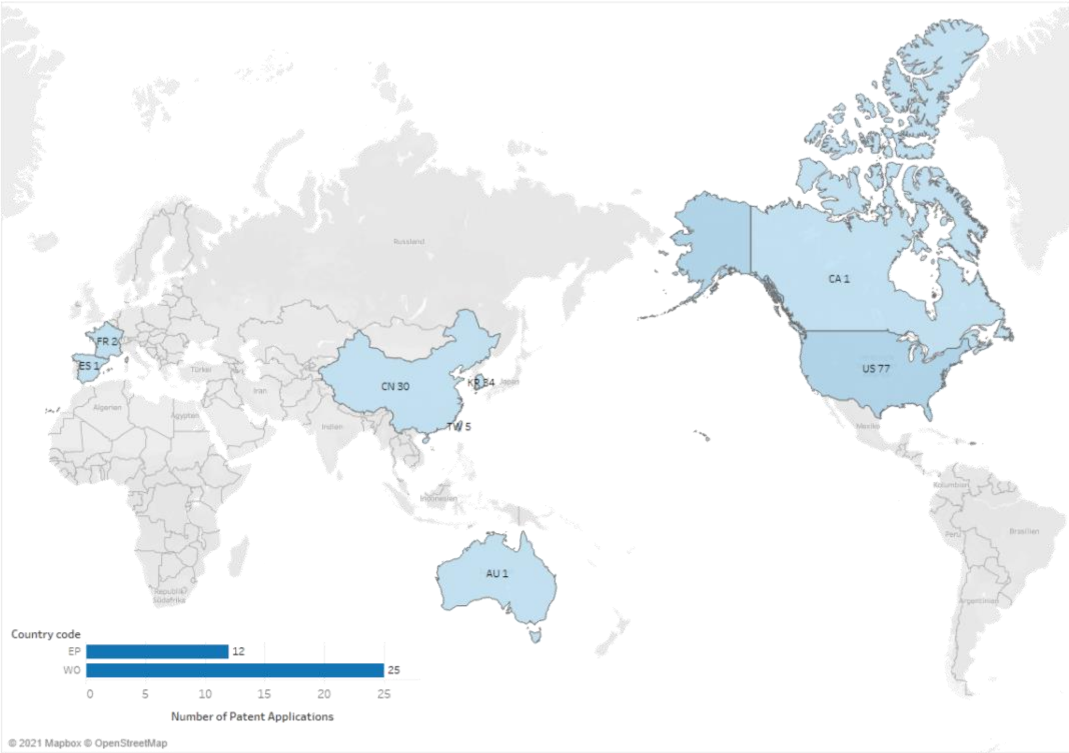



*Figure 19: Number of patent applications in protected areas/patent offices in the HUMs field – considering only SMEs. (data source: data from DEPATISnet databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

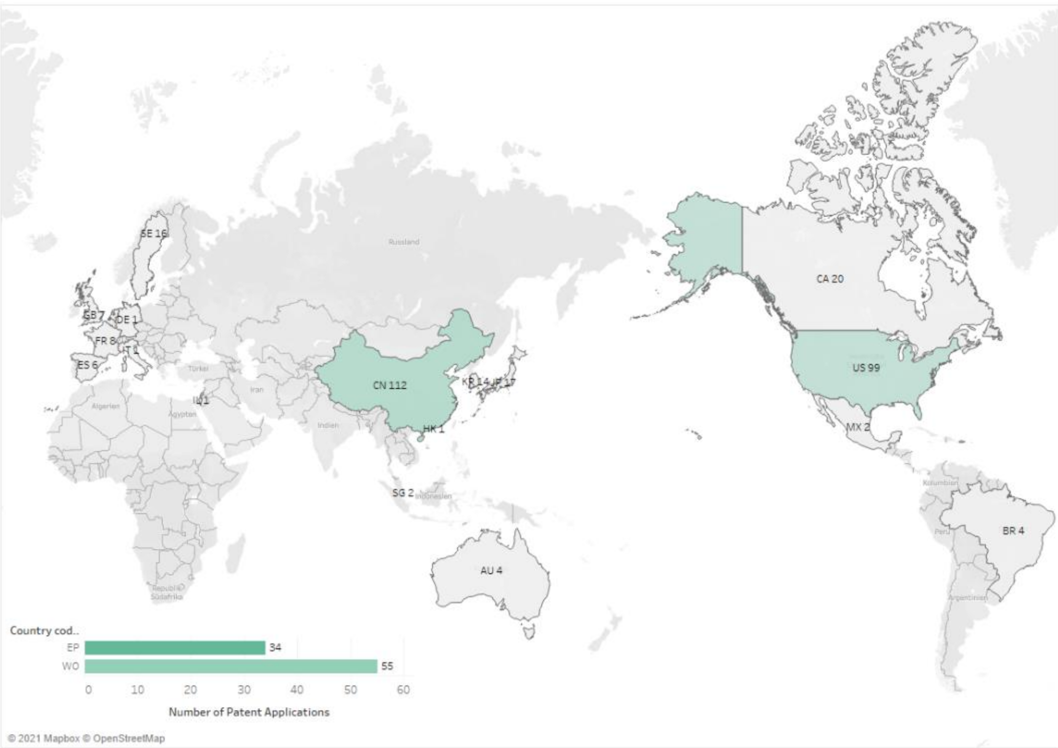



*Figure 20: Number of patent applications in protected areas/patent offices in the WRs field – considering only SMEs. (data source: data from DEPATISnet databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

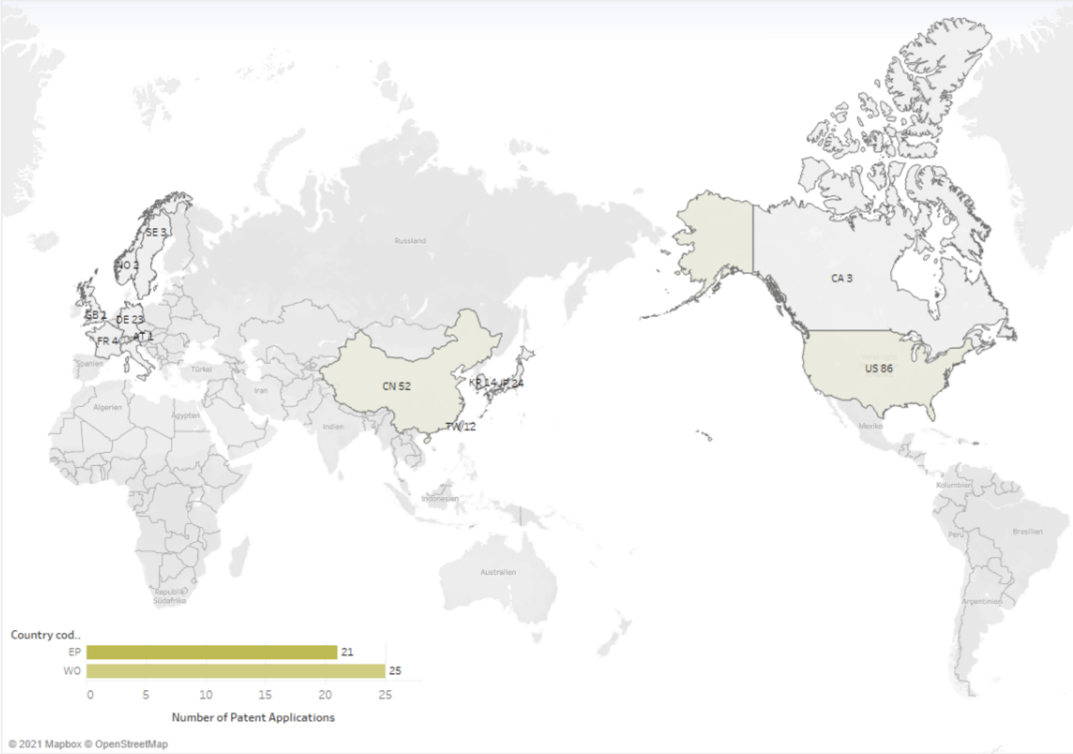



*Figure 21: Number of patent applications in protected areas/patent offices in the IndCOBOTs field. – considering only SMEs. (data source: data from DEPATISnet databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

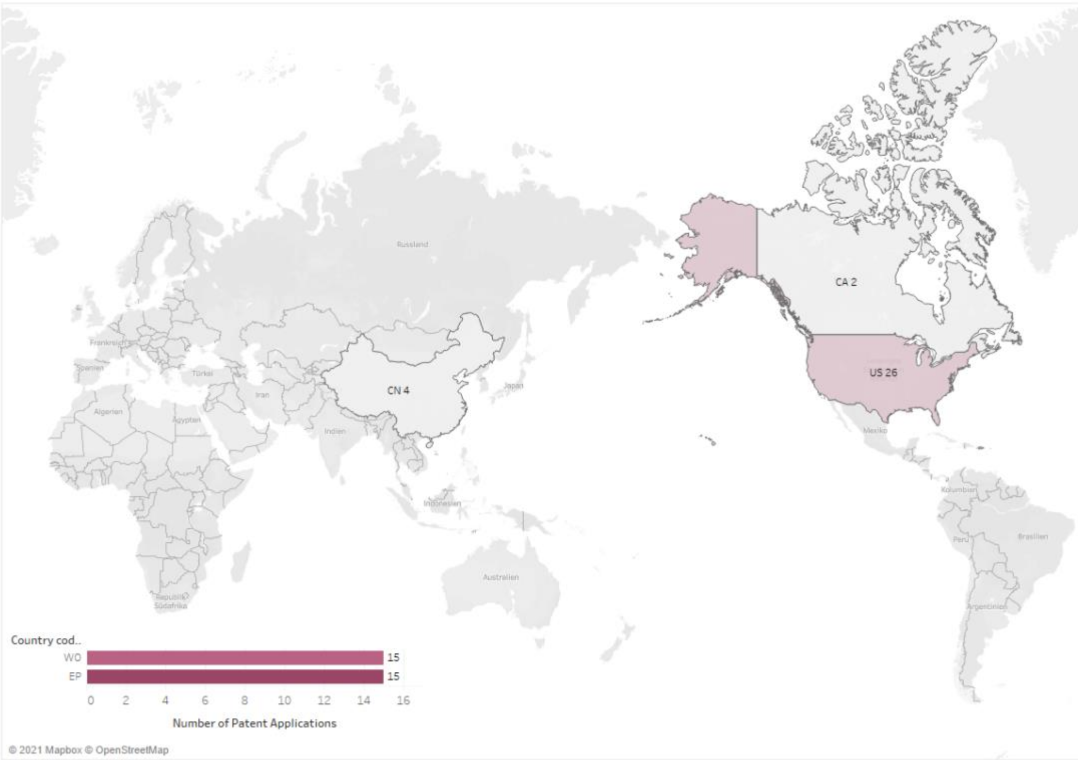



*Figure 22: Number of patent applications in protected areas/patent offices in the SurgCOBOTs field– considering only SMEs. (data source: data from DEPATISnet databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

In Figure 23 are reported the main IPC classes found in the patent analysis for SMEs. The motivation of these bubble-charts is to highlight the most used IPC classes in the four fields, supporting the reader in identifying the most protected core technologies. For HUMs and IndCOBOTs, the most

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

used one is B25J Manipulators, for WRs is A61F Filters Implantable into Blood Vessels; Prothesis etc. and A61H Physical Therapy Apparatus and for SurgCOBOTs is A61B Diagnosis, Surgery, etc. (see Table 12).

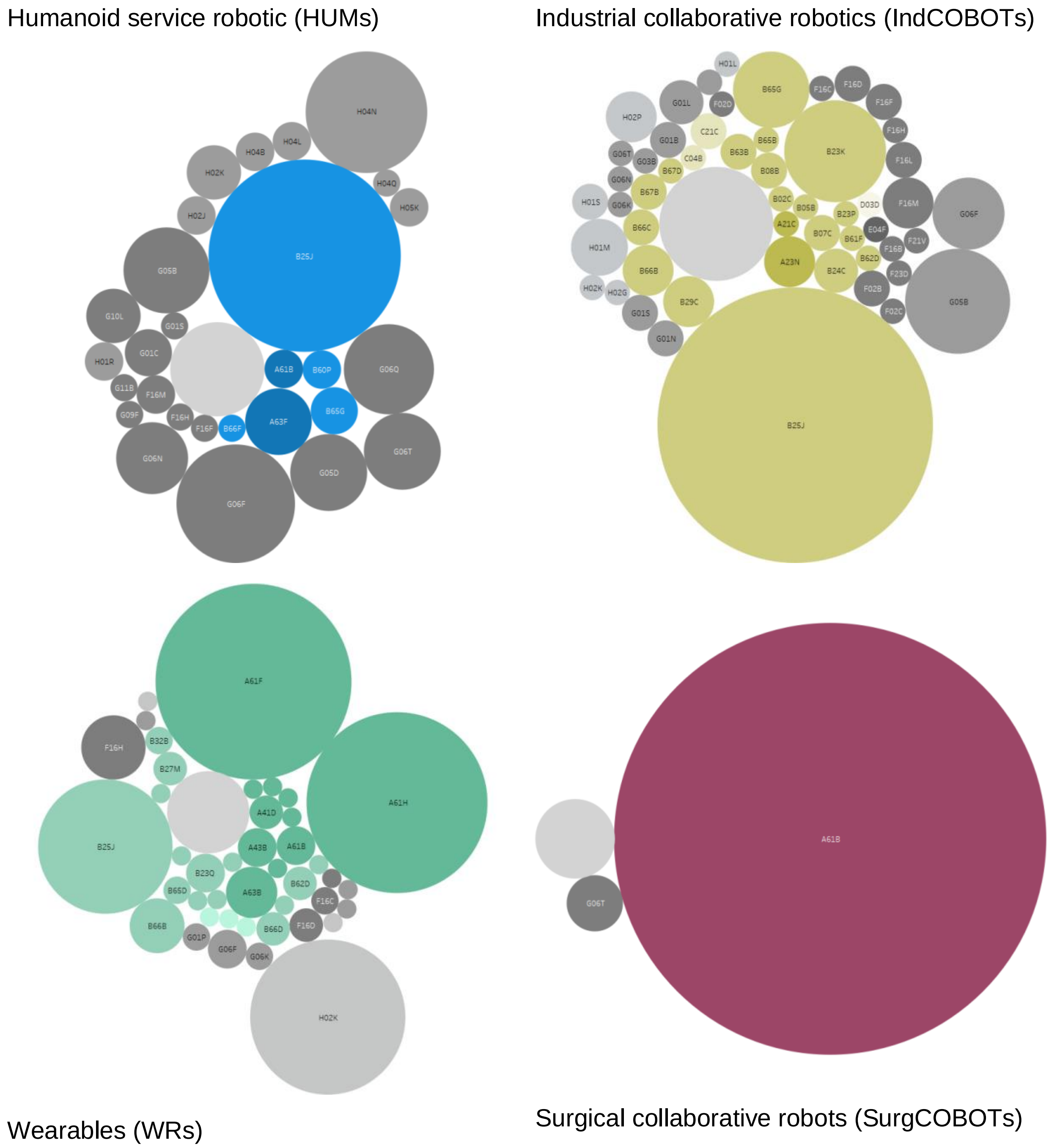



*Figure 23: Most common main IPC classes of patent applications in the field humanoid service robotic for SMEs. (data source: data from DPMA databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

*Table 12: Most common IPC classes.*

| IPC classes | Description |
|---|---|
| **B25J** | MANIPULATORS; CHAMBERS PROVIDED WITH MANIPULATION DEVICES |
| **A61F** | FILTERS IMPLANTABLE INTO BLOOD VESSELS; PROSTHESES; DEVICES PROVIDING PATENCY TO, OR PREVENTING COLLAPSING OF, TUBULAR STRUCTURES OF THE BODY, e.g. STENTS; ORTHOPAEDIC, NURSING OR CONTRACEPTIVE DEVICES; FOMENTATION; TREATMENT OR PROTECTION |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

| | |
|---|---|
| | OF EYES OR EARS; BANDAGES, DRESSINGS OR ABSORBENT PADS; FIRST-AID KITS |
| **A61H** | PHYSICAL THERAPY APPARATUS, e.g. DEVICES FOR LOCATING OR STIMULATING REFLEX POINTS IN THE BODY; ARTIFICIAL RESPIRATION; MASSAGE; BATHING DEVICES FOR SPECIAL THERAPEUTIC OR HYGIENIC PURPOSES OR SPECIFIC PARTS OF THE BODY |
| **A61B** | DIAGNOSIS; SURGERY; IDENTIFICATION |
| **G06F** | SYSTEMS FOR REGULATING ELECTRIC OR MAGNETIC VARIABLES |
| **H02K** | DYNAMO-ELECTRIC MACHINES |
| **H04N** | SYSTEMS FOR REGULATING ELECTRIC OR MAGNETIC VARIABLES |

Figure 24 summarizes the share of the granted patents and patent applications for SMEs. It is interesting to note that in all the four fields, the percentage of granted patent is nearly 20 % of the total.

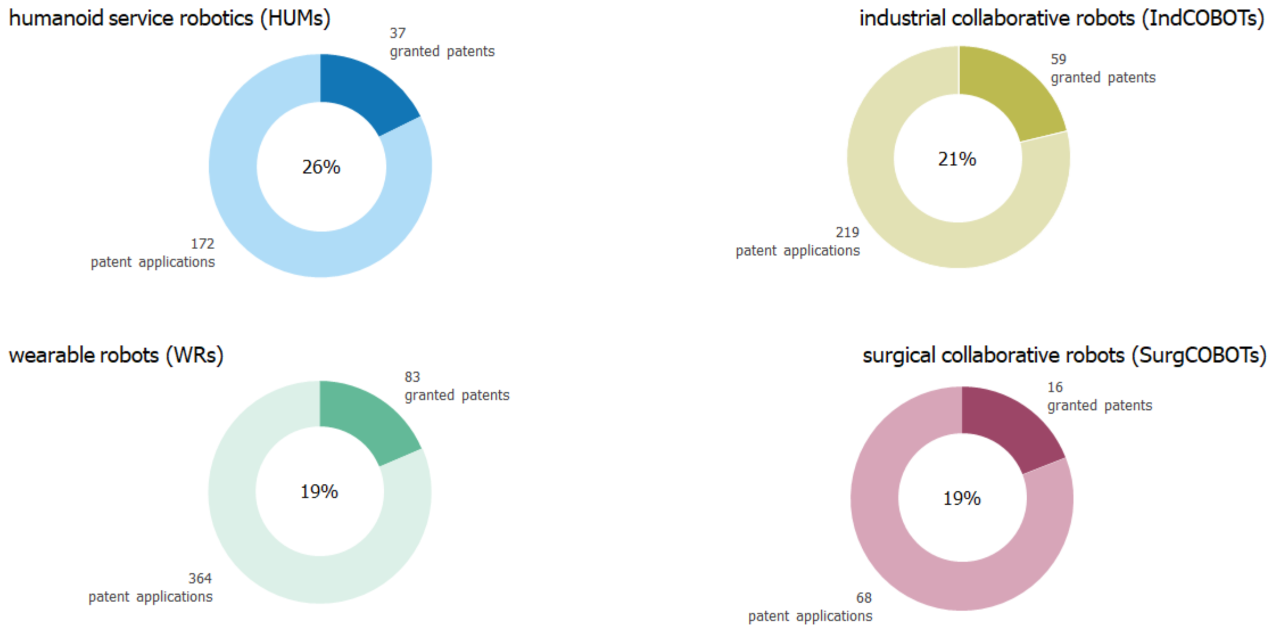



*Figure 24: Share of granted patens of all patent applications in each interactive robotic fields. (data source: data from DPMA databases, illustration: VDI/VDE -IT with Tableau Desktop™)*

Figure 25 shows the different approach of the companies in balancing R&D projects and patents applications. Here are reported the whole picture of patents, including also large companies with high n° of patents. Considering only the small window with a maximum n° of patents set to 10k, it is interesting to see that for IndCOBOTs companies the approach is mainly vertical, with a few exceptions that are involved in EU R&D projects. On the contrary, WR and HUM companies are more involved in EU R&D projects with a relative low n° of patents.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

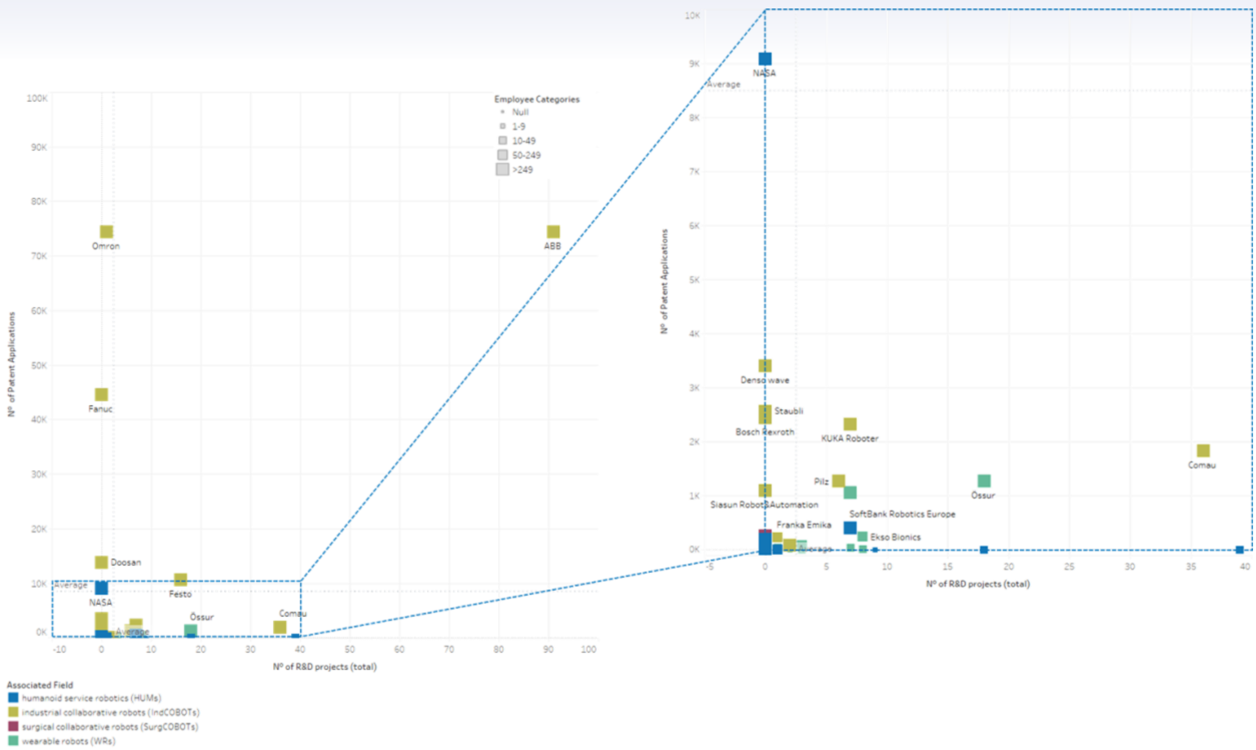



*Figure 25: Company benchmark in terms of patent application vs n° of R&D projects (data source: Cordis, NSF, FedRep, Depatisnet, illustration: VDI/VDE – IT with Tableau Desktop™). High resolution picture can be found in the interactive Tableau visualization on the INBOTS website.*

## Track R&D improvement and collaboration

This section aims at analysing the number of R&D collaboration between collaboration stakeholders and considered companies from the company list. The following figures show the results of a social network analysis in the four different IR fields on the Cordis, NSF and FedRep data extracted for the R&D analysis of the previous section. Since no collaborative projects could be identified for both NSF and FedRep data in the different fields, the following results are based on the Cordis data only. In addition, due to the lack of R&D projects (see Figure 10), the network analysis in the field of SurgCOBOTs has been skipped.

The social network analysis for HUMs (based on Cordis) identifies more than 700 nodes with 13184 edges (Figure 26). It is interesting to note that the four companies reported in R&D projects, involved companies that are working on in bigger cooperation projects (in Table 13).

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

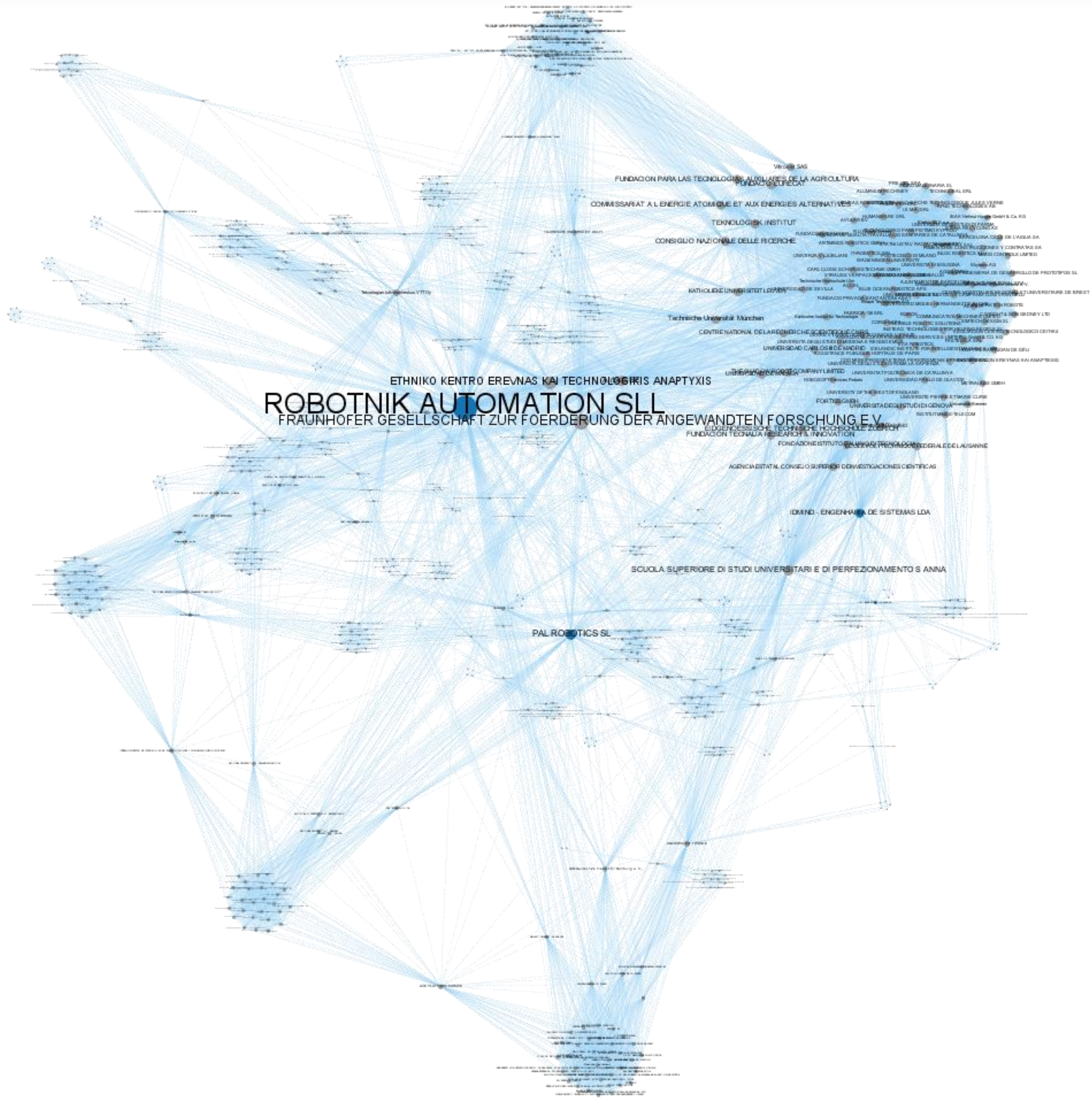



*Figure 26: HUMs cooperation network funded collaboration projects… degree of the nodes indicates count cooperation partners (data source: Cordis database, illustration: VDI/VDE – IT with Gephi). High resolution pictures can be found in the INBOTS website – WP1 community.*

| Organisation | Country | Degree |
|---|---|---|
| ROBOTNIK AUTOMATION SLL | ES | 491 |
| PAL ROBOTICS SL | ES | 196 |
| IDMIND - ENGENHARIA DE SISTEMAS LDA | PT | 167 |
| SOFTBANK ROBOTICS EUROPE | FR | 44 |

*Table 13: Collaborating companies in the field of HUMs (data source: Cordis database, illustration: VDI/VDE – IT with Gephi)*

The social network analysis for WRs (based on Cordis) highlights 301 nodes with 7355 edges (Figure 27). Here, only 9 of 13 companies are involved in cooperation projects (Table 14).

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

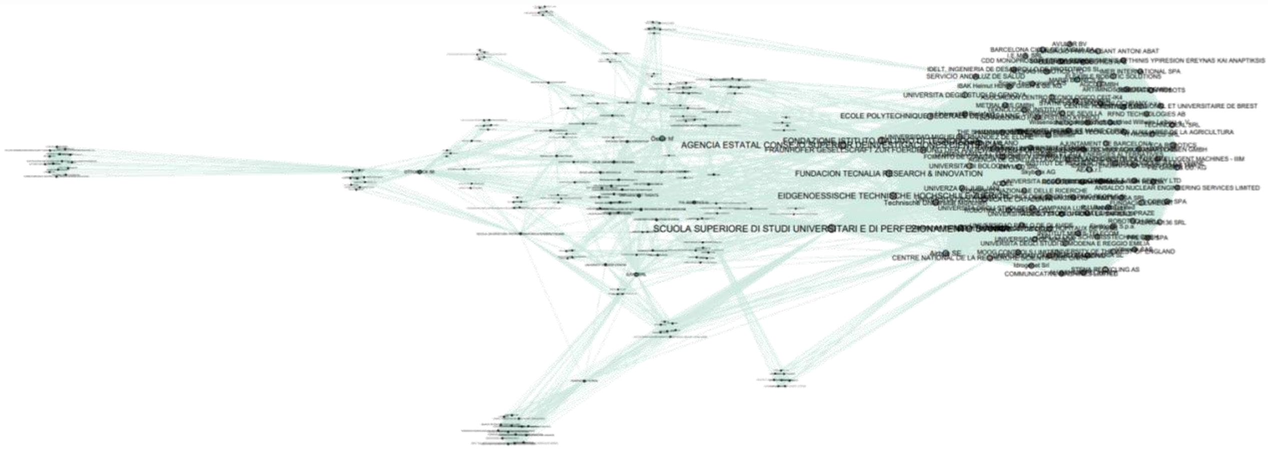



*Figure 27: WRs cooperation network funded collaboration projects… degree of the nodes indicates count cooperation partners (data source: Cordis, NSF and FedRep databases, illustration: VDI/VDE – IT with Gephi). High resolution pictures can be found in the INBOTS website – WP1 community.*

| Organisation | Country | Degree |
|---|---|---|
| MARSI BIONICS | ES | 107 |
| ÖSSUR | IS | 102 |
| IUVO | IT | 70 |
| OTTO BOCK | DE | 67 |
| HOCOMA | CH | 22 |
| BIOSERVO TECHNOLOGIES | SE | 20 |
| WANDERCRAFT | FR | 10 |
| EKSO BIONICS | US | 6 |
| GOGOA MOBILITY ROBOTS | ES | 3 |

*Table 14: Collaborating companies in the field of WRs (data source: Cordis database, illustration: VDI/VDE – IT with Gephi)*

The social network analysis for IndCOBOTs (based on Cordis) shows 2531 nodes with 91070 edges (Figure 28). It is interesting to note that all the 11 companies listed in Table 15 are involved in R&D collaborations.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

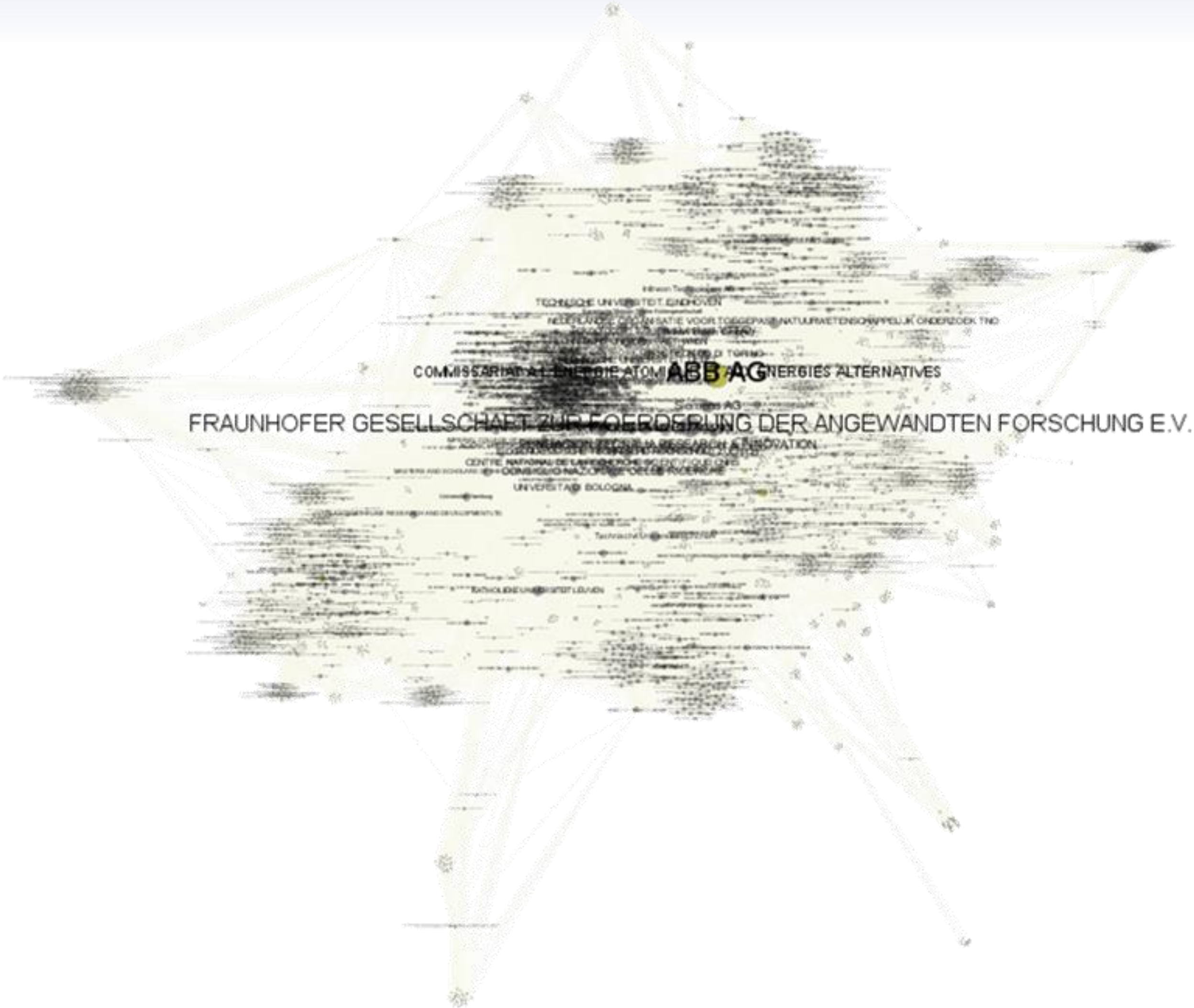



*Figure 28: IndCOBOTs cooperation network funded collaboration projects… degree of the nodes indicates count cooperation partners (data source: Cordis, NSF and FedRep databases, illustration: VDI/VDE – IT with Gephi). High resolution pictures can be found in the INBOTS website – WP1 community.*

| Organisation | Country | Degree |
|---|---|---|
| ABB AG | DE | 1364 |
| COMAU SPA | IT | 420 |
| FESTO AG & Co. KG | DE | 145 |
| COMAU FRANCE SAS | FR | 50 |
| MITSUBISHI ELECTRIC EUROPE BV | NL | 47 |
| DOOSAN SKODA POWER SRO | CZ | 35 |
| UNIVERSAL ROBOTS AS | DK | 29 |
| MITSUBISHI ELECTRIC R&D CENTRE EUROPE B.V. | NL | 22 |
| MITSUBISHI ELECTRIC RESEARCH LABORATORIES INC. | US | 20 |
| FUNDACION EPSON IBERICA | ES | 15 |
| OMRON EUROPE BV | NL | 12 |
| FRANKA EMIKA GmbH | DE | 7 |

*Table 15: Collaborating companies in the field of IndCOBOTs (data source: Cordis database, illustration: VDI/VDE – IT with Gephi)*

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 4. INBOTS website - interactive visualization

To improve the clearness of the document and to enhance further analyses in the robotics community, an interactive modality has been created within the INBOTS website to provide the possibility to the reader to dive deeper into the data sets. Indeed, by setting various filter options, different aspects can be examined more closely. For this purpose, the aggregated Tableau dashboards are directly integrated into the INBOTS website by publishing them on Tableau™ Public Server, including open available data.

For more details see the INBOTS websites: http://inbots.eu/contributing-to-inbots/support-to-smes/

The interactive visualization available on the INBOTS website consists of two dashboards:

- Dashboard #1: it provides all the data and graphics shown in the sections above regarding company data, R&D funding, IP approach in an aggregated manner to highlight the differences between the four interactive robotic fields. The reader can select all the fields together or analysing one of them independently.
- Dashboard #2: it is more focused on the individual company level and thus provides a competitive overview between the individual stakeholders.

Dashboard #1 (Figure 29) consists of two main parts: one fixed part, that is highlighted by the light blue square, showing (i) the total share of the companies analysed for all the four fields, (ii) the share of the companies with R&D projects funded, divided into the four fields and (iii) the share of the companies with IP applications/filed, divided into the four fields; and one variable part, that are all the remaining figures showing (i) the headquarter distribution worldwide and their distributions among the continents, (ii) the share of company sizes, (iii) the founding year, (iv) the founding volumes over the years, (v) patent applications over time and (vi) main IPC classes adopted by the companies. It is interesting to note that the reader can interactively select the associated field on top on the page and analyse in detail the trends in different areas.

Dashboard #2 (Figure 30) consists of variable figures that are updated according to the selection of the specific company through the filter on top of the page; in this way, it is possible for the reader to analyse in details different approaches followed by different companies working either in the same field or in a different one. Main figures shown report the short facts of the company, the level of public funding and R&D projects and the level of innovation and IP strategy. It is interesting to note that in the short facts it is presented and aggregated overview showing the position of the specific company among all the others in terms of N° of funded R&D projects (x axis) and N° of patent applications (y axis).

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073

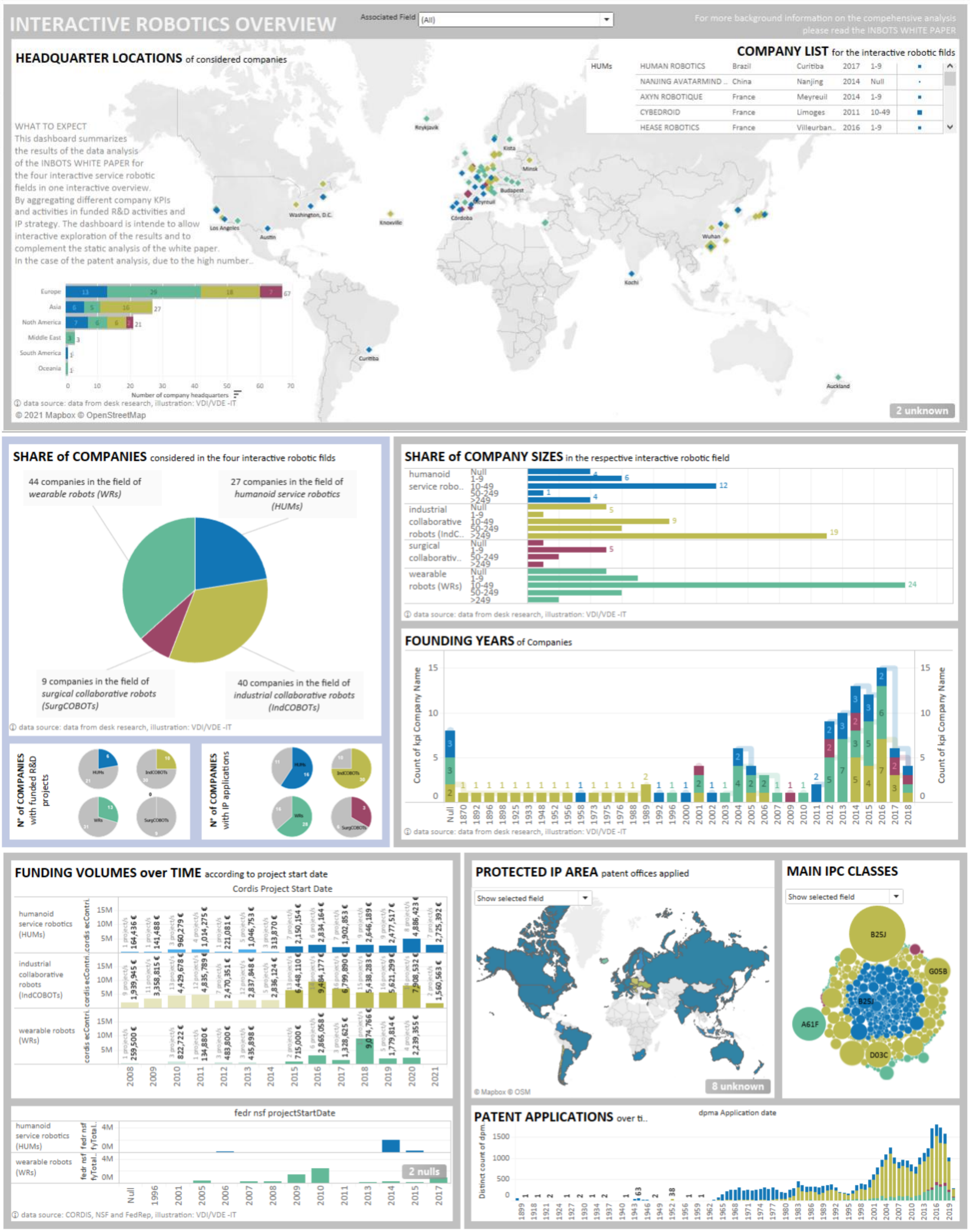



*Figure 29: Dashboard #1 on the INBOTS website, showing all the four fields together.*

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073

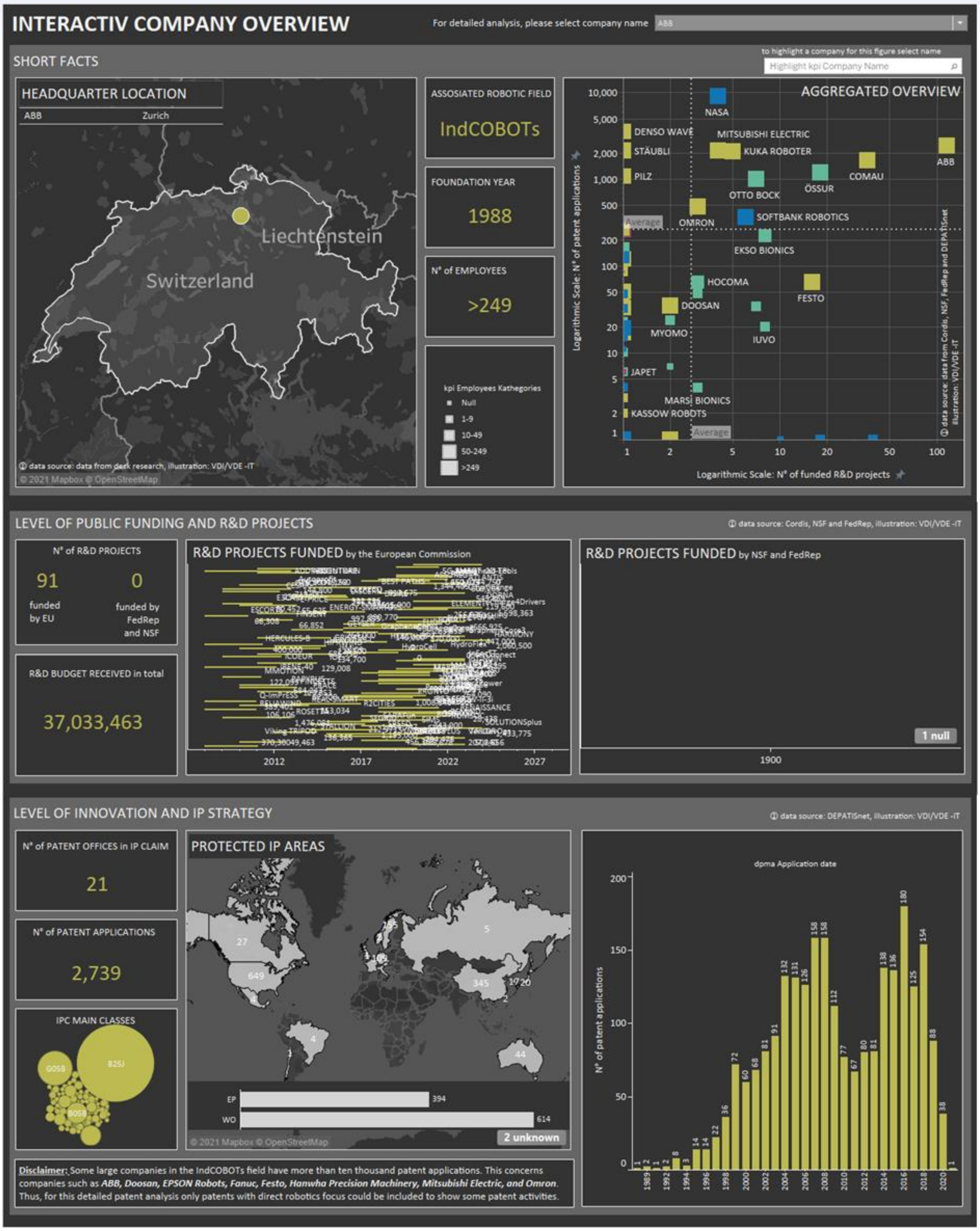



*Figure 30: Dashboard#2 on the INBOTS website - interactive company overview*

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 5. Intellectual Property Rights in Interactive Robotics

Intellectual property (IP) rights are valuable assets for any business. They keep the business away from competitors, they can be sold or licensed (providing revenues) or be used as security for loans, the company can offer something new to customers and they are an essential part of the marketing or branding strategies.

Ignoring or undervaluing the potential of IP can lead to risky situations, for example, opening the possibility of competitors of taking advantage of technical innovations, business, ideas, reputation in the market, etc.

Business can be protected by many ways, which, for the case of robotics and interactive robotics in particular, is of main importance given the nature of the several technologies and aspects integrating an IR (algorithms, software, hardware, middleware, designs, brands, robot names…).

## 1. Tools to support IPR for SMEs

IP protection is important in all R&D intensive industries, and the field of robotics is no exception. Robotics firms often require years of intensive (and expensive) research before being in a position to sell their products and reach commercial success. The lengthy and costly process of delivering profitable products highlights the role of IP rights, which are viewed as necessary to recoup up-front investments and to fend off competitors seeking to capitalize on the R&D investments of their rivals.

Types of IP:

- **Intellectual property** (author rights or copyright).
- **Industrial property** (distinctive signs, forms creation, invention). Rights over brands, commercial names, reports, industrial design, patents, model of utility, industrial secret.
- **Specific protection of software** (EU vs USA). Computer programs and computer assisted inventions.

How to protect:

- Previous knowledge as a starting point.
- Confidentiality agreements with third parties to ensure a secure interchange of information.
- Property, co-property and exploitation agreements for the generated knowledge.
- Record of property rights: patents, patenting process, strategies for patenting (national, European, PCT).
- Technology Awareness: search for patents, publications, etc to know the start of the art, who is working on what, follow the competition, patent infraction…

The strength of the IP /IPR depends on:

- Nature of invention (fundamental / incremental).
- Overall strength of rights: strong / weak).
- Possibility of ties or conflicts (Freedom to use) (none / much prior act).
- Is the invention covered by a range or rights or just one? (strong collection of IPR / single IPR).
- Potential to strengthen IP through partnering (strong / weak).

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

- Potential to strengthen IP through further development (strong / weak).
- How easy to monitor and deal infringers (easy / difficult).


*Figure 31: agents involved in the IPR application*

IP is a valuable asset which can be traded, bought, sold, leased, used in Joint Ventures.

Patents

R&D within the robotics industry often takes place several years before resulting in a viable commercial opportunity, with patents being the main legal instrument to recoup investments. Patents protect innovations and give their owners a right to prevent others from exploiting the patented technology. Both large and small companies can rely on patents to attract investors as well as protect their investments in technology. For example, smaller and more specialized firms often use patents to protect their IP assets defensively against larger players.[8]

The patent route can be particularly valuable for companies whose robots, or their elements, can be easily reverse-engineered (as is also known, reverse-engineering is the process whereby a product can be deconstructed to disclose its elements and the way it is manufactured). Indeed, in situations where reverse-engineering is simple, filing for a patent may be favoured over the alternative tactic - trying to protect the process of manufacturing and/or the relevant product by keeping them secret - with that patent being enforceable against any third party that exploits the invention without the patentee’s consent. Symmetrically, relying on trade secrets to protect robotic inventions can work well where (i) robots are produced

and used in a controlled environment, (ii) reverse-engineering is not easy to carry out and, (iii) those working with the products are committed to secrecy.[9] Also, trade secret protection may potentially last much longer than that offered by patents (20 years from the filing date), as industrial secrets that meet the relevant requirements are protected for as long as they remain confidential (potentially for

---

[8] C. Andrew Keisner et al., “Breakthrough Technologies – Robotics and IP”, Economics and Statistics Division, WIPO (2016), http://www.wipo.int/wipo_magazine/en/2016/06/article_0002.html
[9] Michael R., et al., ”Patents or Trade Secrets: The Choice Is Yours”, Robotics Business Review (2014) https://www.finnegan.com/images/content/8/6/v3/866/IntellectualPropertyConsiderationsfortheRoboticsIndustry-revised.pdf

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 780073

an indefinite period). Thus, the decision to apply for a patent may be influenced by the complexity of the company's products and whether the company's competitors are likely to get their hands on such products and subsequently reverse engineer them. For example, are the robots likely to reach millions of private homes or will they merely be deployed behind closed factory doors? These are factors that need to be considered when it comes to protecting robotics innovation through IP[10].

Trade secrets

As mentioned, robotics firms may rely on trade secrets and the legal protection given to such information, to protect their investments in technology. A reason why trade secret protection could be preferable is that such protection is offered without the need to adhere to certain prescribed formalities, such as filing an application with an office. Robotics companies can therefore avoid certain costs and complexities associated with patent filing and prosecution. Secondly, trade secrets (rather obviously) do not require disclosure, as the patent system does. A patent is granted in return for the disclosure of technical information so that the public at large, including patentees' competitors, will be able to exploit the invention after the 20-years term of protection expires. Therefore, as mentioned above, for robotics inventions that are more difficult to reverse-engineer, the trade secrets option may prove a superior alternative as the protection could potentially last indefinitely.[11] Indeed, patenting robots does not always produce benefits. It has been noted, for instance, that in the 1980s several companies in this field obtained numerous patents that ended up expiring before the owners could commercialise the protected products.[12]

Also, trade secrets can protect subject matter that patents may not,[13] for example innovation related to software and computer code. This option would be particularly beneficial also in light of the fact that protecting software inventions via patents has proven to be a contentious (and complicated) at national and international levels.

Copyright

Certain elements of robotic devices, especially software codes, could be protected by copyright (copyright is indeed the main legal tool to protect software). This is an important option also in light of the fact that – as we have just seen - availability of patents for computer programs has proven contentious. Software code is indeed crucial in this field, with robots being unable to function without them – robots deprived of software would basically be unable to perform their intended tasks. Typical tasks performed by robot include pathfinding, control, locating and sharing data.

Firms in this field may also rely on 'technological protection measures' to restrict access to, and prevent copying of, a robot's copyright-protected code. More precisely, what these companies may be interested in is to attempt to make it difficult for third parties, both competitors and users, to get their hands-on relevant software code, by inserting electronic barriers to prevent access. Copyright laws allow this construction of barriers. This is a type of protection that may be useful against users or competitors that want to access commercially valuable software code.

Trademark

How can trademark rights add value to robotics companies and their products? In general, registering trademarks is crucial to protect products' goodwill and reputation, especially in business-to-consumer industries. Notably robotics – especially interactive robotics - is increasingly becoming

[10] E. Bonadio et al., "Intellectual Property Aspects of Robotics", European Journal of Risk Regulation (2018)
[11] Michael R., et al., "Patents or Trade Secrets: The Choice Is Yours", Robotics Business Review (2014) https://www.finnegan.com/images/content/8/6/v3/866/IntellectualPropertyConsiderationsfortheRoboticsIndustry-revised.pdf
[12] C. Andrew Keisner et al., "Breakthrough Technologies – Robotics and IP", Economics and Statistics Division, WIPO (2016) http://www.wipo.int/wipo_magazine/en/2016/06/article_0002.html
[13] Ibid.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073

an industry where products are sold directly to millions of end-users. The commercial success of products such as nanny-robots, pet-robots, caretaker-robots and medical-robots also depends on a reliable brand which consumers know, trust, appreciate and remember. For this reason, robotics companies with a strong brand name and solid reputation are indeed investing on and registering trademarks (see for instance iRobot,[14] ABB,[15] Kawasaki[16] and Roomba[17] brands).

Designs

As said, today's robots are becoming much more consumer facing, and thus robots' physical appearance and their 'look and feel' play a central role in influencing consumers' choice.[18] Robot designs that meet certain requirements, for example novelty and individual character in the European Union, can be registered.

Some robotics companies in Europe have indeed taken advantage of this chance and obtained EU design registrations protecting the ornamental features of products such as vacuum cleaners,[19] robotic lawnmowers[20] and transportation robots.[21] Also, designs rights may soon be regularly sought by companies active in the field of wearable robots, i.e. devices that are used to enhance people's motion and physical abilities. Despite having functional elements, these products may be devised in a way which makes them more appealing to final consumers – and design rights could exactly be the appropriate legal tool in the hands of such firms to protect the eye-catching elements of their products. In other words, these rights may help these companies to keep pace with the likely "fashionalisation" of the robotics industry.

## 2. Results of the survey on IPR

With the aim to gather information about the non-technical barriers that the robot manufacturers must face when developing interactive robots for real life applications, a survey was developed, and stakeholders were invited to participate.

The survey was structured in 7 sections: (1) impact of topics influencing the development of IR, (2) impact of topics influencing the marketing of IR, (3) impact of topics influencing the protection of intellectual property of IR, (4) interest of companies in the types of IP tools, (5) patent infringement, (6) success stories when developing/marketing/protecting IP, and (7) fail stories when developing/marketing/protecting IP.

The survey was distributed through various channels:

- websites (INBOTS and project partner websites),

[14] *European Union Intellectual Property Office. https://euipo.europa.eu/eSearch/#details/trademarks/W01353068.*
[15] *European Union Intellectual Property Office. webpage https://euipo.europa.eu/eSearch/#details/trademarks/002628964.*
[16] *European Union Intellectual Property Office. https://euipo.europa.eu/eSearch/#details/trademarks/000814681.*
[17] *European Union Intellectual Property Office. https://euipo.europa.eu/eSearch/#details/trademarks/002995108.*
[18] *Meenakshy Chakravorty et a., "Design-Patent Protection for Modern Robotics Companies: What to Do When the Face of Your Robot Becomes the "Face" of Your Company", Robotics Business Review (2014)*
[19] *European Union Intellectual Property Office. https://euipo.europa.eu/eSearch/#details/designs/004680866-0025; https://euipo.europa.eu/eSearch/#details/designs/004680866-0026.*
[20] *European Union Intellectual Property Office. https://euipo.europa.eu/eSearch/#details/designs/002524462-0002.*
[21] *European Union Intellectual Property Office. https://euipo.europa.eu/eSearch/#details/designs/005418506-0001.*

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

- direct contacts with customers and partners of Tecnalia,
- conferences (INBOTS, ICNR, WeRob 2018),
- mailing lists (EU Robotics),
- newsletters (Hisparob), and
- other related research projects (RobotUnion, EUROBENCH).

As shown in Table 16, main concern for SMEs when developing IR in the access to financial resources, access to business networks and potential investors, collaboration with research centres and integration of the product into existing markets, whereas the required infrastructure and location are of minor importance.

Dealing with the marketing of IR (Table 17), SMEs state as the most important issue the demonstration of the added value, followed by the benchmarking of the product and commercialization of the robot. Again, the location and size of the SME are less important.

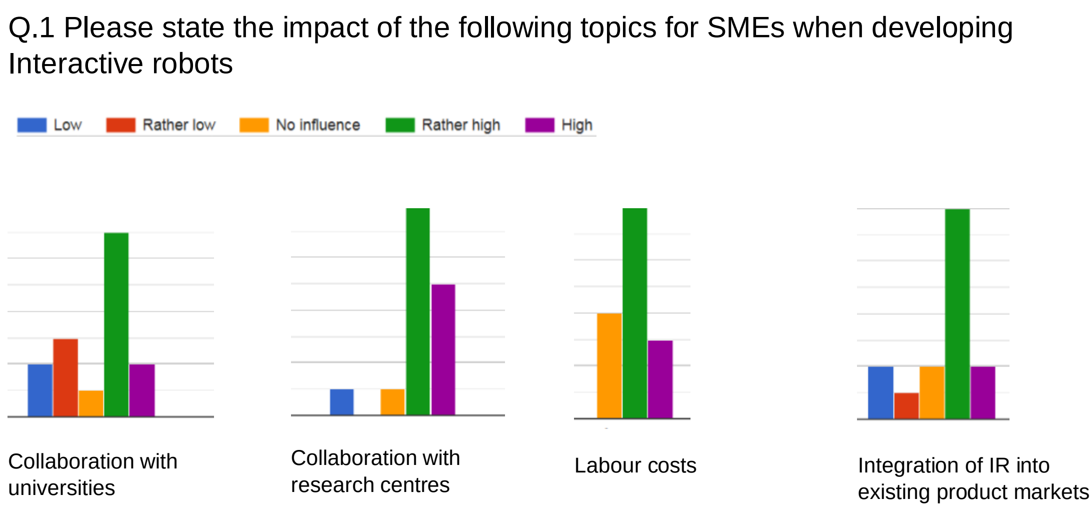
Table 18 shows the main issues when protecting the intellectual property generated. Main concerns are the lack of knowledge, complexity, cost and lead times when managing IPR process, especially if there is collaboration with large companies. The funding seems to be a minor problem.

The most preferred type of IP protection among SMEs (Table 19) is the European and national patent and trade secret. The protection of design and trademarks are also important, this could be explained by the fact that many IR are focused on the domestic and healthcare domains, where the appearance of the robot is important for the end user. Also, already known robot brands (coming from “traditional robotics”) are moving to the interactive robotics markets. The relative moderate influence of the copyright tool is a surprising result, since it is the most common IP tool to protect the software (at EU level).

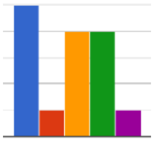
The last question in Table 20 (“Freedom to operate”) shows a coherent result with the answer in: companies give an important role to this point, so there are few patent infringements.

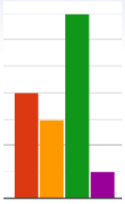
SMEs have declared the main reason for their success stories when developing/marketing/protecting their IR in Table 21. Main issues are good economic results and access to new markets and clients. When they have faced a fail result (Table 22) the main causes are lack of economic resources for the marketing/sales stage and bad economic results.

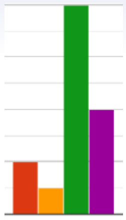
*Table 16: results to question 1*

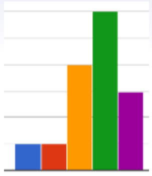


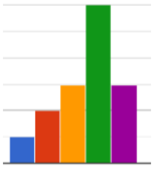

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 780073

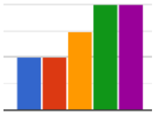

Infrastructure needed to integrate IR in existing environments / society

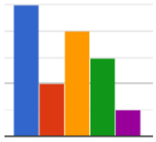

Availability of public funding


Access to financial resources (venture capital, etc)


Support for introduction to potential investors, business incubators, etc


Access to business and knowledge networks


Access to open technology standards based on licensing on FRAND (Fair, Reasonable and Non-Discriminatory)


Location (rural vs urban) and sector addressed

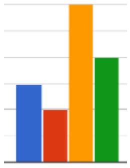
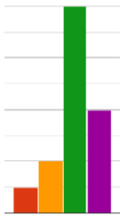

Age and size of the SME

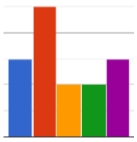
*Table 17: results to question 2*

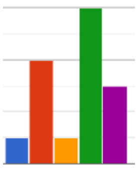
Q.2 Please state the impact of the following topics for SMEs when marketing Interactive robots

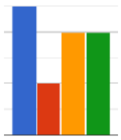


Demonstration of real added value, cost/benefit


Benchmarking applying objective assessments (usability, ergonomy, etc)


Life Cycle Issues


Help to commercialize IR and to build a culture of innovation using IR


Location (rural vs urban) and sector addressed

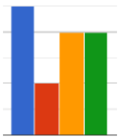
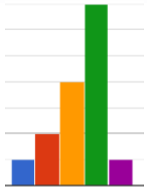

Age and size of the SME

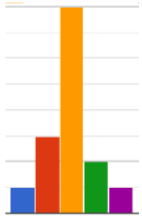
*Table 18: results to question 3*

Q.3 Please state the impact of the following topics for SMEs when protecting Intellectual Property (IP) in Interactive robots

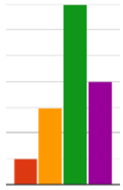

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*



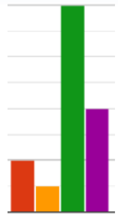
Lack of awareness /knowledge (which IP instrument to use)



Availability of public funding

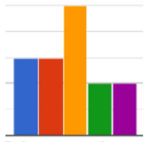


Risk of patent infringement

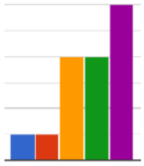


Long lead times when applying for national and international patents

Complexity & cost of IPR management



Enforcement of patent protection (mainly in low developed countries)

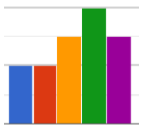


Protection of own IP when entering collaboration with larger companies

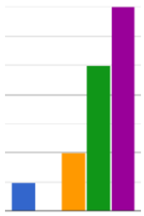
*Table 19: results to question 4*

Q.4 Please state the interest of your company about the following types of IP protection and related topics in Interactive Robots

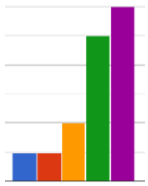
Low / Rather low / No influence / Rather high / High



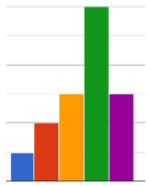
World patent



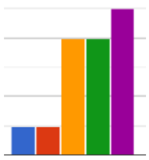
European patent



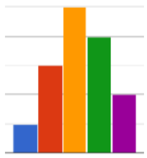
National patent



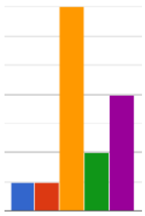
Know-How and Trade secret



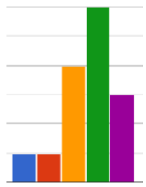
Protection of design



Copyright



Trademarks



"Freedom to operate"

*Table 20: results to question 5*

Q.5 Patent infringement

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

Has your company been reported because of a patent infringement?

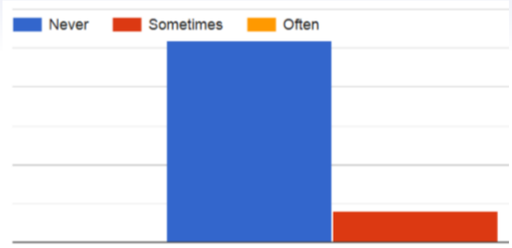



*Table 21: results to question 6*

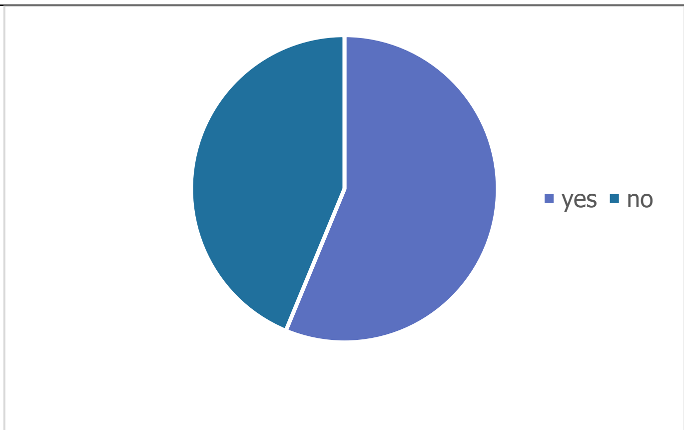
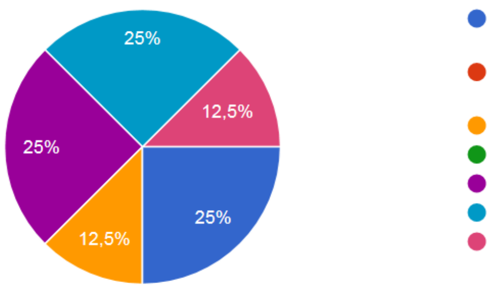
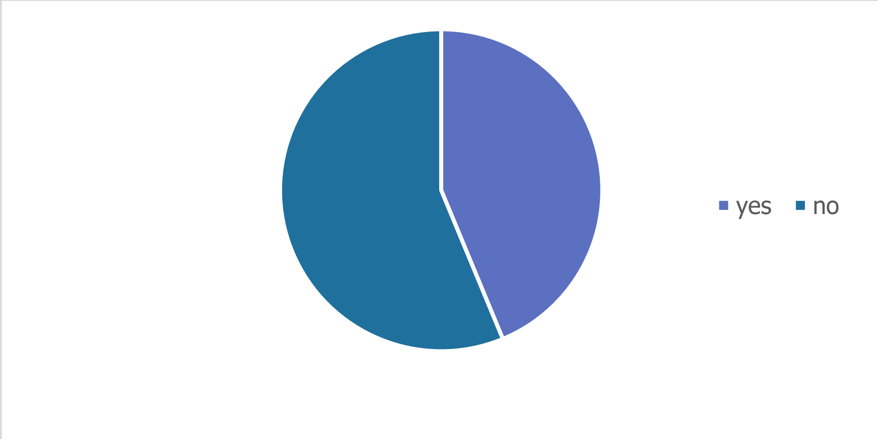
<table>
<tr><td colspan="2">Q.6 Have you ever had a success story when developing/ marketing / protecting IP with Interactive Robotics?</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td colspan="2">Q.6.1 If answer to Q6 is YES, then select the most important cause (one answer):</td></tr>
<tr><td>
</td><td>Good economic revenues by robot sales<br>Good economic revenues by IP (royalties, patents sales)<br>Good technical result<br>The image of the company improved<br>Access to more/new clients<br>Access to new projects<br>Difficulty to define clear business cases</td></tr>
</table>

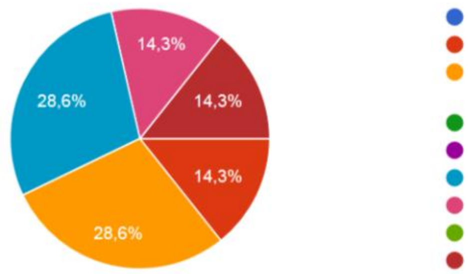
*Table 22: results to question 7*

| |
|---|
| Q.7 Have you ever had a fail story when developing/ marketing / protecting IP with Interactive Robotics? |

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073




Q.7.1 If answer to Q7 is YES, then select the most important cause (one answer):




Bad economic result

Bad technical results

Lack of economic resources for the development

Lack of human resources for the development

Lack of human resources for the marketing/sales

Technical problems

Lack of demand in the market

Lack of legal coverage for protecting IP

Changing requirements from potential clients

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 6. Business models and exploitation strategies

In this chapter, a comprehensive overview of the main economic aspects related to the creation and the growing of an innovative start-up company has been provided to the reader. Indeed, the following sections propose a method for identifying the proper business model for an innovative start-up, Innovative Business Models applied to start-up companies as well as some examples of companies and their business models.

## 1. Business models overview

More specifically, this section analyses how complementarity between Robots and ICT (Information and Communication Technology) and organisational innovation affects the Open Innovation (OI) strategy, contributing to the need to adapt new structures and operations of organisations by creating Business Model Innovation (BMI), which can in turn help create value in SMEs companies. That is, to identify how ICT (especially through the robots) are decisive for developing Absorptive Capacity in its two dimensions, internal and external, and therefore for the success of the Open Innovation strategies through the creation/adaptation of Business Model Innovation that creates company value.

The study covers how companies can use ICT to develop their Open Innovation strategies, by paying attention to how company capacities can impact the success of this form of innovation. Three sets of internal factors are analysed in relation to their impact on Open Innovation: ICT, organisational innovation and employee skills.

Open Innovation[22] and Business Innovation Models[23] are some of the developments that have aroused the greatest interest in the field of Business Administration in the last decade. The Open Innovation approach considers that companies must intensify their search and use of external knowledge to obtain a higher level of success in the development of products and changes in the business models that make them more efficient[24,25,26,27,28,29,30]. From a theoretical standpoint, the need to find a resource such as knowledge outside the organisation is based on fairly deeply rooted theories in Management literature. For example, from an evolutionary economics perspective, Cyert and March (1963)[31] suggested that organisations should look for knowledge beyond their borders in order to reinforce their ability to develop new products. Development of Absorptive Capacity is

[22] Kovacs et al., "Exploring the scope of open innovation: a bibliometric review of a decade of research". Scientometrics 104 (2015): 951
[23] Foss, N et al., "Fifteen Years of Research on Business Model Innovation", Journal of Management, 43 (2017): 200
[24] Chesbrough, H. W. "Open innovation: The new imperative for creating and profiting from technology". Harvard Business Press, 2003.
[25] Sandulli, F. Et al.,. "Open business models: las dos caras de los modelos de negocio abiertos". Universia Business Review 22 (2009): 12
[26] Abdelkafi, N. et al., "Business model innovations for electric mobility: What can be learned from existing business model patterns?", International Journal of Innovation Management 17 (2013): 1.

[27] Holm, A. B, et al., "Openness in innovation and business models: Lessons from the newspaper industry". International Journal of Technology Management, 61 (2013): 324

[28] Schneider, S.; Spieth, P. "Business model innovation: Towards an integrated future research agenda". International Journal of Innovation Management, 17 (2013): 134

[29] Souto, J. E. "Business model innovation and business concept innovation as the context of incremental innovation and radical innovation". Tourism Management, 51 (2015): 142

[30] Karimi, J.; Zhiping, W. "Corporate entrepreneurship, disruptive business model innovation adoption, and its performance: The case of the newspaper industry". Long Range Planning, 49 (2016): 342

[31] Cyert, R. and March, J. *A Behavioral Theory of the Firm*, Wiley-Blackwell, 1963.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

necessary for the success of an Open Innovation strategy[32]. The Open Innovation approach may also be framed as a specific case within the resource dependence model[33]; Absorptive Capacity[34]; open distributed innovation[35]; dynamic resources and capabilities[36,37,38].

However, and although literature has abundantly researched access to external knowledge for decades[39], there is a current need to drive research that provides greater understanding of Open Innovation. This need emerges from the rise of novel Open Innovation practices such as Robots[40,41,42,43], the use of social media[44], electronic marketplaces of knowledge and ideas or the use of new ICT tools to manage the stock and flow of knowledge in the organisation, in short, thousands of data (Big Data) that must be acquired and absorbed, to then transform and use them

[32] Spithoven, A. et al., "Building absorptive capacity to organise inbound open innovation in traditional industries". Technovation, 31 (2011): 10

[33] Pfeffer, J. and Salancik, G.R., *The External Control of Organizations: A Resource Dependence Perspective*, (Harper & Row, New York, 1978)

[34] Cohen, W. M. et al., "Absorptive-Capacity - a New Perspective on Learning and Innovation". Administrative Science Quarterly, 35 (1990): 128

[35] Von Hippel, E. at al., "Open source software and the private-collective innovation model: issues for organization science". Organization Science, 14 (2003): 209

[36] Teece, D.J. et al., "Dynamic capabilities and strategic management". Strategic Management Journal, 18 (1997): 509

[37] Teece, D.J. "Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance". Strategic Management Journal, 28 (2007): 1319

[38] Vanhaverbeke, W. and Cloodt, M. "Theories of the Firm and Open Innovation" in *New Frontiers in Open Innovation* (Oxford: Oxford University Press, 2014)

[39] West J. et al., "Open innovation: The next decade". *Research Policy*, 43 (2015): 805

[40] Bloss, R. "Collaborative robots are rapidly providing major improvements in productivity, safety, programing ease, portability and cost while addressing many new applications". *The Industrial Robot,* 43 (2016): 463

[41] Caic, M., et al., "Service robots: Value co-creation and co-destruction in elderly care networks". *Journal of Service Management*, 29 (2018), 178

[42] Mancher, M. et al., "Digital Finance: the robots are here". *The Journal of Government Financial Management*, 67 (2018): 34

[43] Vasalya, A., et al., "More than just co-workers: Presence of humanoid robot co-worker influences human performance". *PLoS One,* 13 (2018), https://doi.org/10.1371/journal.pone.0206698

[44] Xiaobao, P., et al., "Framework of open innovation in SMEs in an emerging economy: Firm characteristics, network openness, and network information". *International Journal of Technology Management*, 62 (2013): 223

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

to facilitate the flow of external, but also internal knowledge, to be able to generate skills (dynamic and adaptive) for companies to innovate and create value [45,46,47,48,49,50,51].

Automation itself is not bad. In fact, countries with a higher density of robots per worker are countries whose jobs have a lower risk of being replaced by automation. Hawksworth et al., (2018)[52] in their report, "Will robots really steal our jobs? An international analysis of the potential long-term impact of automation", shows a negative correlation between the potential jobs at high risk of automation, adjusted to account for industry composition, against the density of industrial robots in the country. This suggests that workforces in more technologically advanced countries such as Japan, South Korea and Singapore that are increasingly working alongside robots have already adjusted to automation to some degree and so may be at lower future risk. Instead they may be well placed to reap the benefits of automation in terms of higher productivity and real wages.

The theoretical framework of the Skill Biased Technological Change (SBTC), is based on the idea of the existence of strong complementarity between new technologies and skilled workers[53], both at an industry level[54] and a corporate one[55]. In both cases there is evidence of a direct and positive relationship between ICT and employee skills, even Doms et al., (1997)[56] proved at corporate level and in various industries, that the use of the latest technologies entails recruiting and hiring more skilled professional profiles, once again arguing said bias towards the very intrinsic needs of technology itself. Even though human capital does not appear in company financial statements, it is generally accepted that the value of a company could be determined by the value of the human resources comprising it, and this is particularly true in the case of services companies[57].

---

[45] Agarwal, Ritu, et al.,"Big data, data science, and analytics: The opportunity and challenge". *Information System Research* (2014): 443, https://doi.org/10.1287/isre.2014.0546

[46] Ooms, W. et al., "Use of Social Media in Inbound Open Innovation: Building Capabilities for Absorptive Capacity". *Creativity and Innovation Management*, 24 (2015): 136-150

[47] Loebbecke,C. and Picot, A. "Reflections on societal and business model transformation arising from digitization and big data analytics: A research agenda". *The Journal of Strategic Information Systems*, 24 (2015):149

[48] Opresnik, D. and Taisch, M. "The value of Big Data in servitization", *International Journal of Production Economics*, 165, (2015): 174

[49] Erevelles, S., Fukawa, N., Swayne, L. "Big Data consumer analytics and the transformation of marketing". *Journal of Business Research* 69 (2016): 897–904

[50] Richards, D. "Escape from the factory of the robot monsters: Agents of change". *Team Performance Management*, 23 (2017): 96-108.

[51] Vasalya, A., et al., "More than just co-workers: Presence of humanoid robot co-worker influences human performance". *PLoS One,* 13 (2018), https://doi.org/10.1371/journal.pone.0206698

[52] Hawksworth, J., Berriman, R. and Goel, G. "Will robots really steal our jobs? An international analysis of the potential long term impact of automation, PricewaterhouseCoopers". PwC, UK, 2018.

[53] Pianta, M., "Innovation and employment" in *Handbook of Innovation*, ed. I.Fagerberg, D.Mowery and R.R.Nelson ( Oxford: University Press, Oxford, 2003)

[54] Berman, E. et al., "Changes in the Demand for Skilled Labour within U.S Manufacturing: Evidence from the Annual Survey of Manufacturers". *Quarterly Journal of Economics*, 109 (1994): 367

[55] Dunne, T. et al., "Technology and jobs: secular changes and cyclical dynamics". Carnegie-Rochester Conference Series on Public Policy, 46 (1995): 107

[56] Doms, E. et al., "IT Investment and Firm Performance in U.S. Retail Trade". Center for Economic Studies, U.S. Census Bureau, 2013.

[57] Black, S. et al., "How to compete: the impact of workplace practices and information technology on productivity". National Bureau of Economic Research, 2001

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

Changing needs in the various skilled profiles as a result of implementing ICT, are based on the reduction of communication, supervision and organisational costs[58,59] furthermore, these ICT entail a change in the organisational structure that means flattening company hierarchies and a significant reduction of repetitive tasks, allowing more complex decision-making for problems never faced before [60,54]. Assuming all of the above is true, companies with a heavy use of ICT will look for employees with generic skills capable of performing multiple tasks[52,55,61].

We have found literature that focuses on the use of skilled labour to foster organisational change in the context of a rapid absorption of ICT[62]. In a study on companies, Bresnahan, Brynjolfsson and Hitt (2002)[55] concluded that an increase in the demand of skilled workers associated to the dissemination of ICT could be attributed more to the organisational change induced by ICT than to the technology itself. This study highlights the -importance of having a workforce with generic skills that supplement new technologies[57]. We understand there are rewards for skilled workers through organisational change, when transformations are required inside the company to obtain improvements in productivity. It follows therefore, that ICT have an impact on company productivity, leveraging pre-existing and complementary resources [63,64,65]. Frey and Osborne (2017)[66] analyse the average median wage of occupations by their probability of computerisation, and they do the same for skill level (measured by the fraction of workers having obtained a bachelor's degree, or higher educational attainment) within each occupation. They reveal that both, wages and educational attainment exhibit a strong negative relationship with the probability of computerisation. Their model predicts that computerisation will mainly substitute for low-skill and low wage jobs in the near future. By contrast, high-skill and high-wage occupations are the least susceptible to computer capital.

Open Innovation (OI) is a paradigm that studies how organisations expand their innovation efforts beyond their own limits by using incoming and outgoing knowledge flows to improve innovation success[67]. Chesbrough (2003)[62] originally identified two separate processes: A) Use of external innovation internally, and B) external marketing of internal innovation, but companies may also

[58] Milgrom, P. et al., "Complementarities and Fit: Strategy, Structure and Organizational Change in Manufacturing". *Journal of Accounting and Economics*. 19 (1995): 179

[59] Garicano, L. Rossi-Handsberg, E. "Organization and Inequality in a knowledge economy ". National Bureau of Economic Research, 2006

[60] Bresnahan, T.E. et al., "Information, Technology and Information Worker Productivity: Task Level Evidence". *Quarterly Journal of Economics*, 117 (2002): 339

[61] Bartel, A., et al., "How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement, and Worker Skills". *Quarterly Journal of Economics,* 122 (2007): 1721

[62] O'Mahoney M, Van Ark B. "EU productivity and competitiveness: An industry perspective: Can Europe resume the catching-up process?". Office for official publications of the European communities. Luxemburg, 2003.

[63] Barua, A., Lee, S. y Whinston, A. "The Calculus of Reengineering". *Information Systems Research*. 7 (1996): 409-428.

[64] Brynjolfsson, E. et al., "Information Technology and Productivity : A Review of the Literature". *Advances in computers*, 43 81996): 179

[65] Brynjolfsson, E. et al., "Paradox Lost? Firm-Level Evidence of High Returns to Information Systems Spending". *Management Science*, 42 (1996): 54

[66] Frey, B.B.et al., "The future of employment: How susceptible are jobs to computerisation?", *Technological Forecasting and Social Change*, 114 (2017):254

[67] Chesbrough, H. W. "Open innovation: The new imperative for creating and profiting from technology". Harvard Business Press, 2003.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

collaborate combining these incoming and outgoing flows jointly [68]. This idea was later qualified by Chesbrough and Bogers (2014)[69] defining OI as a distributed innovation process based on knowledge flows directed with a purpose through the organisation boundaries, using financial and non-financial mechanisms in line with the company's business model.

Companies that decide to use third-party resources in their own business models face a series of related challenges both in Absorptive Capacity and in their own organisational inertia. Absorptive Capacity is a concept developed in literature that analyses the sharing of knowledge among companies [70], referring to the capacity to recognise the value of new information, absorb it and apply it to business purposes. Therefore, Absorptive Capacity has a potential value in incoming Open Innovation activities. In particular, Absorptive Capacity is considered a key element for company survival, as it facilitates integration of external knowledge, which is crucial for innovation[65].

Popa et al., (2017)[71] provided empirical evidence on the relationship between organisational background and innovation climate in OI, and SME performance. The results revealed that organisation factors such as human resources practices based on engagement had a positive impact on innovation climate and that innovation climate contributes both to incoming and outgoing flows of OI which in turn improve performance. This effect was moderated by environmental dynamism. In another similar study, Martinez-Conesa et al. (2017)[72] evidenced the importance of management capability, absorption, SME knowledge and how the latter is influenced by ICT and human resources practices based on engagement in an OI environment.

A company's Absorptive Capacity is, in turn, associated to three specific capacities: capacity to find resources (acquisition), capacity to integrate resources (absorption and transformation), and capacity to use resources. Expanding the area of application of this concept to the framework of our study of open business models, we can assert that the success of a company that decides to use third-party resources depends on their capacity to detect resources that may create value, their capacity to integrate these external resources with their internal ones, and their capacity to use and capture the value created by these external resources[73,74].

Absorptive Capacity may help understand the incoming flow in the Open Innovation process of a company, since both literature on OI and on Absorptive Capacity back how innovative companies

---

[68] Enkel, E.,et al., "Open R&D and open innovation: exploring the phenomenon". *R&D Management,* 39 (2009): 311–316

[69] Chesbrough, H.W., Bogers, M. "Explicating open innovation: Clarifying an emerging paradigm for understanding innovation", in *New frontiers in open innovation* , ed. H. Chesbrough, W. Vanhaverbeke and J. West. (Oxford: Oxford University Press, 2014)

[70] Cohen, W. M. et al., "Absorptive-Capacity - a New Perspective on Lear- ning and Innovation". *Administrative Science Quarterly,* 35 (1990): 128

[71] Popa, S. Et al.,"Antecedents, moderators, and outcomes of innovation climate and open innovation: An empirical study in SMEs". *Technological Forecasting and Social Change*, (2017): 118, 134

[72] Martinez-Conesa, I. et al., "On the path towards open innovation: Assessing the role of knowledge management capability and environmental dynamism in SMEs." *Journal of Knowledge Management*, 21 (2017): 553-570

[73] Volberda, H.W. et al., "Absorbing the Concept of Absorptive Capacity: How to Realize Its Potential in the Organization Field". *Organization Science* 21 (2010): 931–951.

[74] Tsai, K.-H. et al., "External technology acquisition and product innovativeness: The moderating roles of R&D investment and configurational context". *Journal of Engineering and Technology* Management, 28 (2011): 184–200

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

can benefit from these external sources of technology [75]. Nowadays, we cannot ignore that external knowledge can be generated in alternative ways to patents, technologies, etc., and that this can be the result of the massive analysis of information[76]. Gassmann (2006)[77] had already indicated that research was neglecting to study the access to external knowledge through other tools.

Development of Absorptive Capacity is necessary for the success of an Open Innovation strategy [78]. One of the studies conducted along these lines is by the research group GIPTIC-UCM directed by Sandulli et al. (2012)[79] which noted that in the case of Spanish companies, Open Innovation is more common in large companies, in emerging, knowledge-intensive sectors with little concentration. Size is very important as in general it is considered that due to their lower absorptive capacity and availability of resources, they will have greater difficulties to obtain rents from Open Innovation strategies[80]. However, the results of previous work by the research group[81,82] suggest that with the right tools (ICT) and strategy (alignment between IT-Organisational Innovation-HR Skills), SMEs can offset their lack of resources through Open Innovation strategies. This is where Robotic and Big Data can play a significant role in the generation of external knowledge as a source of Open Innovation for SMEs.

Although business models (BM) have been studied for decades now[83]. First with definitions associated to the operating activity carried out, taking into account IT [84]. It was in the 1990s when they started talking about key business processes and how they are interrelated [85]. Most definitions found in literature have many elements in common with the definition provided by Teece (2010)[86] who defined BM as the design or architecture for value creation, delivery and capture mechanisms in a company. Furthermore, as shown by Saebi, Lien and Foss (2016) [87], in spite of using different terminology, literature agrees upon the components that make up a BM: the company's value

[75] Vanhaverbeke, W.; Cloodt, M. "Theories of the Firm and Open Innovation", in *New Frontiers in Open Innovation*, ed. Henry Chesbrough, Wim Vanhaverbeke and Joel West. (Oxford: Oxford University Press, 2014)

[76] Drexler, G., Duh, A., Kornherr, A. and Korošak, D. "Boosting Open Innovation by Leveraging Big Data", in *Open Innovation: New Product Development Essentials from the PDMA, ed. C. H. Noble, S. S. Durmusoglu and A. Griffin. (*John Wiley & Sons, Inc., Hoboken, NJ, USA)

[77] Gassmann, O. "Opening up the innovation process: Towards an agenda". *R&D Management,* 36 (2006), 223

[78] Spithoven, A. et al., "Building absorptive capacity to organize inbound open innovation in traditional industries". *Technovation*, 31 (2011): 10

[79] Sandulli, F. D. Et al.,"Testing the Schumpeterian hypotheses on an open innovation framework". *Management Decision*, 50 (2012): 1222

[80] Van de Vrande, V. et al.,"Open innovation in SMEs: Trends, motives and management challenges". *Technovation*, 29 (2009): 423-437

[81] Sandulli, F. D. et al., "Can small and medium enterprises benefit from skill-biased technological change?". *Journal of Business Research*, 66 (2013): 1976.

[82] Sandulli, F. D. et al., "Jobs Mismatch and Productivity Impact of Information Technology". *Service Industries Journal*, 34 (2014): 1060-1074

[83] Bellman, R. et al., "On the construction of a multi-stage, multi-person business game". *Operations Research*, 5 (1957): 469

[84] Wirtz, B. W. et al., "Business models: Origin, development and future research". *Long Range Planning*, 49 (2016): 36

[85] Zott, C. at al., "The business model: Recent developments and future research". Journal of Management, 37 (2011):1019-1042

[86] Teece, D.J. "Business models, business strategy and innovation". Long Range Planning. 43 (2010): 172

[87] Saebi, T., Lien, L.; Foss, N. J. (2016). "What drives business model adaptation? The impact of opportunities, threats and strategic orientation". *Long Range Planning*. Advance online publication

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

proposition and the market segments it will compete in; the value chain structure necessary for the value proposition, the mechanisms to capture value deployed by the company, and how these elements are jointly related in an architecture.

Foss and Saebi (2017)[88] proposed a BMI classification based on two variables: A) scope, according to the number of elements involved in the change, if the change is to the architecture or modular; and B) novelty, if the changes are new for the company or the industry.

Therefore, four types of BMI can be differentiated:

- Evolutionary, is new for the company, but it would require an adjustment in certain individual components as a result primarily of the passing of time.
- Adaptive, BMI implies changes in BMs in general which are new for the company, but not necessarily new in the industry[82]. This is the case when companies adapt the architecture of their BM in response to changes in the environment, in response to competition from a new BM in their industry[81]
- Complex can be defined as the process through which management makes changes to the company architecture to conduct a disruptive change in the market (that is, something new in the industry).
- In the case of Focused, the company innovates within an area of the BM, normally in a new market segment which has been ignored by its competitors. Conducting a modular but new change for the industry.

Bi et al. (2017)[89] in a recent study, confirmed a theoretical model, based on RBV, that relates e-business capacities and the business value of rapidly growing SMEs. Results show that internal skills (ICT resources, employee ICT skills and ICT strategic alignment) and external skills (market focus and partner relationships) have a significant and indirect impact on SME performance by developing dynamic e-business capacities while helping them adapt their business processes to the competition.

However, if a company is not capable of adapting and reshaping its resources to absorb this knowledge, it will not generate a competitive advantage, which is why companies should be sufficiently capable of generating dynamic capacities to respond to required changes [90,91,92,93]. Companies should be proactive in their response to changes in the environment by detecting even weak signs from customers and other stakeholders to predict consumer trends and even design new products and reach new markets[88]. For Opresnik and Taish (2015)[94] , the term "dynamic" refers to the ability to renew competencies in order to achieve coherence and alignment with a changing business environment. The term "capacities" stresses the key role played by strategic management in appropriate adaptation, integration of resources and reconfiguration of internal and external organisational skills, necessary resources and functional competencies required to respond to

[88] Foss, N.J. Saebi, T. "Fifteen Years of Research on Business Model Innovation", *Journal of Management* 43 (2017): 200

[89] Bi, R., Davison, R.M., Smyrnios, K,X. E-business and fast growth SMEs. Small Business Economics, 48 (2017): 559–576

[90] Teece, D.J. "Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance". Strategic Management Journal. 28 (2007): 1319

[91] Day, G. S. "Closing the marketing capabilities gap". *The Journal of Marketing*, 75 (2011): 183

[92] Kozlenkova, I. V. et al., "Resource-based theory in marketing. Journal of the Academy of Marketing Science". 42 (2014): 1

[93] Erevelles, S. et al., "Big Data consumer analytics and the transformation of marketing". *Journal of Business Research*, 69 (2016): 897.

[94] Opresnik, D. et al.,"The value of Big Data in servitization". International Journal of Production Economics, 165 (2015): 174-184.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

environment changes. If these changes affect the structure, content and/or governance of a company, new BMI is generated in response to new needs [95,96].

Five cases have been identified. The CASE 1 is a case of External Open Innovation practices (acquisition of robot, external collaboration with other companies and Big Data) have a positive impact on a company's value creation (improve productivity, cost reduction, ...), for the mere fact of incorporating a robot. The CASE 2 is a success case of a company that incorporates a robot and the workers are prepared and have fully accepted it. The robot is part of the strategy and not just a "machine". The practices of Internal Open Innovation (product and process innovation, organizational innovations: ICT capabilities, the skills of ICT workers, the use of networks at work and ICT alienation with the strategy) have a positive influence on the creation of value of the company.

The next case, CASE 3 Table 18, is a success case that is mainly due to the workers ICT capabilities, the skills of ICT workers and ICT alienation with the strategy. Otherwise, the robot wouldn't have succeeded. Finally, two more cases, CASE 4 (industrial sector) and CASE 5 (service sector), are companies that has implemented a high degree of automation and had to redesign its business model (eliminating jobs to create others, customer relations, relations with suppliers, ...). Following this suggested classification, next table offers a guide to recommended business model for SMEs developing innovative IR.

*Table 23: Quick guide for recommended business model.*

| Type of SME | Type of product / innovation | Description | Recommended business model |
|---|---|---|---|
| **All SME** | External Open Innovation | Acquisition of robot, external collaboration with other companies and Big Data. Have a positive impact on a company's value creation (improve productivity, cost reduction, ...), for the mere fact of incorporating a robot | Evolutionary |
| **SME that incorporates a robot and the workers are prepared and have fully accepted it.** | Internal Open Innovation | The robot is part of the strategy and not just a "machine". The practices of Internal Open Innovation have a positive influence on the creation of value of the company | Evolutionary |
| **SMEs with workers with high ICT capabilities and skills and the automation is aligned with the strategy** | Workers and Robots are aligned with the strategy | SMEs use robots and ICT to change and replace processes. Workers perform highly skilled tasks. The SME already has previous experience in the use of robots, and it has been a success. | Adaptive |
| **SMEs with very high degree of automation** | High degree of automation and had to redesign its business model | The SME completely redesigns its business model. Allowing to obtain an important competitive advantage. Makes changes to the company architecture to conduct a disruptive change | Adaptive and complex |

95 Foss, N.J. Saebi, T. "Fifteen Years of Research on Business Model Innovation", *Journal of Management* 43 (2017): 200

96 Zott, C.; Amit, R. "Business Model Innovation: How to Create Value in a Digital World.", GfK MIR, 2017

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 2. Identification of technological assets

In the following section conclusions from research projects that have just been finished are presented with respect to strategies on how to identify technological assets. The institutions involved in the projects need to put their results into exploitation strategies. These sections present information on how technological assets are handled in German national research projects in the context of service robotics.

There are multiple approaches on how technological assets are handled by the institutions involved in the research projects. They range from rather simple steps to sophisticated strategies and are going to be discussed in the following paragraphs. One approach is the economic exploitation through further development of the company's own product range, e. g. new adaptive behaviours for the products offered by the company or new products that are completely self-contained. This also includes the certification processes. Specific examples are the development of further applications, associated markets and other sectors, e. g. in the design of human-robot assembly stations in the industrial sector, through experience in the use of safe and real-time interaction forms and corresponding interfaces or new products in the field of support systems for people with physical disabilities. A growing market segment for service robotics has been identified by the institutions in the coming years. In this context large retail chains in which business is already involved play a role. New or extended products and further applications could thus be transferred to the customers much quicker. Also, entering completely new market segment has been mentioned in the context of further applications.

Thus, requirements for flexible production and assembly in the electronics industry and new fields of cooperation and research in the field of the development of multimodal interaction approaches for intuitive use by humans are an asset as well. Hence the possibilities to offer multimodal interaction technologies in other economic areas that go beyond the scope of intuitive interaction in the specific sector have been mentioned. Another way to deal with technological assets from research project is the general approach of capacity building, e. g. by a thorough documentation of the results and by integrating them into company processes. Linking up with existing fields of activity in the field of industrial robotics, like finding new distribution partners was also part of many strategies. A strategy that has often been applied by the companies is the quantification of the market size by several measures, e. g. the number of potential users per year or region, the planned sales/licensing price per system, the sale of a specified number of units over a certain period of time, an estimation of the total turnover, by making the sales price of the product flexible or by estimating the sale potential. There are also a variety of different market launch strategies, e.g. launching the product in different regions shuffled over a certain period of time or the adaptation for market requirements, e g. a special focus on data security in Europe.

On the one hand the results of the research projects led to the specialization in a certain field, e. g. the development of components for a general robot platform to perform specific tasks. On the other hand, the results were used for a broadening, e. g. testing the developed system on as many platforms as possible to demonstrate the universality of the interaction strategies. This could then be used as a general basis for a social robot offering possibilities for using the robotic system in multi-robot applications in which the domain knowledge collected by the individual robots is made accessible to all other robots on a cloud basis. A broader use of the robotic system was also part of some dissemination strategies.

The different strategies and their combinations have proven more or less successful in the past years. Very often it is the case that success stories are published in big campaigns and are sometimes unavoidable considering the German market. This is for example the case for the robotic system “Franka Emika” [https://www.franka.de/](https://www.franka.de/). Unfortunately, the success story of “Franka Emika”

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

has only very little to offer to conclude tips or recommendations which could be used by other companies. It seems that the success of "Franka Emika" is more a complication of coincidences. As it is very often the case the worst-practice example are usually the ones from which we are able to learn the most. But usually there is very little information on why exactly one specific company or product has failed. The following paragraph tries to shed light on the strategies mentioned above which have been described in national German funding projects. We should keep in mind that very often the application of different strategies in a complex world is more than the sum of their parts. This means that even the analysis of every single step of an exploitation strategy cannot fully explain the success or failure of a company or product.

Early steps in the lifetime of a company, product or service are the analysis of the market that needs to be addressed and the quantification of its size. At this early step it has to be decided whether the activities to launch and develop a product are worth the effort. It is a very crucial moment since it could cause the investment of large sums or the discontinuation of the activities. A market analysis should be planned wisely and economical since the company has only limited resources. A market analysis that takes too long and takes up too much money raises the threshold at which the company can expect a return of investment. So, the market analysis should be as short and focused as possible.

Cooperation is another important keyword for an exploitation strategy. The company should search for potential partners. It is always easier to team up with a potential opponent than to destroy each other's sales markets. Maybe the potential partners could combine their products or services in a symbiotic way. To find potential cooperation partners a lot of activities should be conducted e. g. the participation in conference, desktop research, database research or the usage of the personal professional network of the employees.

Once a product is ready for the market launch the work is not done. The exploitation strategy has to continue along the whole product cycle. Documentation is a very important keyword in order not to lose the capacities that have been built up. Especially with changing staff documentation is extremely important. There are a lot of good strategies for documentation that have their roots in software and hardware engineering e. g. Kan-Ban boards or git. It is very often useful to invest time into setting up these systems even though the initial work might seem high. These systems save up a lot of time in the later process.

The companies involved in German research projects have discussed the issue of specialization and broadening of their target points for their products in their final project reports. We can conclude here that neither of the two has proven better or worse. Specialization has usually been more successful if the market was tackled by opponents that have a larger production capacity. The companies could survive by finding their own niches. And often from these niches these companies still have an influence on the market. The broadening of the product range was successful whenever the demand (B2B and B2C) for specialized products was low. It was used by the companies to build up several new pillars, e. g. broadening from purely medical applications to applications in the care for the elderly or, and even bolder, into the consumer electronics industry.

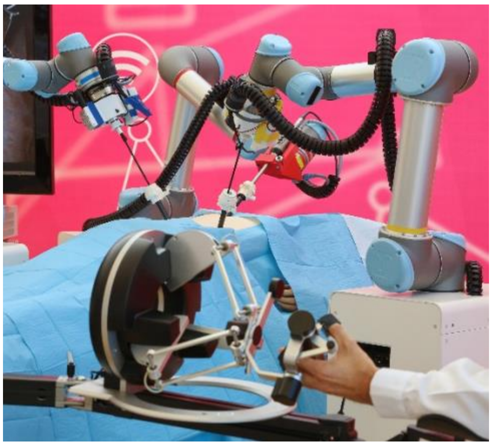
# 3. Best practices & Success stories

This subsection shows several examples of success stories and best practices of start-ups and SMEs when introducing new products on the market, based on interactive robots.

The information is provided in a tabular format, following the structure proposed in the previous section: (i) sector where the robot is being developed/used, (ii) type of business and innovation strategy followed, (iii) applied tools for protection of intellectual property, (iv) source of funding.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

*Table 24: KIRUBOTICS surgical solutions*

| CASE: | KIRUBOTICS Surgical Solutions, S.L. |
|---|---|
| SECTOR: | Service sector / robotics for health/ surgical robotics. |
| TYPE OF SME / INNOVATION STRATEGY: | "External Open Innovation":<br>The new company has external collaboration for part of its technological developments. |
| ROBOT NAME: | JR-10 (from Universal Robots) |
| PHOTO OF ROBOT: |  |
| ROBOT TYPE: | The system is composed of 3 UR-5 collaborative robots, which are teleoperated by a surgeon, to perform laparoscopic procedures. The robots have 6 degrees of freedom and are manufactured for general purpose (mainly for industrial sector: manufacturing, assembly, packaging, etc.). |
| ROBOT MANUFACTURER: | Jniversal Robotics (Denmark) |
| VALUE CREATION: | For this specific surgical application, the robots have been integrated together with a specific software development, with the aim to create a modular solution at a low cost. |
| CASE STUDY DESCRIPTION: | The robotic system from Kirubotics consists of three six-axis UR robotic arms that can be controlled individually or in coordination depending on the operation. The surgeon sees the surgical field on a 3D screen transmitted by an endoscope attached to one of the three arms. The surgical instruments that are attached to the two adjacent arms are controlled via a joystick console. The system's modular construction and the flexible options for using the UR robotic arms are its most advantageous features. Competitor applications are larger and more rigid by comparison and are generally only available in the form of expensive end-to-end packages so that hospitals end up paying for features that they do not even need to use. The UR robots and the software are combined into an open and low-cost system that is compatible with a range of different medical applications from numerous providers. The cost of acquiring, operating and in particular maintaining this innovative system will be significantly below the prices of other products currently available in the market. Robotic surgery is still out of reach for many public hospitals for cost reasons. The company Kirubotics pursues the |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

| | |
|---|---|
| | goal of making an affordable, supportive robot available for doctors all over the world to assist them in operations that are difficult or even impossible to perform manually. Kirubotics will perform this approach through external collaboration with technological companies, specialized in robotics and software development. Also, a strong agreement with the manufacturers of robots is foreseen. |
| APPLIED IPR: | European patents. |
| APPLIED FUNDING: | **Private:** Funds from corporate investors (engineering companies and Tecnalia Ventures) and private investors. **Public:** R&D programs at regional (*SOPREA* Program from Andalusian Gov.), national (*Cervera* program from Spanish Gov.), European (H2020 ICT Call). |

*Table 25: Case: Cyber Surgery*

| CASE: | CYBER SURGERY (EGILE group) |
|---|---|
| SECTOR: | Service sector / robotics for health/ surgical robotics. |
| TYPE OF SME / INNOVATION STRATEGY: | "Internal Open Innovation" The research and use or IR robots is made by employees of Cyber Surgery with previous expertise. |
| ROBOT NAME: | They have used several types during the prototype phase. Now they are evaluating Kuka. |
| PHOTO OF ROBOT: |  |
| ROBOT TYPE: | The system is composed of a 7 degree of freedom collaborative robot (probably a Kuka LBR) |
| ROBOT MANUFACTURER: | .UKA Roboter (Germany) |
| VALUE CREATION: | Assistant robot for spinal surgery, to help surgeons to insert prothesis with high accuracy and minimal risks. |
| CASE STUDY DESCRIPTION: | The EGILE Group started developing prothesis for maxillofacial applications, and later for spinal operations. The next step involved in prosthesis development was the development of its implantation methods in the operating theatre using intra-operative navigation and robotic technologies. They developed an "proof of concept" solution validated on animals. Thanks to the support of the Ministry of Economy and Competitiveness MINECO, through the project ELCANO from |

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073

| | |
|---|---|
| | the national INNPACTO 2012 programme, they were able to advance in enabling technology integration and design capacity: Infrared navigation and robotics. Following step was the creation of the spin-off Cyber Surgery. |
| APPLIED IPR: | European patents. |
| APPLIED FUNDING: | **Private:** Funds from the mother company (Grupo Egile) for the new business unit Cyber Surgery. **Public:** R&D programs at regional (programs from Basque Gov.), national (*INNPACTO* & *RETOS* programs from Spanish Gov.), European (H2020 ICT Call). |

*Table 26: Case - GOGOA Mobility Robots*

| CASE: | GOGOA Mobility Robots |
|---|---|
| SECTOR: | Service sector / robotics for health/ Wearable robots for mobility and neurorehabilitation |
| TYPE OF SME / INNOVATION STRATEGY: | "External Open Innovation": The new company has received external collaboration for its technological developments. |
| ROBOTs NAMEs: | HANK (lower limb exoskeleton) / Hand of Hope |
| PHOTO OF ROBOTs: |   |
| ROBOT TYPE: | Exoskeleton / Robotic hand |
| ROBOT MANUFACTURER: | The prototype of the exoskeleton robot was developed by the Neural Rehabilitation Group (Cajal Institute, CSIC) in Spain. |
| VALUE CREATION: | **HANK** is a lower limb exoskeleton designed for rehabilitation of adults between 1.50 and 1.95 m in height, with a maximum body weight of 100 kg, such as stroke patients following neurological insults. It also can be used for gait compensation in patients who have paralysis of the lower limbs following spinal cord injuries. It is conceived for over ground gait training in a clinical environment as a bilateral wearable device with six |

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073

| | |
|---|---|
| | degrees of freedom (DoF), in which hip, knee and ankle are powered joints. Various criteria informed the mechanical design: an exoskeleton design should be ergonomic, comfortable and lightweight, with a strong structure, adaptable to different users and with safety in mind. In HANK, aluminium 7075 is primarily used in the mechanical structure in consideration of mechanical resistance and lightweight. |
| CASE STUDY DESCRIPTION: | GOGOA born from a license of the Cajal Institute (which belongs to CSIC, the Spanish National Science Institute), and with the collaboration of Toledo National Paraplegics Hospital (main hospital in Spain focused on this kind of disabilities).<br>The company designs and manufactures wearable robotics to assist and rehabilitate the movement capacity of people with Acquired Brain Damage (ABD) or Spinal Cord Injuries and to increase the movement performance of humans (rescue services, fire fighters, workers under special conditions).<br><br>GOGOA´s Business model is open and focus on the rent, leasing and sale of wearable robotics for Hospitals and rehabilitation centres, to particulars, to public rescue services and to companies both to rehabilitate the capacity to move and to increase the movement capacities or reduce the lesions risk |
| APPLIED IPR: | European patents. |
| APPLIED FUNDING: | **Private:** Currently involved in funding rounds.<br><br>**Public:** Funds for start-ups from the province of Gipuzkoa (Basque Country, Spain), R&D programs at regional (programs from Basque Gov.), national (*ICEX & ICEXNEXT* funds from Spanish Gov.), and European level (FEDER funds & FTI project funds). |

*Table 27: Case: ARMASSIST*

| CASE: | ARMASSIST: Cost-effective, comprehensive upper-limb robotic device for neurorehabilitation |
|---|---|
| SECTOR: | Service sector / robotics for health/ Wearable robots for mobility and neurorehabilitation |
| TYPE OF SME / INNOVATION STRATEGY: | “External Open Innovation”:<br>The new company will have external collaboration for part of its technological developments. |
| ROBOT NAME: | ARMASSIST |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

| | |
|---|---|
| PHOTO OF ROBOT: |   |
| ROBOT TYPE: | 2 degrees of freedom, own design. |
| ROBOT MANUFACTURER: | Internal development. |
| VALUE CREATION: | ARMASSIST is a low-cost portable device to rehabilitate upper limbs in patients who have suffered neuromuscular diseases or ictus. The system uses a mobile base to record shoulder and elbow movements, and monitors patients' improvements. There is a tele-rehabilitation platform that enables the real-time connection with the therapist to correct possible errors. The software platform allows remote patient progress assessment and management of the therapy based on serious games, which motivate patients to actively participate in their rehabilitation and **maximize the outcome**. |
| CASE STUDY DESCRIPTION: | Robot developed by Tecnalia. Currently is in a TRL 6-7. Tecnalia Ventures is looking for entrepreneurs, investors and licensees. |
| APPLIED IPR: | 2 EPO patents (pending), 2 registered software |
| APPLIED FUNDING: | **Private:** ReHub Investments S.L. Also, there are contacts with a Chinese licensee to industrialize the system and commercialize it in Europe and USA.<br><br>**Public:** R&D programs at regional, national and European level. |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 7. Fundraising strategies and business fora

This section aims at presenting the two different approaches for fundraising: private funding methods and public funding opportunities. It is important to highlight that the aspect of guaranteeing self-sustainability of the company is fundamental in all the stages and it is highlighted very well by the results of the interviews and surveys did within this project. This section covers these issues, offering a general view of the types of private and public funding opportunities, business fora and how to deal with them.

## 1. Private funding strategies

Different strategies can be adopted for get funding by private investors but all of them are based on one simple question: is this business profitable? To be able to answer to this simple question, it is important to be ready to explain the characteristics of the proposed business. Therefore, to attract potential investors to fund the innovative new companies developing IR, the entrepreneurs need to know how to identify the opportunity for their new business related to integrating / using IRs:

1. Customer-Problem-Solution:

   The customer does not know the advantages of integrating IR in his/her company.

2. Does the opportunity match the founders experience, skills and interests?

   The opportunity should enable the entrepreneur to use and leverage the expertise he/she has acquired over time, (sometimes it comes from traditional robotics).

3. Can they recruit and lead the team (technical and management) needed to exploit the opportunity? (lack of available workforce experienced in interactive robots?)
4. Do the resource needs of the opportunity shorten the odds-on success?

   The new business needs capital, facilities, equipment, materials, etc.

5. Is the timing of the opportunity right?

   Understanding the temporal dimensions of the opportunity (regulation, technology, market demands, etc.)

6. Do they need to comply with legal requirements? (lack of standardization & legal framework for IR)
7. Does the opportunity constitute a scalable (and saleable) business?

   How big the business could become? The size depends not only on the type of IR to sell, but also on external factors (e.g., certification).

8. Does the opportunity offer good margin potential?
9. When the intellectual property of a development expires, it is important to have a replacement or additional incomes related to the main IR equipment. The advantage when dealing with IR is that they may integrate many different technologies (electronics, motors, control software, image & voice analysis, learning functionalities, etc.), so there is potential to grow and new developments.
10. Which one is the best channel to expand the business?
11. Are they developing an opportunity or simply an idea?

    The value to be delivered to the customer is the key to be found. Uniqueness lies in the particular blend of experience, skills and other resources that can be brought to bear on the opportunity exploiting in a way that others cannot easily replicate (e.g., dog robot Aibo).

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

12. How are they going to make money?

    The entrepreneur should design a specific business model for her/his business.

13. Who are their competitors and their competitive advantage? (difficulties in identifying competition since IR is a relatively new technology)

    The new company need to create a unique value proposition which differentiates from competitors. Barriers of entry (e.g., standardization, certification and legal framework).

14. Which one is the Exit strategy?

    It is important to know who will be willing to buy the new company to gain more market share, to avoid getting out of the market, etc.

It is also important to know why investors invest, they must believe in the proposed business/idea:

- Trustworthiness of the entrepreneur (often they are spin-offs, start-ups)
- Expertise and enthusiasm of the entrepreneur
- Track record of the entrepreneur
- Perceived rewards for the investors (maybe it is difficult to differentiate from "traditional robotics"?)
- Sales and growth potential of the market
- Expected rate of return (sometimes it is difficult to compute, especially when dealing with IR for social applications)
- Quality of product
- Overall competitive protection of the product
- Potential exit routes (liquidity)

Some things the entrepreneur should know about potential investors:

- What kinds of investments have they made in the past?
- What kinds of deals are they looking for currently?
- How do they make investment decisions? What kinds of deals do they like?
- Do they understand and have experience of the IR sector (or robotics sector in general)?
- How much detail are they looking for?
- What are they like? What is their style?

The entrepreneur must be ready to answer to potential questions the investors ask:

- Can the new company accomplish the tasks described in the business plan?
- How does the new company and IR product fit into the industry?
- What are the trends in the IR market?
- What are the drivers to success in the IR industry?
- What type of business experience does the management team have?
- How did you determine total sales of the industry and its growth rate?
- What industry changes most affect your company's profits? (regulation, standardization…)
- What makes your business different and makes it succeed?
- What are the major business risks?
- Why is this IR product useful? What will it do for the user?
- What is the expected life cycle of the IR product? What is the product liability? How does the regulatory environment affect the IR?

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

The new trends in start-ups creation is that the firm must share the value that it creates (*value of the firm*) with its customers and suppliers. This strategy involves three basic rules:

- To attract customers away from competitors, the company must provide sufficient customer value as compared to rival firms.
- To attract key suppliers away from competitors, the company must offer sufficient supplier value.
- To attract investment capital in competition with other market investment opportunities, the company must increase the value of the firm for its investors.[97]

When trying to put a new IR on the market, the developer must have answer for these open questions:

- Why will the business succeed when it must compete with larger companies? There are a lot of robotics companies which started manufacturing robots many years ago, and now they are moving to the IR sector.
- Does the product meet a specific need or perceived need of the customer? The customers hardly show a need to have an IR in their lives.
- Does the product have brand-name recognition?
- Are there repeat uses for the product? It is assumed that an IR is flexible enough to be used in several applications.
- Is the consumer the end user of the product? For example, for IR in domestic or industrial sector, probably yes, but when dealing with medical sector, probably not.
- Does this product have mass appeal or single large buyers? There is a big difference between IR for industry and IR for domestic use.
- Who is the competition and what advantages does the competition have over the new company?
- What advantages does the new company have over its competition? Price, performance, service, warranties?
- Are there any substitutes for your product?
- How does the new company expect the competition to react to the new business? The most common movement from competitors is to buy the company.
- How do advances in technology affect your product and business? An IR integrates and depends completely of several advanced technologies, so any change / discontinuity / lack of compatibility may affect the production of future versions of the IR.

The investment risks depend on the TRL of the product: high risk for early stage (TRL 1-3), low risk for market ready (TRL 7-9). Usually the financing follows these three main stages:

1. Financing early stage technologies to make ready for license or sale (pre-seed or seed funding).
2. Financing a start-up.
3. Financing a company for growth and exit by investors.

Types of funding sources: Venture capital vs Business Angels

Venture Capital: case of Tecnalia Ventures as a tool for private funding

97 ECONOMICS AND MANAGEMENT OF COMPETITIVE STRATEGY
© World Scientific Publishing Co. Pte. Ltd.
http://www.worldscibooks.com/business/7171.html

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

Tecnalia Ventures[98] develops business opportunities for the valorization and commercialization of technology by connecting the main pillars of an entrepreneurial ecosystem: minds, management and money. When the results of a research project reach a certain TRL, they look for:

- people with an entrepreneurial profile / business vision capable of transferring the developed technology to the market.
- smart investors that not only provide the necessary financial muscle to transform technologies into revenues but are also committed to supporting the development of the company.

They offer services such as: acceleration programs, entrepreneurs' club, technology transfer training programs, support for business diversification, set up of proof-of-concept funds, etc. They identify technologically disruptive solutions, exposing them from early stages of development to investment criteria, focusing the efforts on the business opportunities with highest commercialization potential.

- Entrepreneurs' club: connecting entrepreneurs that want to turn groundbreaking technology into business opportunities which have an impact on the market and on society.
- Omega Funds / Pre-acceleration program: aimed for a business idea which:
    - is technologically innovative
    - is in the initial development stage
    - is aimed at industry
    - could solve the financial problems of companies

The entrepreneurs can take part in Tecnalia Challenges – an 8-week pre-acceleration programme that will help the new business idea take shape and give access to OMEGA proof of concept fund. The programme covers the following areas:

- Identifying technological risks
- Developing the business model and marketing
- Legal support
- Analysing patentability
- Access to the OMEGA proof of concept fund. This fund is linked to a timebank for Tecnalia's researchers. The result is that it helps innovative start-ups to cross the valley of death, increasing the value of their R&D, developing technological skills that set them apart and therefore mitigating the technological risk to which private investors are so averse. Once the business opportunities have taken root, the process of speeding up the incubation of these technology-based business opportunities begins by exposing them to investment criteria from an early stage and concentrating efforts on ventures that have the greatest marketing potential, thereby ensuring that they are ready for private investment.

Tecnalia Ventures also organizes the *Inspiring Business Forum*, a corporate investment forum, to offer to its members business opportunities that are at the marketing stage. The members (corporate ventures, investment funds, etc), also show their needs for investment and diversification.

Other related initiative is the Innovation Forum, a network created by the universities of Cambridge and Oxford which connects entrepreneurs and researchers with investors and business angels worldwide. The network already has more than 15 nodes in Europe, Asia, USA and among the partners there are big companies such as Johnson & Johnson Ventures, IBM, Roche and Astellas Pharma.

98 https://www.tecnaliaventures.com/?lang=en

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

These tools help value the technological aspects of a business opportunity so that the potential investor can be sure before they invest. This involves checking all aspects related to technology, including valuation, protection, solidity, standards, integration, etc. Once the work has been carried out, the investor will be provided with a report outlining the conclusions and identified risks.

**Business Angels**

An *angel investor* is a high-net-worth individual who makes use of their personal disposable finance and makes their own decision about making the investment. The investor would normally take shares (an equity stake) in the business in return for providing equity finance (funds). The angels normally seek to not only provide the business with money to grow, but also bring their experience and knowledge to help the company achieve success. They can invest alone, or as part of a syndicate (a group of angels). [99]

Venture capital differs from angel investing because it invests in businesses through managed funds, coming from private or public money. The venture capitalist manager invests the money on behalf of the fund which has to be profitable. Due to high costs of administration and the need to ensure a return on the fund, VC funds are more risk averse and thus make fewer small investments in start stage.

That is why business angels are becoming more significant in funding new ventures by supplying smaller amounts of capital to companies that cannot be economically funded by the established venture capital market. Business angels make their own decisions about investments they make and generally engage directly in meeting the entrepreneurs, often seeing them pitch their business. Angels also engage directly in the due diligence and investment process. Angel investors then follow their deal either actively taking a role on the board or actively supporting the business or may act passively as part of a group with a lead angel taking this role on their behalf.

# 2. Taxation and incentives for Research, Development and Innovation affecting Robotics: a review of scientific literature and State Aid cases

The activities classified either as Research, Development or Innovation may enjoy tax advantages if incentives are established by national policy makers to that purpose. Taxation is a common tool to promote this type of behavior. The tax systems often allow tax credits to this respect in the calculation of the domestic Corporate Income Tax. This has been the case for a number of years in the OECD countries, where this trend can be easily identified in the past100. Despite observing an increased use of these instruments, even within the European Union (EU), this scenario may change in the near future. As the robotics industry relies on them, it is worth to pay attention here to this warning on the situation of the State aid regime. All the EU Member States have to respect the EU legal order in the design of tax incentives. Under the current circumstances, due to the Covid-19 impact on economy, the normative framework is being adapted for a green and digital recovery in the EU. This means that some traditional limits to the exercise of the legislative power in taxation are varying. States have relatively more leeway to overcome the effects of this pandemic. In fact, the first variation in the regime has led to temporarily relax this control of the public aid within certain parameters that are constantly reviewed. In the long run, after the shock, Covid-19 inclusive baselines will be

[99] https://www.ukbaa.org.uk/

[100] Grau Ruiz, M.A.: "Redesigning Tax Incentives for Inclusive and Green Robotics in theEuropean Union Reconstruction", in *Wearable Robotics: Challenges and Trends*, Juan C. Moreno et al (eds), Vol. 27, Biosystems & Biorobotics, Springer, 2021 (forthcoming).

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

probably considered. Thus, we are focusing here on how the State Aid regime has affected robotics in the past and alerting of its ongoing changes[101].

The scientific literature addressing tax aspects in robotics is relatively new. Most of the issues debated by the experts have been dealt in D2.1 and their analysis will be completed in D2.2.

The Article 107(1) of the Treaty on the Functioning of the European Union[102] states that, unless otherwise provided in the Treaties, any aid granted by a Member State or through state resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall be incompatible with the internal market, in so far as it affects trade between Member States. Due to its importance, the Commission has clarified this concept[103] and regularly offers sectoral guidelines to provide legal certainty.

In the field of robotics, it is worth taking into account a Communication from the Commission, adopted in 2020, concerning the prolongation and the amendments of several Guidelines (e.g. on Regional State Aid for 2014-2020, on State Aid to Promote Risk Finance Investments, for Environmental Protection and Energy 2014-2020, for rescuing and restructuring non-financial undertakings in difficulty, or to Promote the Execution of Important Projects of Common European Interest) and, particularly, the Communication from the Commission – Framework for State aid for research and development and innovation[104.] In the Framework for State aid for research and development and innovation, in point 10 the following sentence is added: "This Framework shall, however, apply to undertakings which were not in difficulty on 31 December 2019 but became undertakings in difficulty in the period from 1 January 2020 to 30 June 2021 (according to para. 15)". These temporary adaptations are exceptional, mainly due to the economic and financial consequences that the COVID-19 outbreak may have on undertakings. To support the economy a temporary framework was adopted and has been prolonged several times, in general, now until the end of 2021[105.]

The European Commission basically assesses any type of public support that companies receive to ensure it does not distort the market and fair competition in the light of the necessity and

[101] Various WP2 workshops have dealt with the design of tax incentives for responsible research and innovation. More information is available in these open access documents: Tools For Inclusive Robotics: Ethics, RRI, Taxation & Social Dialogue (Workshop at European Robotics Forum, Málaga, 2020) https://eprints.ucm.es/59990/
Self-coaching tools for conducting responsible research & innovation (RRI) with social robots (Workshop at ICSR, Madrid, 2019) https://eprints.ucm.es/59171/
Responsible Research and Innovation in Robotics (International Workshop at Universidad Complutense de Madrid, 2018) https://eprints.ucm.es/56514/
On how to combine labour and innovation, a false dilemma, see Grau Ruiz, M.A.: "El actual dilema fiscal por el impacto de la robótica: ¿innovación o empleo?" in *Tributos, servicios digitales y robótica*, Juan José Hinojosa Torralvo, Ignacio Cruz Padial (dir.), Thomson Reuters Aranzadi, 2021, pp. 327-346.
[102] Consolidated version of the Treaty on the Functioning of the European Union - PART THREE: UNION POLICIES AND INTERNAL ACTIONS - TITLE VII: COMMON RULES ON COMPETITION, TAXATION AND APPROXIMATION OF LAWS - Chapter 1: Rules on competition - Section 2: Aids granted by States - Article 107 (*ex* Article 87 TEC). Official Journal of the European Union (OJ) C 115, 9.5.2008, p. 91–92. ELI: http://data.europa.eu/eli/treaty/tfeu_2008/art_107/oj

[103] Commission Notice on the notion of State aid as referred to in Article 107(1) of the Treaty on the Functioning of the European Union C/2016/2946 *OJ C 262, 19.7.2016, p. 1–50.*

[104] OJ, C 224/2, 8.7.2020.
[105] The European Commission has decided to prolong until 31 December 2021 the State aid Temporary Framework adopted on 19 March 2020 to support the economy in the context of the coronavirus outbreak. The Commission has also decided to expand the scope of the Temporary Framework by increasing the ceilings set out in it. https://ec.europa.eu/competition/state_aid/what_is_new/news.html

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

proportionality principles[106]. When searching for cases affecting the robotics industry, the results are relatively scarce. In the following table, one can easily check the Member States involved and the title of the respective scheme in each case.

| Policy Area | Case Number | Member State | Last Decision Date | Title |
|---|---|---|---|---|
| State Aid | SA.42816 | United Kingdom | | The University of the West of England, Bristol, Robotics Laboratory. |
| State Aid | SA.43195 | Portugal | | ENDURE - Enabling long-term deployments of underwater robotic platforms in remote oceanic locations |
| State Aid | SA.49220 | Germany | | Richtlinie zur Förderung von Forschungs- und Entwicklungsvorhaben auf dem Gebiet „Autonome Roboter für Assistenzfunktionen - Interaktive Grundfertigkeiten" |
| State Aid | SA.49235 | Germany | | Richtlinie zur Förderung von Forschungs- und Entwicklungsvorhaben auf dem Gebiet „Autonome Roboter für Assistenzfunktionen - Interaktionsstrategien" |
| State Aid | SA.50037 | Germany | | Elektronik- und Sensorsysteme für neuartige Robotikanwendungen (SensoRob) |
| State Aid | SA.50936 | Netherlands | | NL_BZK_CSDO_GR Project Glasbesparend smeren: autonome smeerrobot voor energiebesparing in glasindustrie |
| State Aid | SA.51935 | Germany | | Richtlinie im Rahmen der Strategie der Bundesregierung zur Internationalisierung von Bildung, Wissenschaft und Forschung zur Förderung von Vorhaben der strategischen Projektförderung mit der Republik Korea unter der Beteiligung von Wirtschaft und Wissenschaft im Bereich Robotik |
| State Aid | SA.52593 | Germany | | Bekanntmachung „Robotische Systeme für die Pflege" |
| State Aid | SA.53690 | France | | Dispositif de déduction exceptionnelle en faveur des investissements de transformation numérique et de robotisation des PME industrielles. |
| State Aid | SA.54476 | Estonia | | Toetus digitaalsete tehnoloogiate, robotite ja automatiseerimise kasutamisele töötlevas tööstuses ning mäetööstuses |
| State Aid | SA.54979 | Netherlands | | NL_BZK_CSDO_ LB Field Lab Robotics Roermond |
| State Aid | SA.56521 | Germany | | Bekanntmachung „Roboter für Assistenzfunktionen: Interaktion in der Praxis" [BMBF] |
| State Aid | SA.56575 | Netherlands | | NL_BZK_CSDO_ LB Field Lab Robotics Roermond (DG Comp) |
| State Aid | SA.58906 | Germany | | Richtlinie zur Förderung von Vorhaben der strategischen Projektförderung mit Südkorea unter der Beteiligung von Wissenschaft und Wirtschaft („2 + 2"-Projekte) zu den Themen „Robotik" und „Leichtbau/Carbon" [BMBF] |
| State Aid | SA.60754 | France | | Dispositif de déduction exceptionnelle en faveur des investissements de transformation numérique et de robotisation des PME industrielles. |

*Figure 32: state aids table*

Most of these cases are related to interest rates as direct subsidies. Only two have dealt with tax advantages or exemptions, and both were established by France. These are a mechanism for exceptional deduction in favour of investments for digital transformation and robotization of industrial SMEs, currently active until the end of 2021 (SA.60754) and a similar previous one in force until the end of 2020, estimated in 3 million euro in 2019 (SA.53690).

[106] For instance, the ICT sector mainly benefits from State aid for broadband network development, for R&D and regional development. The Commission examines whether a market failure has occurred and whether aid is an appropriate way to address it; the aid is necessary and the aid is proportionate and kept to a minimum. https://ec.europa.eu/competition/sectors/ICT/overview_en.html

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

**SA.60754 Dispositif de déduction exceptionnelle en faveur des investissements de transformation numérique et de robotisation des PME industrielles.**

| | |
|---|---|
| **Member State:** | France |
| **Region:** | FRANCE |
| **Objective(s):** | Investment aid to SMEs (Art. 17) |
| **Aid instrument:** | Tax advantage or tax exemption |
| **Case Type:** | Scheme |
| **Duration:** | until 31.12.2021 |
| **Notification or Registration Date:** | 28.12.2020 |
| **DG Responsible:** | Competition DG |
| **Related Cases:** | SA.53690 |

*Figure 33: Tax aid description*

**SA.53690 Dispositif de déduction exceptionnelle en faveur des investissements de transformation numérique et de robotisation des PME industrielles.**

| | |
|---|---|
| **Member State:** | France |
| **Region:** | FRANCE |
| **Objective(s):** | Investment aid to SMEs (Art. 17) |
| **Aid instrument:** | Tax advantage or tax exemption |
| **Case Type:** | Scheme |
| **Duration:** | from 01.01.2019 to 31.12.2020 |
| **Notification or Registration Date:** | 11.03.2019 |
| **DG Responsible:** | Competition DG |
| **Expenditures (in Millions):** | 2019 : EUR 3 |
| | 2018 : EUR 0 |
| | 2017 : EUR 0 |
| | 2016 : EUR 0 |
| | 2015 : EUR 0 |
| | 2014 : EUR 0 |

*Figure 34: tax aid description*

The full text of these French rules is reproduced here, because it may serve as a useful example:

Article 39 decies B [Version in force on the 31st of March 2021]

“Creation LOI n°2018-1317 of 28 December 2018 - art. 55 (V)

I. - Small and medium-sized companies subject to corporate income tax or income tax under a real system may deduct from their taxable income an amount equal to 40% of the original value of assets entered in the fixed assets, excluding financial expenses, allocated to an industrial activity, when these assets fall into one of the following categories:

1° Robotic and cobotic equipment;

2° Additive manufacturing equipment;

3° Software used for design, manufacturing or transformation operations;

4° Integrated machines for intensive computing;

*This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 780073*

5° Physical sensors collecting data on the company's production site, its production line or its transitique system;

6° Production machines with programmable or numerical control;

7° Augmented reality and virtual reality equipment used for design, manufacturing or transformation operations.

The deduction is applicable to the goods mentioned in 1° to 7° acquired new as of January 1, 2019 and until December 31, 2020 that have been the subject of a firm order as of September 20, 2018. It also applies to the goods mentioned in the same 1° to 7° manufactured as of January 1, 2019 and until December 31, 2020 for which the management of the company has made the final decision to manufacture them as of September 20, 2018.

The deduction also applies to the goods mentioned in the said 1° to 7° acquired as new as of January 1, 2021, provided that they have been the subject as of January 1, 2019 and until December 31, 2020 of an order accompanied by the payment of installments of an amount at least equal to 10% of the total amount of the order and provided that this acquisition takes place within a period of twenty-four months as of the date of the order

The deduction is spread on a straight-line basis over the normal period of use of the goods. In the event of the sale of the asset or its allocation to a non-industrial activity before the end of this period, it is acquired by the company only up to the amount already deducted from the result on the date of the sale or the change of allocation, which is calculated pro rata temporis.

A small or medium-sized company that assigns to an industrial activity a new asset mentioned in the first paragraph of this I that has been leased under the conditions provided for in Article L. 313-7 of the Monetary and Financial Code, pursuant to a leasing contract or under a lease with a purchase option entered into as of January 1, 2019 and until December 31, 2020, may deduct an amount equal to 40% of the original value of the new asset, excluding financial expenses, at the time of signing the contract. This deduction is spread over the period mentioned in the eleventh paragraph of this I. If the lessee or tenant company acquires the asset, it may continue to apply the deduction. The deduction ceases as from the transfer or the cessation by it of the leasing contract or rental with option of purchase or of the good and cannot apply to the new operator.

The company which gives the good in leasing or in renting with option of purchase cannot practise the deduction mentioned in the first paragraph.

II. - For the application of I, the industrial activity is understood to be that which directly contributes to the manufacture or the transformation of movable tangible goods and for which the role of the material and the tooling is preponderant.

III. - This Article shall apply to small and medium-sized enterprises within the meaning of Annex I to Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty.

IV. - The benefit of the deduction is subject to compliance with Article 17 of the above-mentioned Commission Regulation (EU) No. 651/2014 of 17 June 2014".

In accordance with II of Article 55 of Law No. 2018-1317 of December 28, 2018 of Finance for 2019, these provisions apply to fiscal years ending on or after January 1, 2019[107].

[107] LAW No. 2018-1317 of December 28, 2018, for the 2019 budget.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

Article 39 decies B [Version previously in force after 1st January 2019]

Creation LOI n°2018-1317 of 28 December 2018 - art. 55 (V)

I. - Small and medium-sized companies subject to corporate income tax or income tax under a real system may deduct from their taxable income an amount equal to 40% of the original value of assets entered in the fixed assets, excluding financial expenses, allocated to an industrial activity, when these assets fall into one of the following categories:

1° Robotic and cobotic equipment;

2° Additive manufacturing equipment;

3° Software used for design, manufacturing or transformation operations;

4° Integrated machines for intensive computing;

5° Physical sensors collecting data on the company's production site, its production line or its transitique system;

6° Production machines with programmable or numerical control;

7° Augmented reality and virtual reality equipment used for design, manufacturing or transformation operations.

The deduction is applicable to the goods mentioned in 1° to 7° acquired new as of January 1, 2019 and until December 31, 2020 that have been the subject of a firm order as of September 20, 2018. It also applies to the goods mentioned in the same 1° to 7° manufactured as of January 1, 2019 and until December 31, 2020 for which the management of the company has made the final decision to manufacture them as of September 20, 2018.

The deduction also applies to the goods mentioned in the said 1° to 7° acquired as new as of January 1, 2021, provided that they have been the subject as of January 1, 2019 and until December 31, 2020 of an order accompanied by the payment of installments of an amount at least equal to 10% of the total amount of the order and provided that this acquisition takes place within a period of twenty-four months as of the date of the order.

The deduction is spread on a straight-line basis over the normal period of use of the goods. In the event of the sale of the asset or its allocation to a non-industrial activity before the end of this period, it is acquired by the company only up to the amount already deducted from the result on the date of the sale or the change of allocation, which is calculated pro rata temporis.

A small or medium-sized company that assigns to an industrial activity a new asset mentioned in the first paragraph of this I that has been leased under the conditions provided for in Article L. 313-7 of the Monetary and Financial Code, pursuant to a leasing contract or under a lease with a purchase option entered into as of January 1, 2019 and until December 31, 2020, may deduct an amount equal

---

Section 55

I. - Amended the following provisions:

- General Tax Code, CGI.

Art. 39 decies B

II.-I shall apply to financial years ending on or after 1 January 2019.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

to 40% of the original value of the new asset, excluding financial expenses, at the time of signing the contract. This deduction is spread over the period mentioned in the eleventh paragraph of this I. If the lessee or tenant company acquires the asset, it may continue to apply the deduction. The deduction ceases as from the transfer or the cessation by it of the leasing contract or rental with option of purchase or of the good and cannot apply to the new operator.

The company which gives the good in leasing or in renting with option of purchase cannot practice the deduction mentioned in the first paragraph.

II. - For the application of I, the industrial activity is understood to be that which directly contributes to the manufacture or the transformation of movable tangible goods and for which the role of the material and the tooling is preponderant.

III. - This Article shall apply to small and medium-sized enterprises within the meaning of Annex I to Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty.

IV. - The benefit of the deduction is subject to compliance with Article 17 of the above-mentioned Commission Regulation (EU) No. 651/2014 of 17 June 2014.

In accordance with II of Article 55 of Law No. 2018-1317 of December 28, 2018 of Finance for 2019, these provisions apply to fiscal years ending on or after January 1, 2019.

# 3. Public funding opportunities

## Public funding for Robotics in the EU.

The following section covers all the EU funding opportunities, in the field of robotics, found in the Research and Innovation Framework Programmes (H2020, Horizon Europe). In the preliminary version of this White Paper, Horizon 2020 was explained and analysed in detail in order to find Robotics-related funding opportunities. In this version, a section with the introduction of Horizon Europe[108], the next EU Research and Innovation programme, has been added to stay up to date with the latest funding opportunities. However, it is important to note that, to this date, Horizon Europe is not officially published since its approval was delayed due to the COVID19 crisis, therefore the information presented in this White Paper is still preliminary and was extracted from the circulated drafts of this programme.

Horizon Europe[1] is the EU's next funding programme for research and innovation. It will run from 2021 to 2027 with a proposed budget of €100 billion. The Horizon Europe programme for the period 2021-2027 is still pending for approval therefore its start is delayed, however, it is expected to launch during April 2021. The Horizon Europe programme for the period 2021-2027 will have a three-pillar structure (See figure 1). Actions in robotics are expected amongst the three different pillars. In addition to the three pillars, the new Horizon Europe also has five specifically identified missions which form an integral part of the programme. These research and innovation missions[109] aim to provide solutions to some of the biggest challenges that the world is currently facing. Each mission is a mandate to solve an urgent challenge in society within a given timeframe and budget. The five missions are: **1)** Adaptation to climate change, including societal transformation, **2)** Cancer, **3)** Healthy oceans, seas, coastal and inland waters, **4)** Climate-neutral and smart cities, **5)** Soil health and food. Robotics are expected to be a transversal subject throughout these missions and projects that include robotics to solve any of these challenges will be susceptible to apply for funding.

[108] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en
[109] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe_en#:~:text=EU%20Missions%20are%20a%20novelty,and%20the%20New%20European%20Bauhaus.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

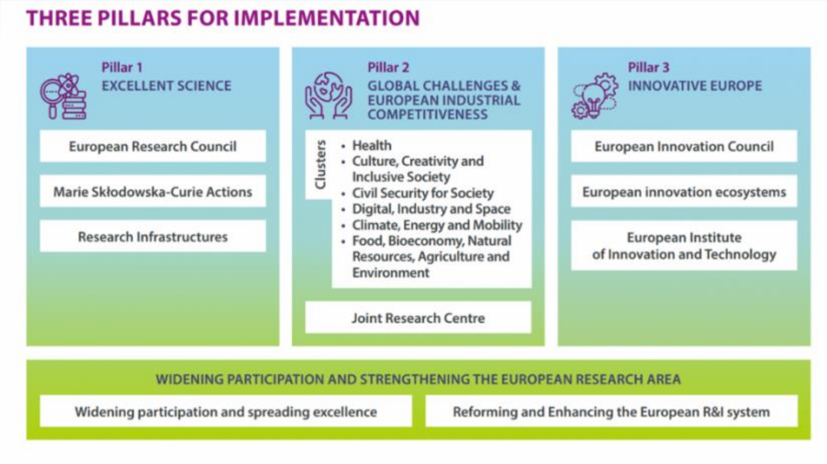



*Figure 35: Horizon Europe structure*

The following tables show a resume about some of robotics work programmes and calls included in Horizon Europe. All the **updated information can be found in the main online tool for searching any funding opportunities in the whole Horizon Europe Framework, which is the EC Funding and Tenders Portal[110]**.

| Cluster 1. Health[111] | | |
|---|---|---|
| **Destination 1. Staying health in a rapidly changing society** | | |
| **Work Programme: Staying healthy** | **Objectives** | **Achievements** |
| **HORIZON-HLTH-STAYHLTH-2022-01-two-stage-02: The Silver Deal: "A comprehensive engagement on the challenges of the ageing population"** | Assistive technologies for the variety of problems and challenges of demographic changes; Build enhanced understanding and knowledge; Provide new approaches for effective health services; Coordinate existing to facilitate mutual learning, to reduce the patchiness, to change ineffective patterns and to develop a more comprehensive, common policy approach for the benefit of our ageing society<br>Action type: RIA | Ensure integration of age-friendly, smart innovative solutions: connected wearables, ambient sensors, social robots, assistive technologies, diagnostic screenings, self-monitoring devices, robotics into the daily life of ageing population |
| **HORIZON-HLTH-STAYHLTH-2022-01-two-stage-04: AI tools to predict the risk for chronic diseases and/or their progression** | Validated disease risk algorithms; Robust, trustworthy and privacy-preserving AI; Evidence-base recommendations for the development of AI-based personalised prevention strategies for chronic diseases,; Quantitative indicators for the identification of chronic diseases progression<br>Action type: RIA | The AI tools may include a broad range of technological solutions on their own and/or in combination with other relevant state-of-the-art technologies (i.e., AI algorithms, mobile apps and sensors, robotics, e-health tools, telemedicine etc.) |
| **Destination 6. Maintaining an innovative, sustainable & globally competitive health industry** | | |

110 https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/home
111 https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-1-health_en

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

| Work programme: A competitive health-related industry | Objectives | Achievements |
|---|---|---|
| **HORIZON-HLTH-IND-2021-07-01: Green pharmaceuticals** | To help maintaining and bringing back pharmaceutical ingredients manufacturing process in the EU, while using the full potential of the climate transition and digitalization.<br>Action type: RIA | Explore innovative uses of digital transformation or robotic for competitive methods of production. |

| **Cluster 4. Digital, Industry and Space**[112] | | |
|---|---|---|
| **Destination 1. Climate neutral, circular and digitized production** | | |
| **Call Identifier** | **Objectives** | **Achievements** |
| **HORIZON- CL4-2021-TWIN-TRANSITION-01-01: AI enhanced robotics systems for smart manufacturing** | To strengthen the capacity of EU to manufacture and re-manufacture goods in a sustainable and competitive way to be ready to expand into new value chains. Importance focused on resilient, flexible, reconfigurable and responsive data-driven manufacturing lines.<br><br>Action type: IA | To seize the opportunities arising from the latest SoA in AI and robotics to deploy intelligent and autonomous systems for flexible production. To enhance collaborative robotics systems in order to develop advanced smart manufacturing human-machine collaborative systems ensuring safe physical and social interactions and efficient collaboration with human workers. |
| **Destination 4. Digital and emerging technologies for competitiveness and fit for the green deal** | | |
| **Call Identifier** | **Objectives** | **Achievements** |
| **HORIZON-CL4-2021-DIGITAL-EMERGING-01-09: AI, Data and Robotics for the Green Deal** | Develop innovative AI, data and robotics solutions for resource optimization and minimization of waste in any type of sector. To optimize AI, data and robotics to maximise contribution of the Green Deal in various applications. To develop advanced physical intelligence and physical performance of robotics solutions in diverse harsh environments serving the Green Deal.<br><br>Action type: IA | To integrate and optimize AI, data and robotics solutions in order to demonstrate, by addressing use-cases scenarios in actual or highly realistic operating environments, how they can directly contribute to the Green Deal. |
| **HORIZON-CL4-2021-DIGITAL-EMERGING-01-10: AI, Data and Robotics at work** | To contribute to a new human-centred paradigm to keep people away from unsafe and unhealthy jobs via collaborative embodied (physical) AI, engaging and empowering end-users and workers. To contribute to Human-centric AI supporting professionals in trustworthy hybrid decision-making and optimising their tasks. | To demonstrate how AI, data, robotics and automation solutions can support workers in their daily tasks, improving working conditions and work performance/efficiency, while considering safety, security and resilience, as appropriate. |

[112] https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-4-digital-industry-and-space_en

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

| | | |
|---|---|---|
| | Action type: IA | |
| **HORIZON-CL4-2021-DIGITAL-EMERGING-01-11: Pushing the limit of robotics cognition** | To contribute to the new generation of AI-Powered Robotics: Enabling robots to have ore profound impacts than they currently have, in powering them with a deeper kid of AI, endowing them with a better perception and understanding of the world. This would allow the next generation of autonomous robots, with increased capabilities to work without/with limited supervision, as well as the next generation of interactive robots, with greatly improved intuitive, safe and efficient cognitive, social and physical capabilities, to assist humans.<br><br>Action type: RIA | To develop technologies and systems that significantly enhance the cognitive ability of robots from the current SoA to achieve greater levers of interaction and autonomy. |
| **HORIZON-CL4-2021-DIGITAL-EMERGING-01-12: European Network of Excellence Centres in Robotics.** | To contribute to scientific and technology advances in the major robotics challenges hampering its deployment and to a strong an tightly networked European research community in robotics, making it a world-class powerhouse for robotics excellence.<br><br>Action type: RIA | To ensure European strategic autonomy in robotics, with huge potential socio-economic impact, it is essential to reinforce and build on Europe's assets. To develop mechanisms to reinforce and network excellence centers in AI-powered robotics, bringing the best scientists from academia and industry to join forces in addressing the major robotics challenges hampering its deployment, and to reinforce excellence in robotics throughout Europe via a network of collaboration that focuses research excellence on future industrial needs. |
| **HORIZON-CL4-2022-DIGITAL-EMERGING-01-05: AI, Data and Robotics for Industry optimization (including production and services (IA)** | To contribute to advancing AI, data and robotics, and automation for the optimisation of production and services value-chains, optimisation of products, services, processes, to increase competitiveness, working conditions, and environmental sustainability, and supporting to EU economy using AI, data and robotics technologies.<br><br>Action type: IA | To integrate and optimize AI, data and robotics solutions in order to demonstrate, by addressing use-cases scenarios in actual or highly realistic operating environments, how they optimize production and service use cases. Special focus in Industry-empowering AI, data and robotics. |
| **HORIZON-CL4-2022-DIGITAL-EMERGING-01-07: Increased robotics capabilities demonstrated in key sectors** | To develop demonstrators able to show the added value of robotics and their performances in addressing challenges in major application sectors, or in dangerous, dull, dirty tasks or those strenuous for humans or in extreme environments.<br><br>Action type: IA | |
| **Destination 6. A human-centred and ethical development of digital and industrial technologies** | | |
| **Call Identifier** | **Objectives** | **Achievements** |
| **HORIZON-CL4-2021-HUMAN-01-02: European coordination, awareness, standardisation & adoption of trustworthy European AI, Data and Robotics** | To contribute to efficient AI, Data and Robotics Public-Private Partnershop supporting the community and the implementation of the SRIDA. To contribute to reinforced links among initiatives in AI, Data and Robotics in H2020, HE, DEP. To widespread educational and outreach programmes. Contribute to an increased adoption of AI technologies and increase adoption of trustworthy AI, data and | To support the PPP on AI, Data and Robotics to develop a strong and inclusive network bringing academia, industry, and public and industry users, including the major industrial sectors and all relevant stakeholders, to guarantee strong coordinated efforts towards trustworthy AI. To coordinate and establish links with all relevant initiatives in AI, Data and Robotics in H2020, DE, DEP and other programmes. To support and encourage the adoption of AI. To |

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

| | | |
|---|---|---|
| | robotics in procurement both public and private. Contribute to standardisation methods for trustworthy and ethical AI to foster AI, data and robotics industry, and in support of the EC regulatory framework.<br><br>Action type: CSA | widespread educations and outreach programmes including public awareness and addressing acceptability and trustworthiness. To investigate and promote the potential contribution of AI, data and robotics to social welfare and sustainability, promote their adoption and support to standardisation and in support of the EU regulatory framework, fostering vast deployment of AI-based solutions. |
| **Cluster 5. Climate, Energy and Mobility**[113] | | |
| **Destination 2. Cross-sectorial solutions for the climate transition** | | |
| **Call Identifier** | **Objectives** | **Achievements** |
| **C5-D2-BAT-06-2022: Furthering the development of a materials acceleration platform for sustainable batteries** | Autonomous synthesis robotics and orchestration software: The transition from low/no automated robotics for the synthesis of battery materials requires several R&I steps towards fully autonomous systems<br>RIA Action | Demonstrate a robotic system that is capable of material synthesis for inorganic, organic or hybrid compounds. Activities are expected to achieve TRL3-4 |
| **Destination 3. Sustainable, secure and competitive energy supply 2021-2024** | | |
| **Call Identifier** | **Objectives** | **Achievements** |
| **C5-D4-BEE-02-2021: Industrialization of deep renovation workflows for energy-efficient buildings** | Investigate the use of robotic systems and automation to augment workers' capability and safety (e.g., lift robots, exoskeletons) for deep renovation) | Upskilled workforce for industrialized renovation workflows, including automated and robotized construction / renovation. Enhanced safety of the construction workforce and increased acceptance of robotic support for deep renovation.<br>Activities are expected to achieve TRL8 |

In parallel to Horizon Europe, it is of utter importance to talk about **Next Generation EU[114].** On 21 July 2020, after four days of negotiation, the European Council agreed to a massive recovery fund of 750 billion € branded Next Generation EU (NGEU), which will be running from 2021-2023, in order to support member states, hit by the COVID-19 pandemic. It is expected that funding opportunities as form of grants and loans will be given to the field Robotics with applications in Health sector and Digital transformation, which will be application domains of the pillars of the programme. It is highly recommended for interested beneficiaries to keep up with the programme publication, which is still at very early stages and provisional. **All the relevant information about Next Generation EU[115] can be found in the main online tool of the EC for giving information about this huge initiative.** It is also very important to note that each EU country provides information about all the interesting opportunities and funding opportunities within this initiative through their correspondent Ministries

113 https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-5-climate-energy-and-mobility_en
114 https://europa.eu/next-generation-eu/index_en
115 https://ec.europa.eu/info/strategy/recovery-plan-europe_en

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

and their national COVID-19 recovery plans. However, all the information can be found in the central online tool mentioned above.

## Impact of public funding at a European level on Interactive Robotics

This section of the White Paper aims at providing to the reader a global picture of the impact that public funding has had at a European level in the field of Robotics and, more specifically, on Interactive Robotics. Data from the two latest finalized Europe's Research and Innovation Programmes: FP7 Framework Programme (2007-2013) and Horizon 2020 (2014-2020), was gathered and studied to extract relevant information about the impact of funding in the field of robotics and how much money was destined to robotics as well as the trends and the impact on robotics SMEs.

### Data collection

For the purposes of this project, an extensive investigation was made around the public funding opportunities received by R&D projects in the field of Robotics in the most recent years. This research has been mainly supported by online data gathering and collection of information about projects funded by the European Union during the H2020 Framework Programme (2014-2020) and its predecessor, FP7 Framework Programme (2007-2013). This data collection could not have been possible without the help of the Community Research and Development Information Service (CORDIS), which has been the primary and official source of results from the projects funded by the EU's framework programmes for research and innovation (FP1 to Horizon 2020). The followed methodology for gathering data consisted in searching all the projects that received funding in the field of Robotics, and then narrowing the list by reading the project summary to Interactive Robotics projects only. It is important to note, that in order to give a global picture of the impact of funding, both physical and cognitive robotics have been considered in all application fields (e.g. industrial collaborative, health, exoskeletons, AI, VR, Industry 4.0, etc.).This aspect of considering all the application fields was made to provide to the reader a broader view of the current funding situation. As a result of this research within CORDIS database, 339 projects on Interactive Robotics funded under FP7 and H2020 programmes have been identified. In the case of FP7 programme, it has been identified a total of 175 projects with coordinators from 19 different countries and with an accumulated budget of 950.8 million euros, which received around 706.7 million euros in funding. This represents and average funding of 4.04 million euros per project (Figure 36).

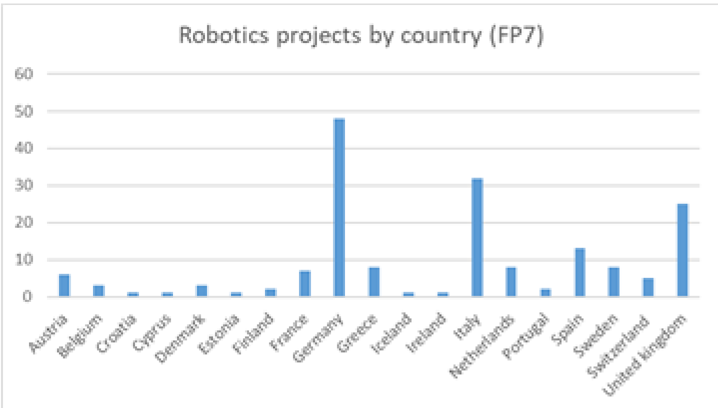



*Figure 36: Identified FP7-funded projects on Robotics sorted by country of coordinator.*

With regards to H2020 programme, a total of 164 projects have been identified, with coordinators from 25 different countries and an accumulated budget of 611.7 million euros (Figure 37). These projects received in total a funding of 571.4 million euros, which supposes a relative funding of 93.4 % and an average funding per project of 3.48 million euros per project.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

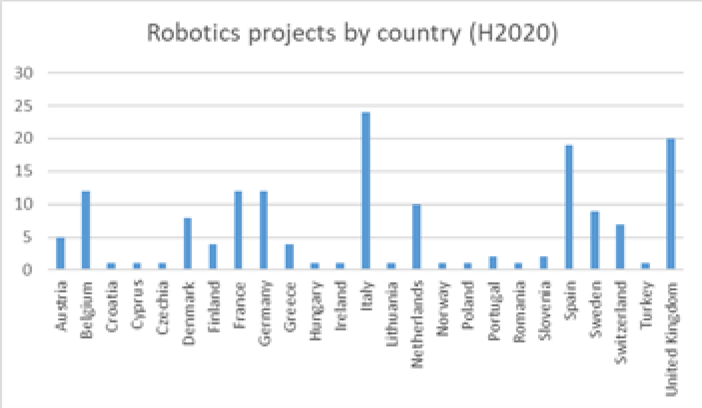



*Figure 37: Identified H2020-funded projects on Robotics sorted by country of coordinator.*

Further detail and analysis about the collected data for these projects is explained in Data Analysis and statistics section.

## Investigation of the relationship between public funding and development of SMEs in the field of Interactive Robotics

According to the evidence proceeding from the collected data, and from several independent research, direct subsidies used alone or with tax incentives strengthen the R&D orientation of the SME as well as some aspects of innovation output and absorptive capacity. Moreover, subsidies seem to be the best instrument in order to contribute to the success of SMEs[116]. Many researchers agree with the fact that public R&D subsidies have a strong crowding-out effect on private investment and real effects on private innovations[117,118,119]..

Some studies reject full crowding-out effects but also conclude that subsidies increase innovation output, but the effect depends on firm size [120,121]. The results suggest that subsidies have a positive impact on innovation output and in the long term on employment [122].. Czarnitzki and Licht (2006)[123] find that firms which receive direct R&D subsidies spend more on innovation and R&D, and that direct subsidies influence firms' patenting activities in a positive way. Moreover, studies show that subsidies can have not only a positive impact on the breadth of innovation but also lead to changes

[116] Radas, Sonja & Anic, Damir & Tafro, Azra & Wagner, Vanja. (2014). The effects of public support schemes on small and medium enterprises. Technovation. 38. 10.1016/j.technovation.2014.08.002.
[117] Trigkas M., Andreopoulou Z., Papadopoulos I. (2015). Public funding and SME's;; investigating factors determining R&D and environmental projects at firm level
[118] Busom, I. (1999) An Empirical Evaluation of the Effects of R&D Subsidies, Working Paper No. B99-05, Berkeley: Burch Center, University of California.
[119] Hussinger, K. (2003) R&D and Subsidies at the Firm Level: An Application of Parametric and Semi-Parametric Two-Step Selection Models, Discussion Paper No. 03-63. Mannheim: Centre for European Economic Research (ZEW).
[120] Reinkowski,J.,Björn,A.,Mitze, T. and Untiedt, G. (2010) Effectiveness of Public R&D Subsidies in East Germany: Is it a Matter of Firm Size?, Ruhr Economic Papers, 204.
[121] Herrera, L. and Sánchez-González, G. (2013) Firm Size and Innovation Policy. International Small Business Journal, vol 31, no. 2, pp. 137-155.
[122] Lehto, E. (2000) Regional Impacts of R&D and Public R&D Funding,Labour Institute for Economic Research Studies No. 79. Helsinki.
[123] Czarnitzki, D. and Licht. (2006). Additionally of public R&D Grants in a Transition Economy: The Case of Eastern German, Econ. Transition, vol 14, no.1, pp.101-131.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

in the technological and business strategies of the firm[124,125,126]; Conclusions suggest that these effects are especially notable for SMEs, given their usually higher structural difficulties in securing their financing needs compared to large firms[127,128,129];. Logically, this effect is also particularly notable in Robotics SMEs, given the nature of their activities, fundamentally based on R&D and innovation, for which public funding plays a strong support.

From the 339 different projects on Interactive Robotics that have been identified during INBOTS project to be funded under FP7 or H2020 EU programmes, 56 projects were coordinated by private for-profit entities (13 projects in FP7 and 43 in H2020), which represents 16.5 % of the total. The majority of these projects were coordinated by big companies.

In conclusion, it is important to highlight that the European Commission is giving more importance to the growth of European SMEs and their sustainability. This change of paradigm has been translated in many funding opportunities directly devoted to SMEs during H2020 and the continuation of many of these programmes in Horizon Europe. The priority of the European Commission to ensure the growth of European SMEs may be seen in most topics and new calls for funding, where the presence of SMEs in the consortiums is mandatory. This has been translated in a very relevant and increasing presence of SMEs as part of the consortiums in projects funded by FP7 or H2020 programmes (coordinated by any kind of entity), not only in small consortiums but also in big ones. For instance, SMART project (Grant agreement ID: 860108) has a consortium made of seven partners, from which there is one SME (Suprapolix BV) and one private research organisation (Polymer Competence Center Leoben Gmbh). Presence in public-funded R&D projects has resulted for SME participants in the opening of new commercial paths, the strengthening of their brand-name, and the possibility of developing and fostering their innovative activities.The most important funding scheme for small and medium enterprises from FP7 and H2020 programmes has been SME Instrument, introduced by the European Commission in 2014. It was designed to alleviate financial constraints which can limit the development and growth of smaller and younger innovative firms, by supporting businesses with high-growth potential in need of external finance.

In total, from all the identified projects on Interactive Robotics, 25 projects from 20 different participants have been funded by this scheme (13.6 million euros). The high ratio of European financing for these projects (70%) shows to have been an important asset to success of SME participants, since 7 projects reached the second phase of the programme, designed for the execution of innovation projects which have previously proven their concept and feasibility in phase 1. Some Interactive Robotics companies that benefited from this funding scheme are The Kobi Company (BRAIN, ID: 859711), GLEECHI AB (VirtualGrasp, ID: 829467) and Robo Technologies GMBH (Robo Wunderkind, ID: 961665), which are examples of companies that have surpassed the valley of death after receiving public funding from this programme and continue operating in 2021. At the close of 2019, The Kobi Company had 7 employees and received about 480 hundred dollars

[124] Buisseret, J., Cameron, M and Georghiou, L. (1995). What Difference Does It Make? Additionally in the Public Support of R&D in Large Firms, International Journal of Technology Management, vol. 10, no`s. 4/5/6,pp.

[125] Clarysse, B., Wright, M. and Mustar, P. (2009). Behavioral Additionally of R&D Subsidies: A Learning Perspective. Research Policy, vol. 38, pp.1517-1533.

[126] Hsu, Fang-Ming, Horng, Der-Juinn, Hsueh, C. (2009). The effect of Government-Sponsored R&D Programmes on Additionally in Recipient firms in Taiwan, Technovation, vol 29.no. 3, pp. 204-217.

[127] Gregory, T., Rutherford, M., Oswald, S. and Gardiner.L. (2005). An empirical Investigation of the Growth Cycle Theory of small Firm Financing. Journal of Small Business Management, vol.43, no. 4, pp 382-393.

[128] Vos, E., A. Jia-YuhYeh, Carter, S and Tagg, T. (2007). The Happy Story of Small Business Financing. Journal of Baking and Finance, vol.31, pp, 2648-2672.

[129] Trigkas, Marios & Andreopoulou, Zacharoula & Papadopoulos, Ioannis. (2015). Public funding and SME's;; investigating factors determining R&D and environmental projects at firm level.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

in sales[130], GLEECHI AB had a turnover of 1.2 million euros[131] and Robo Technologies GMBH had 22 employees and a revenue of almost 4 million euros[132].

Moreover, the success of of SME Instrument can be noticed when analysing the general evolution of all these 20 Robotics companies that participated in the SME Instrument (Figure 38): all of them except one are still alive and continue their R&D initiatives, in some cases still with their respective SME Instrument projects and in others with new own initiatives.

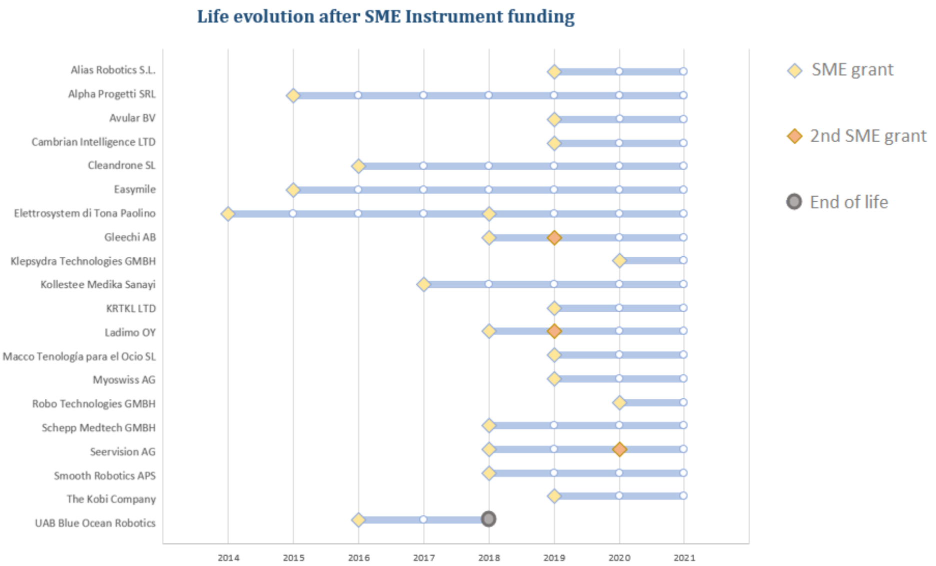



*Figure 38: Life evolution of SME Instrument funded companies after receiving the grant.*

In conclusion, public funding initiatives, and more particularly, specific programmes such as SME Instrument, which will evolve to EIC Accelerator in Horizon Europe 2021-2027, have demonstrated the potential of public participation to contribute for SME success, allowing their growth and development and reducing their financial constraints in order to help or fully permit their innovative projects, which otherwise may have not been feasible.

## Data analysis and statistics

As previously explained, 339 projects on Interactive Robotics which have been funded by the European Commission (within FP7 and H2020 programmes) have been identified. This sums an accumulated investment in Robotics initiatives between 2007 and 2020 of almost 1,562.5 million euros, from which almost 1,278.1 million euros come from European public funding, which reflects the commitment of the European Union with this area of research.

### FP7-funded projects (2007-2013)

A total of 175 projects on Robotics have been identified during this programme. With a total induced investment of 950.8 million euros and a public funding of 706.7 million euros, European contribution represents 74.3 % of the budget for these projects. This is, European funding during this period covered almost three quarters of the costs of these projects, which otherwise may have not been possible from an exclusively private investment point of view. It can be then assumed that public

[130] https://www.dnb.com/business-directory/company-profiles.the_kobi_company.093a9660ddaaa5765c4cee467816fad2.html#:~:text=The%20Kobi%20Company%20has%207,%24480%2C242%20in%20sales%20(USD).
[131] https://rocketreach.co/gleechi-ab-profile_b5f04988f69057f0
[132] https://www.zoominfo.com/c/robo-technologies-inc/363201379

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

investment has played a relevant part in fostering the development of complex projects on Interactive Robotics.

Collaborative projects stand out as the most preferred type of projects within this period (Figure 39), since 163 of the identified projects run under this funding scheme, which represent 93.1% of the proposals. Second place corresponds to Coordination and Support Action projects, with a total of 6 proposals.


*Figure 39:Robotics projects during FP7 programme by funding scheme.*

Regarding the type of participants, only 4 projects are individual (6.03 M€), being the rest projects executed in consortium. Apart from coordinators, a total of 1452 partners have participated in the identified projects during this period (an important part of them collaborate in several projects). This means that, on average, 8.3 partners work together for the success of European FP7 funded projects.

About the coordinators for European projects on Robotics, several institutions of different nature and origin have taken part in the programme, Figure 40. Higher or Secondary Education Establishments (mainly universities) are the most common coordinators (113), followed by Research Organisations (44), which is a clear reflect of the innovative character of European funded projects and its bid for research and innovation in Robotics. This can also be seen in the average duration of these projects, which is almost 42 months (41.93).

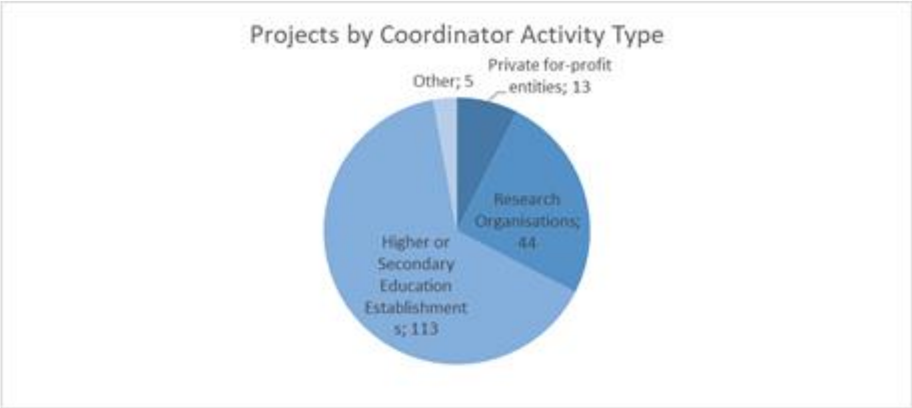



*Figure 40: Robotics projects during FP7 programme by coordinator activity type.*

Entities from 19 different countries have coordinated EU funded projects on Robotics during FP7 programme. Germany (48), Italy (32) and United Kingdom (25) stand out as the most prolific countries during this period with regards to project coordination presences. It is also remarkable the fact that in 6 projects, the coordinator was from a country outside of the European Union (Iceland, 1 project; Switzerland, 5 projects).

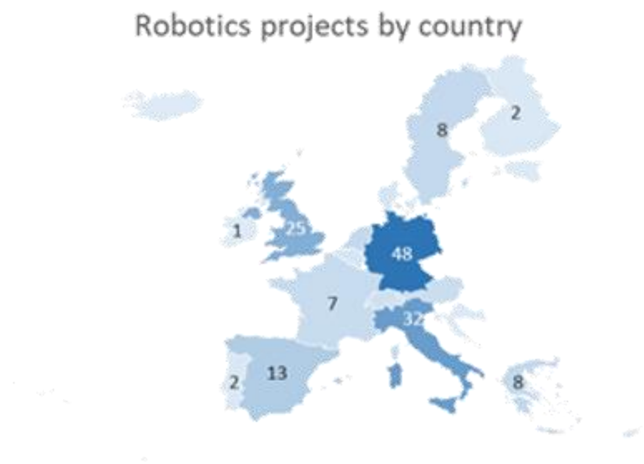



*Figure 41: Robotics projects during FP7 programme by country of project coordinator.*

### H2020-funded projects (2014-2020)

H2020 continues the path started with FP7 and thus the conclusions made for this programme follow the natural evolution for the ones that have just been exposed.

A total of 164 projects on Robotics have been identified during H2020 programme. An accumulated investment of 611.7 million euros was made, from which a total public funding of 571.4 million euros was distributed. Although this could seem as less support by H2020 to research on the field of Robotics in comparison to FP7, this cannot be stated, since this lower absolute contribution for Robotics projects was compensated by a huge increase in the percentage of public participation, which escalated to an outstanding 93.4 %. This is, although the absolute public funding has been lower than in the previous programme, the great growth in the relative funding allows to consider that EU's commitment to Robotics investigation remains strong and will continue in this way in the following years.

In order to evaluate and analyse the collected data for H2020 Robotics projects, these have been divided into three groups: i) main projects (RIA, IA, CSA and ERC); ii) SME projects (SME-1 and SME-2); and iii) MSCA projects (all types) and others. This is because the projects from the first group tend to have considerably higher budgets, consortiums and lengths than the other two (Figure 42). The following conclusions focus on group i), but a brief conclusion for the rest is also provided: A total of 119 projects from group i) have been identified, with a total budget of 562 million euros and an EU public funding of 527.6 million euros (93.9%). From these, Research and Innovation Action (69) stands out as the most common type of project during this period, followed by Innovation Action projects (31). European Research Council (10) and Coordination and Support Action (9) projects appear in a lower position.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

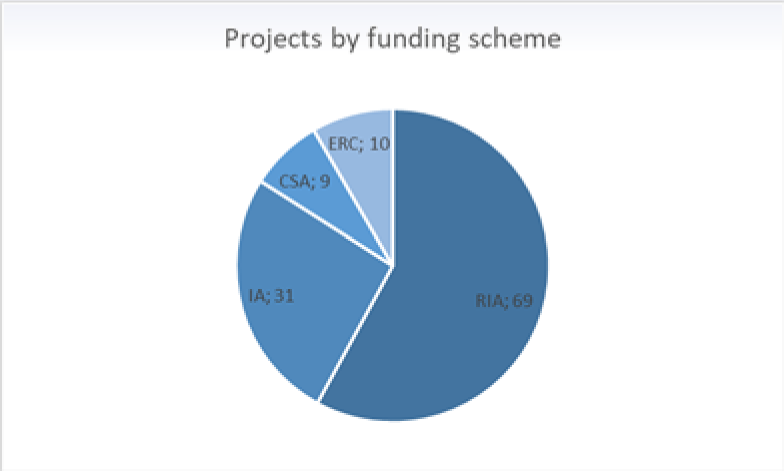



*Figure 42: Robotics projects during H2020 programme by funding scheme (RIA, IA, CSA and ERC).*

With regards to the type of participants, only 3 projects are individual (2.34 M€), being the rest of the projects executed in consortium. 827 partners have participated in these projects in collaboration with different coordinators (as in FP7 programme, some partners participate in several projects during H2020 period). A typical consortium for a H2020 Robotics project will be formed by a coordinator and 7.3 partners, on average.

As in the previous programme, in H2020 Higher or Secondary Education Establishments remain as the most common coordinators (69), mainly being universities, followed again by Research Organisations (28). This proportion is very similar to the one that has been exposed for FP7 projects. The same happens with the duration of these projects, with an average of 43 months (43.36), which is slightly higher (Figure 43).


*Figure 43: Robotics projects during H2020 programme by coordinator activity type (RIA, IA, CSA and ERC).*

In H2020, coordinators origin is more compensated than in the FP7 programme: Italy is the first in the number of project coordinators (20), closely followed by Spain (15), United Kingdom (14) and Germany (12), Figure 44. As before, it is remarkable the presence of 4 projects coordinated by non-EU members (Norway, 1 project; Switzerland, 3 projects).

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

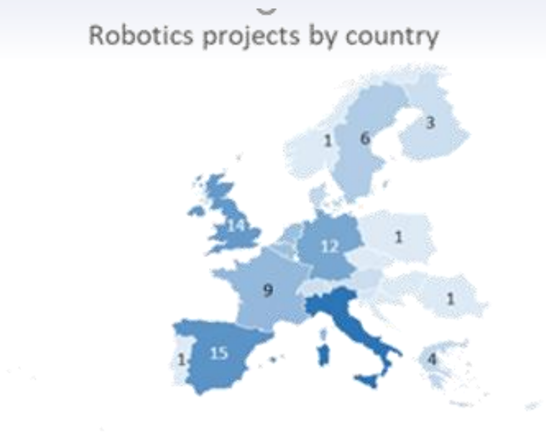



*Figure 44: Robotics projects during H2020 programme by country of project coordinator (RIA, IA, CSA and ERC).*

About the group ii), SME projects, a total of 25 funded proposals have been identified, as mentioned in the previous section. These individual projects, developed by private for-profit entities, have resulted in a total investment of 19.4 million euros, with a total EU public funding contribution of 13.4 million euros (70%). Although SME Instrument phase 1 provided only 50.000 euros of funding, this amount increased remarkably for projects which passed to phase 2, where the average budget was of 2.27 million euros (average EU funding of 1.59 million euros). A total of 7 projects passed to SME phase 2, which shows the potential of public funding to the success of innovative SME. Although the origin of the participants in these projects is very diverse, it is notable the presence of entities from two countries out of the EU: one SME-1 project from Turkey (FUE-Robotic System), and three coming from Switzerland, one of it reaching phase 2 (Multi RoboDOP).

Finally, it is worth mentioning the role of the Marie Skłodowska-Curie Actions (MSCA) projects identified during the H2020 period, which sum up to 20 funded projects. These projects, which intended to provide for all stages of researchers' careers - be they doctoral candidates or highly experienced researchers - and to encourage transnational, intersectoral and interdisciplinary mobility, have resulted in a total budget of 30.3 million euros and a funding of 30.2 million (almost 100 %). Coming from very diverse countries, three different durations have been identified for these projects: 24, 36 or 48 months.

## Conclusion and future trends

Robotics was particularly active in H2020 scope with around €700 million in financial investments from the European Commission under H2020 which was complemented by SPARC initiatives up to 2.8 billion euros. More than 100 innovative projects related to robotics have been funded through European Union's Horizon 2020 programme. Most projects address one or more of these 4 main areas: Healthcare, Inspection and maintenance of infrastructure, Agriculture-food, Agile production, which shows the potential of this cutting-edge technology. As a summary of H2020 achievements related to robotics, the next figure shows the net EU contribution by country. According to the data (Figure 45), Germany is the country with the highest EU contribution and the highest participation in H2020 (more than 146 German entities participated, as a partners o coordinator, in topics related to robotics), followed by Italy, France, Netherlands and Spain. More than 100 robotics grants have been signed during H2020. These results have been impacted directly in the business growth of over 900 European entities. This is particularly significant given the high density of SMEs working at the leading edge of robotics technology in Europe.

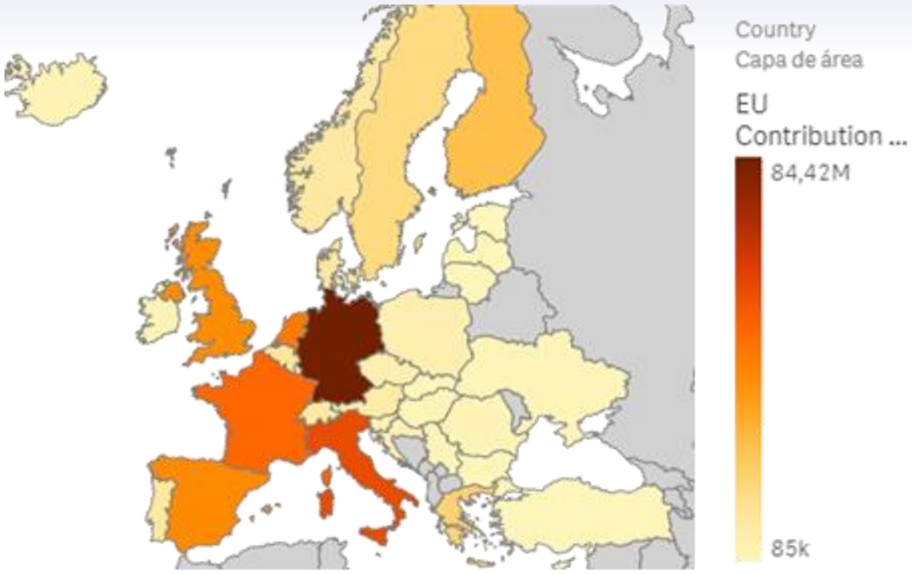



*Figure 45: Net EU contribution by country. Source: Horizon Dashboard.*

Horizon Europe, is the EU's next funding programme for research and innovation. It will run from 2021 to 2027 with a proposed budget of €100 billion. The new programme has stablished a new cross-sectoral cluster approach. 6 different clusters have been defined operated in a great number of intervention areas. The new groups are:

- Cluster 1. Health
- Cluster 2. Culture, creativity and inclusive society
- Cluster 3. Civil security for society
- Cluster 4. Digital, Industry and space
- Cluster 5. Climate, Energy and Mobility
- Cluster 6. Food, bioeconomy, natural resources, agriculture and environment.

As mentioned above, robotics is a multidisciplinary science which can be useful in any of the previous Horizon Europe clusters. Nevertheless, 'Digital, Industry and Space' group is more focused on the Europe digital transformation, consequently, robotics has a stronger impact on that.

### Identified barriers and gaps

The evolution of robotic research is a direct response to the evolution of human social needs. Over years, robots have been implemented in industrial tasks as well as service labours to assist human beings. New trends in robotics research have been denominated interactive robotics because of their general goal of getting robots closer to human social needs[133]. These new uses are more focus on the interaction between human and robots. In the last decades, the development of interactive robots has progressed significantly, however, some kinds of barriers and gaps could be identified.

- Societal and culture barriers. A recent study led by Naneva et.al.[134] suggested that people generally have positive attitudes towards social robots and are willing to interact with them. However, there is also a growing awareness of the ethical, legal and societal impact of robotics. The use of robots within healthcare and other fields that are traditionally dominated by humans

[133] Garcia, E., Jimenez, M. A., De Santos, P. G., & Armada, M. (2007). The evolution of robotics research. IEEE Robotics & Automation Magazine, 14(1), 90-103.

[134] Stanislava, N., Sarda, G. M., Webb, T. L., & Prescott, T. J. (2020). A systematic review of attitudes, anxiety, acceptance, and trust towards social robots. *International Journal of Social Robotics*, *12*(6), 1179-1201.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

generates negative attitudes towards the use of interactive robots. Additionally, the different work cultures between countries also play an important role as a barrier to implement robots. Robotics knowledge should be spread into society so as to defeat these cultural barriers. Training needs to be provided for learning of new skills (such as programming) and outside upgrading of skills[135].

- Regulation barriers. Due to this awareness growth, a new generation of ethical standards in robotics and AI is emerging. However, robotic regulation has not yet consolidated which generates important gaps and barriers regarding legislation issues. Regulations about product safety of robots have been pointed out as the most challenging barrier to market penetration. Likewise, different regulatory barriers can be expected depending on the main domain[136]:

- Deviation of regulation. Different regulation policies between European countries and other countries.

    2. Unclear boundaries: The lack of knowledge about what regulation should be applied can lead to legal uncertainty and risks.

    3. Missing regulation: The development of a cutting-edge technology, such as social robots, is associated with gaps in standards and laws.

- Financing barriers. The development of robotics and its implementation in the industry can incur a high capital cost. In addition, a substantial financial commitment for the required investment in R&D is also needed. Not only more public and private investments necessary to bring robots to workplaces and general life, but new business models and approaches as well. However, these investments could be high risk in some cases, and finding business angels to invest in robotics is a problem. In this case, European grants are essential to make progress in this research area.

## Future Trends in Robotics

A new robotic revolution is starting. Nowadays, systems can physically interact with the world and assists with daily tasks, work, and leisure activities. The “old” robot systems were largely mechanical support systems. Through the gradual availability of inexpensive computing, user interfaces, and sensors it is possible to build robot systems that were difficult to imagine before. The confluence of technologies is enabling a revolution in use and adoption of robot technologies for all aspects of daily life[137].

The maturity of techniques on AI and mechanical engineering will result in a growth of application on robotics.

- Healthcare: As a result, there is a booming trend in robots humanization. Humanoid robots can be used in several scenarios to healthcare as medical surgery, to pain relief by distracting children’s attention, to help disabled and aged people to complete the tasks they cannot do by themselves, to transfer patients from bed to wheelchair.

- Manufacturing: next generation robotics will enable shorter production run, factories, higher productivity, collaborative robots (cobots).

[135] Mahbub, R., (2008). An investigation into the barriers to the implementation of automation and robotics technologies in the construction industry

[136] Jacobs, T. (2017). Report on regulatory barriers. RockEU 2 Robotics Coordination Action for Europe Two

[137] A Roadmap for US Robotics. From Internet to Robotics. 2020 Edition

*This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 780073*

- Logistics and e-commerce: universal picking for robots, robots for retail front-of-store operations like monitoring and re-stocking shelves.

- Transportation: Future autonomous vehicle transport could drastically improve mobility for children and for elderly and handicapped persons who are currently dependent upon human assistance. Robotic technologies that will drive the future development of near-autonomous and autonomous vehicles include better sensing and perception, especially under bad weather and hazardous conditions.

- Agri-food industry: crops monitoring, data collection, herbicides application, milking robots, process meat automatization.

Over the last year, the COVID-19 has changed our lives. COVID exposed a number of opportunities for robotics from cleaning/disinfection over e-commerce to manufacturing and transportation. Robots are primarily designed to empower people to do things better, in some cases in terms of accuracy in other cases as power or sensory extensions, and access. In the aftermath of the 2009 recession adoption of robotics grew significantly. In a post-COVID world new behaviour patterns for social interaction, cleaning, collaboration, and delivery will be seen. There are thus many new opportunities for utilization of robot technology to enhance many of everyday life activities[138].

[138] A Roadmap for US Robotics. From Internet to Robotics. 2020 Edition

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 8.Summary of the white paper

As highlighted in the executive summary and along all the sections, this document has been conceived to collect different types of information in four specific fields of the Interactive Robotics:

- Wearable Robots (WRs)
- Humanoid Service Robots(HUM).
- Industrial Collaborative Robots (IndCOBOTs)
- Surgical Collaborative Robots (SurgCOBOTs)

Particularly, the document highlights some guidelines found during interviews with experienced entrepreneurs (i.e. founders of companies or long-time members) and provide an overview of the current situation in terms of companies operating in those specific sectors. In addition, it has been provided a summary of the main funding opportunities, both in private and public sectors, and the IPR strategies adopted by SMEs.

For the sake of clarity, the main outcomes of the document are reported hereafter.

- IR field is a very attractive and promising market (a lot of new companies have been founded in the last ten years, considering all the four fields) that, however, presents some barriers highlighted by interviews carried out to the real actors of the market (i.e. the founders of the companies). In particular, as defined shown in section 3, most of them identified as the "most critical element for the growing of a company" the limited acceptance of new technologies by stakeholders. In the second position, entrepreneurs highlighted the difficulty in creating a working team with a business-oriented mindset as well as well motivated. On the other hand, considering the "Barriers to the creation/growing of SME companies", interviewees indicated as the most voted as the fundraising issues/identification of the proper business model. In the second position, again the limited acceptance of new technologies by stakeholders.
- Section 4 defined KPIs suitable to evaluate the evolution of the four interactive robotics sectors the consortium has defined. Indeed, after the collection of the main projects goals in relation with the desired project impact, a list of eleven KPIs needed to evaluate the sector has been provided. The challenges related to the collection of the data necessary for the calculation of all the KPIs has been presented dividing the KPIs in three different categories according to the challenge encountered in their calculation (data collection issues, time consuming, no collection issues). The list of the final six KPIs used to monitor the dynamics of the sector has been then provided, and the methodology used for the data collection has been detailed. The list of the final KPIs used for the analysis is the following:
  - New businesses created in a sustainable manner
  - Number of FTE/company size
  - Total companies per location/geographical distribution
  - Number of R&D projects
  - Change in the number of patents
  - Change in the total number of R&D collaboration
- The overview of the companies working in the four IR fields (section 4) highlighted that (i) most of the companies operating in WR, SurgCOBOTs and HUM are micro (staff headcount<10) or small (staff headcount<50) enterprises, while for IndCOBOTs companies most of them are large companies; (ii) most of the companies in all fields have been founded in the last 10 years and they are located mostly in Europe and (iii). The overview also outlined the different approach followed in the two fields for the patents: for HUM companies, only 7 out of 27 companies have registered patents, highlighting the difficulties found by these companies to deal with high costs of patenting. WR companies have a completely opposite situation: only 12 out of 41 companies have not registered patents meaning that patents are

one of the key factors for differentiating from competitors, creating a real added value to the robotic solutions proposed to the market.

- As shown in section 4, database analysis is an accessible tool for companies to analyse the robotic market from different perspectives: it was presented the method followed in the white paper analysis to identify the different KPIs data required (see Figure 4). In particular, it has been very useful to identify most of the IR companies worldwide (through the Crunchbase database) and get an overview of the connections with public research grants (funded either by national agencies or by European Union) through the CORDIS-NSF-FEDREP databases and to the patents owned by companies, through the Depatisnet database. It is worth noting that all the companies working in these sectors are in general well connected to the research world, being former spin-off companies and focused on innovative technologies (indeed, companies that are present in two or more research projects have a lot of first-hand access to the innovative results from the projects to eventually improve their products and services).
- Intellectual property (IP) rights are, in general, valuable assets for any business. They keep the business away from competitors, they can be sold or licensed (providing revenues) or be used as security for loans. Ignoring or undervaluing the potential of IP can lead to risky situations especially for SMEs, for example, opening the possibility of competitors of taking advantage of technical innovations, business, ideas, reputation in the market, etc. However, finding the right tool is not an easy task. Therefore, in Section 5, a summary of tools to support the protection of the intellectual properties is provided, covering topics on "how to protect the developments", important issues and potentials to be considered, and types of protection (i.e., patents, trademarks, trade secrets, copyright, designs). The survey on intellectual property rights shown that the most used tools are the European and international patent, and trade secret. Surprisingly, the copyright tool is not widely used, but it is the only means to protect software (at least in Europe). The main concern of SMEs when dealing with IP protection is the complexity and lack of knowledge on the process itself; this leads to an underestimation of the effort needed (both in terms of time and economic resources) for protecting IP.
- Sections 6 and 7 are dedicated to the main barrier raised during interviews collected in Section 3: "Fundraising issues and/or identification of the proper business model". As shown in Section 3, this barrier is transversal to all the stages of maturity of a company, and the access to funding, financial resources, potential investors and business networks is one of the pillars for the success of a SME. Therefore, Section 6 dealt with these two aspects: (i) identification of the proper business model and (ii) fundraising issues.
- Section 6 provided an overview of the state of the art regarding the Business Model (BM) adopted by SMEs to address new ICT technologies (like IR). In these sections, quick guide to recommend the suitable business model starting from the type of company among four different BMs: evolutionary, Adaptive, Complex and Focused is described. In addition to that, a guide to identify technological assets is also provided, offering to SMEs some strategies for market launch through cooperation with new partners and linking up with existing fields of activity where IR are not yet present ("broadening"). On the other hand, also a strategy for specialization has been applied by other SMEs.
- An analysis is shown on how complementarity between Robots and ICT (Information and Communication Technology) on one hand, and organisational innovation, on the other, affects the Open Innovation (OI) strategy. It shows the need to adapt new structures and operations of organisations by creating Business Model Innovation (BMI), which can, in turn, help create value in SMEs companies. Some real examples of best practices and success stories are also provided.
- Section 6 and 7 aimed at presenting the main solutions to access to funding, financial resources, potential investors and business networks. These sections provide information about these aspects, offering a detailed overview of the types of private funding opportunities

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

(i.e., venture capital and business angels) and public funding opportunities, focusing specifically on European Research and Innovation Framework Programmes.

- Considering private funding opportunities, some guidelines can be found on how to identify the opportunity, know why investors invest, know about potential investors, know how to answer to potential questions that investors ask. Among private and public funding opportunities, it is presented a short section providing an overview of financial and tax laws, labour and social security laws in Interactive Robotics to highlight the close connection between economic sustainability of a company and all the legal aspects related to taxation (deeply analysed in the White Paper of WP2).
- Public funding opportunities were studied and analysed in the final part of Section 7; it was concluded that the field of Interactive Robotics is very important for the European Research and Innovation Framework Programmes, having been an important pillar with multiple funding opportunities during H2020 (2014-2020) and the tendency will continue in that direction during Horizon Europe (2021-2027) and Next Generation EU. In addition, this section studied the relationship between public funding and the development of SMEs in the field of Interactive Robotics and it was concluded that public funding is a key factor in the development and survival of innovative SMEs in the field of robotics, that the trend of the European Commission is to increase the funding allocated to SMEs (making it even mandatory to have SMEs in some big consortiums) and help them overcome the valley of the death and be able to scale-up and grow.
- Regarding European policies, the main current working frameworks were presented and summarized, and the main barriers and gaps in the future of robotics uptake were identified, regrouping them in 4 main groups: i) Societal and culture barriers, ii) Regulation barriers, iii) Deviation of regulation, iv) Financing barriers. Finally, the future trends of robotics in public funding and R&D and innovation were analysed and it was concluded that a new generation of robotics is coming with the new revolution guided by the maturity of techniques and technology on AI and mechanical engineering with some clear application domains: i) Healthcare, ii) Manufacturing, iii) Logistics and e-commerce, iv) Transportation and v) Agri-food industry.

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# 9. Annexes

In the INBOTS website (http://inbots.eu/inbots-experts-community/support-to-smes/) are available publicly the following documents:

- The Table of companies used as input for collecting all the data referred to the companies working in these fields.
- All the interviews collected during the three years INBOTS project.
- State of the art about taxation literature

*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 780073*

# INBOTS

## Inclusive Robotics for a better Society

www.inbots.eu

@INBOTS_CSA

@INBOTS_CSA

@INBOTS_CSA

This project has received funding from the European Union's Horizon 2020
research and innovation program under grant agreement No 780073