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Universities and Collaborative Innovation in EC-funded Research Projects: An Analysis based on Innovation Radar Data

JRC / DG CONNECT EURIPIDIS Joint Project nr 32944-2013-09

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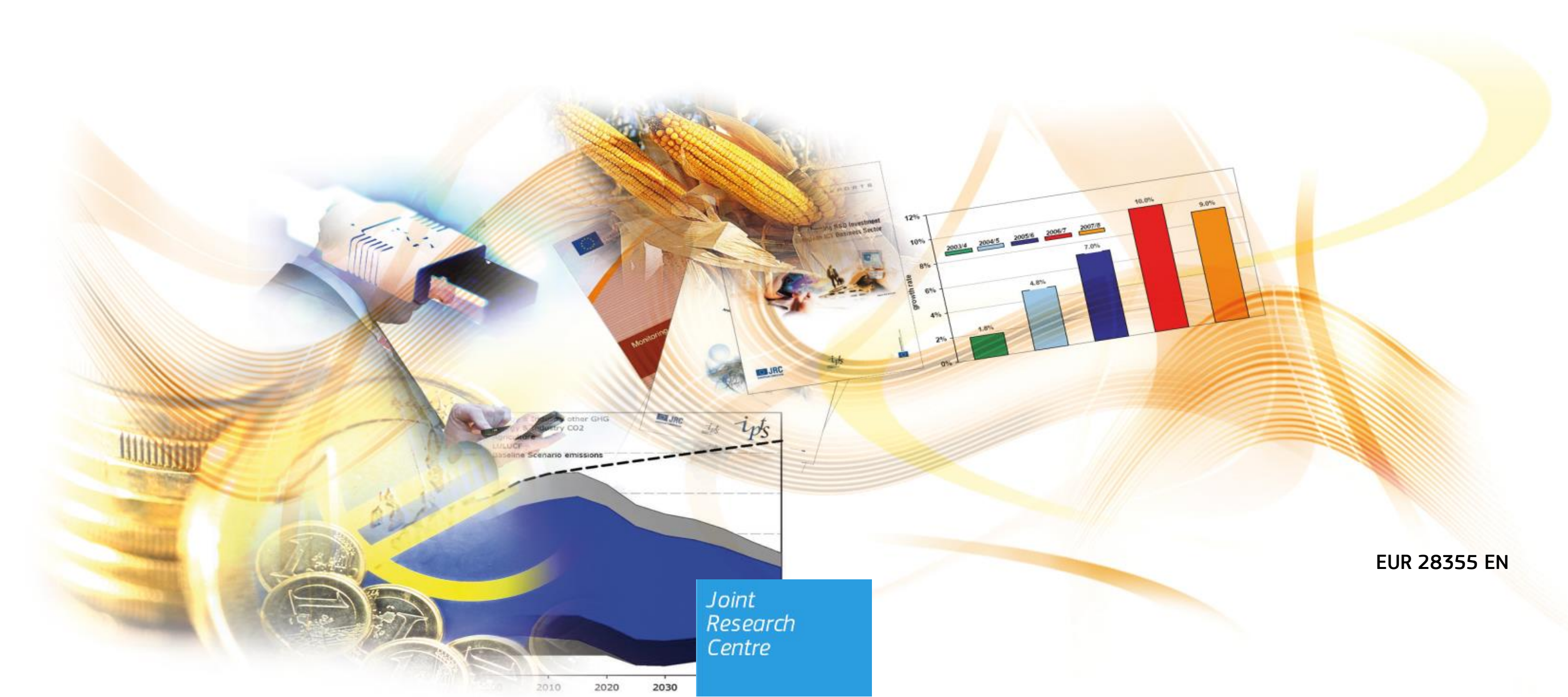

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Abstract
The European Commission's Framework Programme (FP) contributes an important share of R&D expenditure in Europe. For example, the Horizon 2020 is the biggest EU Research and Innovation programme ever launched which makes nearly €80 billion available over 7 years (2014 to 2020). In addition to financing science and technology development, one of the main objectives of the FP is to foster international collaboration among research organizations and private firms, both large and small. Collaboration is a key conduit for innovation-related knowledge flows for both firms that use R&D and those that are not R&D-active. The main idea behind the Framework Programme is that innovation often results from the interaction and cooperative efforts of different organisation devoted to the achievement of a common goal. This study builds on the first IR report: it extends the number of reviewed projects, and it looks at the relationship between the type of innovators and the potential of their innovations. A particular emphasis is put on collaboration between universities and private organizations. Furthermore, the report analyses whether universities and private organizations have different needs and face different bottlenecks to bring their innovations to the market.

Acknowledgments

This analysis was produced in the context of the European Innovation Policies for the Digital Shift (EURIPIDIS) project, jointly launched in 2013 by JRC and DG CONNECT of the European Commission.

The authors wish to thank and acknowledge the following experts and colleagues for their valuable input and comments: Eoghan O'Neill (DG CONNECT), Paul Desruelle (JRC), Vincent Van Roy (JRC). Finally, thorough checking and editing of the text by Patricia Farrer is gratefully acknowledged.

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Preface

This report was prepared in the context of the three year research project on European Innovation Policies for the Digital Shift (EURIPIDIS), jointly launched in 2013 by JRC and DG CONNECT of the European Commission. EURIPIDIS aims to improve understanding of innovation in the ICT sector and of ICT-enabled innovation in the rest of the economy.

The project's objective is to provide evidence-based support to the policies, instruments and measurement needs of DG CONNECT for enhancing ICT Innovation in Europe, in the context of the Digital Single Market for Europe and of the ICT priority of Horizon 2020. It focuses on the improvement of the transfer of best research ideas to the market.

EURIPIDIS aims:

1. to better understand how ICT innovation works, at the level of actors such as firms, and also of the ICT "innovation system" in the EU;
2. to assess the EU's current ICT innovation performance, by attempting to measure ICT innovation in Europe and by measuring the impact of existing policies and instruments (such as FP7 and Horizon 2020); and
3. to explore and suggest how policy makers could make ICT innovation in the EU work better.

This study reports the findings of the Innovation Radar since its launch in May 2014. The Innovation Radar is a DG Connect / JRC support initiative which focuses on the identification of innovations with high potential and the key innovators behind them in FP7, CIP and Horizon2020 projects.

Glossary

CIP: Competitiveness and Innovation Framework Programme.

Horizon2020: Horizon 2020 is the EU Research and Innovation programme, which makes nearly €80 billion available over 7 years (2014 to 2020).

High Capacity Innovator: Innovators with ICI scores at least one standard deviation above the average ICI score.

Innovations with high potential: Innovations with an IPI score at least one standard deviation above the average IPI score.

IAI (Innovator's Ability Indicator): A composite indicator used in innovator capacity assessment, which focuses on the innovation performance of an individual organization seen as the key organization behind an innovation.

ICI (Innovator Capacity Indicator): A composite indicator used in innovator capacity assessment.

ICT FP7: The European Union's Research and Innovation funding programme for 2007-2013, dedicated to Information and Communication Technologies.

IEI (Innovator's Environment Indicator): A composite indicator used in innovator capacity assessment. It focuses on the composition and activity of an inventor's partner organizations, the performance of the project in terms of innovation and the commitment of relevant partners to exploiting the innovation.

IMI (Innovation Management Indicator): A composite indicator used in innovation potential assessment which focuses on the capability of the management team to take the steps needed to transform a novel technology or research results into marketable products and, finally, to prepare their commercialisation.

Innovation: New product, process, service or other type of innovation identified during the ICT FP7/Horizon2020 project review with the help of the Innovation Radar Questionnaire.

Innovator: Key organization in the ICT FP7/Horizon2020 project, that delivers an innovation identified during an ICT FP7/Horizon2020 project review with the help of the Innovation Radar Questionnaire.

Innovation Radar: a joint DG Connect / JRC support initiative which focuses on the identification of innovations with high potential and the key innovators behind them in FP7, CIP and Horizon2020 projects and their needs as regards innovation commercialisation.

Innovation Radar Questionnaire: A questionnaire developed by DG Connect / JRC which identifies and analyses innovations in FP7, CIP and Horizon2020 projects.

IPI (Innovation Potential Indicator): A composite indicator which aggregates the three indicators, i.e. MPI, IRI and IMI, used in the assessment of innovation potential.

IRI (Innovation Readiness Indicator): A composite indicator used in the assessment of innovation potential which focuses on the technical maturity of an evolving innovation.

Low Capacity Innovator: Innovators with an ICI score at least one standard deviation below the average ICI score.

Innovations with low potential: Innovations with an IPI score at least one standard deviation below the average IPI score.

Market Potential Indicator (MPI): A composite indicator used in the assessment of innovation potential which focuses on the demand and supply sides of an innovation.

Medium Capacity Innovator: Innovators with an ICI score within one standard deviation of the average ICI score.

Innovation with medium potential: Innovations with an IPI score within one standard deviation of the average IPI score.

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Executive Summary

The Innovation Radar (IR) is part of the 3 year EURIPIDIS project, which is a joint **DG Connect**/**JRC** support initiative launched in August 2013. The IR focuses on the identification of innovations with high potential and the key innovators behind them in ICT **FP7**, **CIP** and **Horizon 2020** projects.[1] Today, the IR provides **up-to-date intelligence** on the innovative output of EU-funded research projects and **guidance on how to leverage this** by suggesting a range of targeted actions that can help these innovations to fulfil their potential in the market place.

This study builds on a first report that presented the IR methodology and first results (De Prato, et al., 2015) by extending the number of projects reviewed, and also looking at the relationship between the type of innovators and the potential of their innovations. Particular emphasis is put on projects where there is **collaboration between universities and private organizations**. Furthermore, the report analyses whether universities and private organizations face different needs and bottlenecks in bringing their innovations to the market.

What is the innovative output of EC-funded research projects?

ICT FP7/CIP projects deliver a substantial number of innovations. On average, nearly **2 new or substantially improved products or services** are developed within each project. Most of the innovations are related to **data processing** or **software development,** whereas only a few of them are related to hardware development.

Most of the innovations that are still under development are classified as innovations with medium potential. Thus, this is the group of innovations that requires the most attention and support to increase their commercialisation chances. This can be achieved by addressing the shortcomings of the innovations and/ or the innovators' needs that are vital for the delivery of these innovations to the market. In particular, **innovation management** can be described as the innovators' biggest weakness. They may need to clarify issues of **innovation ownership**, prepare **business plans** and **market studies** or **secure investment** for further development and commercialisation of their innovative outputs.

Market potential and readiness of innovations

Commercial exploitation is planned for over 63% of these innovations and for almost all the innovations with high potential. Currently, **12% of the innovations are already being exploited**, either on the market or internally by a partner organization. However, 28% of the innovations that are already mature are not being exploited yet. This includes nearly 50% of the innovations with high potential.

Bearing in mind that 74% of the innovations with high potential belong to projects that are in their **final stages**, one can conclude that new ideas and technologies developed during EU-funded research projects mature and increase their potential as the projects advance.

The amount of project funding does not seem to affect the potential of the innovation.

Innovators in EC-funded research projects

Innovations with high potential are often delivered by SMEs. In fact, 44% of the organizations behind these innovations are SMEs. This is nearly three times more than the share of SMEs that participate in ICT FP7. Hence, it can be assumed that SMEs are important vehicles for co-creating

[1] Innovation is defined as new product, process, service or other types of innovation as defined by Oslo Manual that are identified during ICT FP7/CIP project review with the help of the Innovation Radar Questionnaire. Innovators are key organization in the ICT FP7/CIP project delivering an innovation identified during ICT FP7/CIP project review with the help of the Innovation Radar. For a detailed methodological description see the first Innovation Radar report (De Prato, Nepelski, & Piroli, 2015).

and commercialising the innovative technologies developed within ICT FP7 projects. Second, it is the category that includes universities and research organizations. Altogether, about 28% of the key organizations behind innovations with high potential are universities or research centres. 22% of the organizations that participate in the development of innovations with high potential are large.

There is a strong geographic concentration of innovators. Germany, the UK, Italy and Spain are the countries with the most organizations identified as key players in delivering innovations.

There is **a positive relationship between an innovator's capacity score and innovation potential**. However, a high score in one indicator does not automatically translate into high performance in another. Often, high capacity innovators participate in delivering innovations with low or medium potential and low capacity innovators were identified as key organizations in developing innovations with medium potential. Improving overall innovative performance requires a **focus on both the innovations and the organizations behind them**.

The role of universities as co-innovators

70% of innovations with high potential are **co-developed with universities.** Collaboration between **universities and SMEs** seems to be particularly fruitful.

New products are co-developed considerably more often in the course of collaboration that involves universities. Although private-private partnerships are also an important source of new products, these partnerships show equal interest in developing new processes, services and organizational methods. This may suggest that **universities are a source of new products** that are then channelled through private organizations to the market. Thus, considering that universities often report that what they most need in order to bring their innovation to the market is "partnership with other companies", one can conclude that universities are **seeking complementary capabilities**, to help them commercialise their technologies. These capabilities can be brought in by private organizations, often SMEs. This is emphasized by the finding that **innovations co-developed with universities have equal chances of commercial exploitation** as those that are introduced by private-private collaborations.

Universities and private organizations have to meet different needs in order to fulfil the market potential of their innovations. Universities tend to report more needs related to the finalisation of the innovation and the subsequent steps to bring it to the market. Private organisations needs are more related to the commercialization of the innovation and the need to create or expand their market, i.e. scaling-up.

The ecosystem of collaborative innovation of EC-funded research projects

Innovations produced within EU-funded research projects are a result of **collaborative work**. On average, there are 1.9 innovators per innovation.

Among the over 1,000 participants identified as key innovators, Nr 1 is **Arduino SA**, a **global leader in Open Source Software and Hardware** development. Internet-enabled worldwide collaboration leads to a transformation of the modes of innovation. OSS and Linux are prime examples of innovative products developed outside hierarchical, top-down, vertically-integrated firms such as IBM and Microsoft. The decentralized mode of innovation has become the model for software development and is increasingly being used for hardware development. By being on the front-line of this transformation, Arduino, a European-based technology platform, is setting the standards and direction for the emergence of future technologies. Behind its success lies collaboration among global community members, who contribute to a common pool of resources.

Consulting **end-users in innovation processes** is a source of ideas and feedback. It increases the innovation potential.

Collaboration between heterogeneous organizations leads to synergies by combining the **complementary capabilities** of each partner. Partnership with other organizations is one of the main needs of innovators in EC-funded research projects.

Steps and barriers to innovation commercialisation

When taking innovations to the market, projects tend to **focus on technology-related steps over business-related ones**. For example, 65% of the projects that plan to commercialise their innovations either created, or plan to create, a prototype. In contrast, only 39% of projects have carried out or plan to carry out a market study. Writing a business plan is on the agenda of only 36% of projects that plan innovation commercialisation. Hence, in order to increase the chances of successful commercialisation of an innovative output, projects must take into account more than the technological aspects and **introduce business-related elements into their organizations' activities**.

Projects that involve **interactions with external actors are relatively uncommon**. For example, only 4.5% to 9% of the projects have sought, or are planning to seek, private or public funding. At the same time, one of the most common needs of key organizations trying to deliver innovations is partnership with other companies. This creates a demand for **opening-up projects to more** interactions with external specialised actors, e.g. business coaches or venture capitalists, who could help to improve the chances of commercialising innovations.

Financing is seen as the main external barrier to innovation exploitation. 30.7% of project partners see lack of finance as a barrier to exploiting their innovative products or services. However, there seems to be **a contradiction between what they claim to be a barrier and their actual behaviour**; i.e. **only between 4.5% and 9% of the projects have sought or are planning to seek private or public funding**. Moreover, between 40% and 33% of the projects do not plan to seek capital or public investment. On the other hand, organizations claim that, in order to fulfil their innovations' market potential, their primary need is partnerships with other companies and business plan development.

1 Introduction

The European Commission's Framework Programme (FP) constitutes an important share in R&D expenditures in Europe. For example, the **Horizon 2020** is the biggest EU Research and Innovation programme ever launched, making nearly €80 billion of funding available over 7 years (2014 to 2020). In addition to financing science and technology development, one of the main objectives of the FP is to foster international collaboration among research organizations and private firms, both large and small. Collaboration is a key conduit for innovation-related knowledge flows for firms that use R&D (either internally developed or externally acquired) and also for those that are not R&D-active (OECD, 2015). The main idea behind this is that innovation often results from the interaction and cooperative efforts of different organisations devoted to the achievement of a common goal. The importance of collaboration for innovation is generally well accepted (Chesbrough, 2003; von Hippel, 2005).

Despite the fact that fostering collaboration is among the key objectives of EC-funded organizations, the impact of bringing universities, research organizations and private firms together to produce technological and innovative output is unclear. The reason for this is diverging motivations and objectives of the different types of organizations that participate in EC-funded research projects. For example, universities are looking mainly for complementary resources that allow them to advance basic research (Caloghirou, Tsakanikas, & Vonortas, 2001; Polt, Vonortas, & Fisher, 2008). They are more motivated by the opportunity to build up new knowledge and technology capabilities and to investigate new research areas than they are by technology commercialisation. In contrast, SMEs have explicit goals related to innovation outputs such as developing a prototype, a patentable technology, or a complementary technology that will enhance competitiveness (Polt, et al., 2008). They focus on projects with an applied orientation and engage only in cooperative agreements that are likely to yield tangible benefits, guaranteeing them immediate survival and growth. Large firms also have different motives for participating in joint projects with universities and other firms. In general, they appear much less inclined to commercialise directly from the project, than SMEs (Hernan, Marin, & Siotis, 2003). Larger companies participate in collaborative R&D projects in order to carry out *technology watch*, acquire new knowledge and build partnerships.

Considering that various types of organizations are driven by various motivations to participate to EC-funded research projects, one can expect that these dissimilarities are likely to affect the efforts of various partners, the outcomes of collaboration and how their results are appropriated by among them. For example, large firms are less willing to share their economic knowledge with smaller rivals and have a preference to collaborate with other large firms in order to maximize the internalization of spillovers (Röller, Siebert, & Tombak, 2007). Moreover, as many research collaboration projects do not lead straight to economic benefits (Siebert, 1996), diversity in firm size and efficiency level, can impede effective R&D collaboration. The same applies to collaborations between companies and universities. It was found that the impact of collaboration with a university depends on the company size (Okamuro, 2007). In general, SMEs can benefit more from R&D collaboration with universities rather than larger firms.

In order to improve our understanding of the collaborative innovation efforts in EC-funded research projects, the current study builds on the first release of the **Innovation Radar** (IR) (De Prato, et al., 2015). Between October 2014 and January 2016, 603 projects were reviewed using the IR Questionnaire. In addition to the several background aspects the IR takes into account in order to assess the process of innovation development, the maturity of the innovation, the actions needed to fulfil the market potential of innovation, this document looks also at innovation collaboration patterns. In particular, it analyses whether collaboration affects differently innovation according to the organisation type involved, e.g. university, SME or large firm, and the engagement of end-users.

This report is structured as follows: Section 2 briefly reviews the methodological details of the IR assessment frameworks to identify innovations and innovators in EC-funded research projects and describes the underlying data. Sections 3 and 4 present the results of the innovation potential assessment and the innovator capacity assessment, respectively. Section 5 analyses whether different types of partnerships matter for the innovative outcome, with a particular emphasis on universities as co-inventors. Section 6 describes the impact of end-user engagement on projects innovation performance. Section 7 shows the responses to the questions about steps that project consortia have taken to bring innovations to the market and what kind of obstacles to innovation commercialisation they have found. Section 8 summarises the main lessons learned.

2 Innovation Radar Methodology and Data

The Innovation Radar methodology uses two assessment frameworks: one for ranking innovations and the other for ranking of innovators. A detailed description of the construction of both the frameworks and the indicators used can be found in the first Innovation Radar Report (De Prato, et al., 2015). Below the key methodological elements are briefly presented.

2.1 Innovation potential assessment framework and indicators

The innovation potential assessment framework includes a set of criteria and indicators which assess the strength of each innovation in terms of innovation readiness, innovation management and market potential.

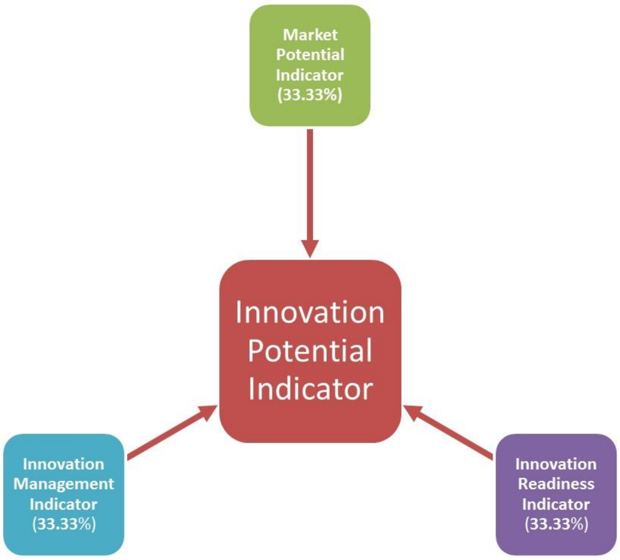
Innovation readiness: Innovation readiness relates to the technical maturity of an evolving innovation. It takes into account the development phases of the innovation, e.g. conceptualization, experimentation or commercialisation. It also looks at the steps that were taken in order to prepare an innovation for commercialisation (e.g. prototyping, demonstration or testing activities or a feasibility study) and to secure the necessary technological resources (e.g. skills, to bring the innovation to the market). In addition, this criterion takes into account the development stage of an innovation and the time to its potential commercialisation. It is measured by the **Innovation Readiness Indicator (IRI)**.

Innovation management: This criterion assesses the project consortium and its commitment to bring an innovation to the market, an element that is often seen as the most important success indicator of a technology venture. It aims to research or confirm the capability of the project's development and/or management team to execute the steps necessary for transforming a novel technology or research results into a marketable product and, finally, to prepare its commercialisation. These steps may include, for example, clarifying the related ownership and IPR issues, preparing a business plan or market study, securing capital investment from public and/or private sources, or engaging an end-user in the project. Innovation management is measured by the **Innovation Management Indicator (IMI)**.

Market potential: This criterion relates to the demand and supply side of an innovation. Regarding the demand side, it assesses the prospective size of the market for a product and the chances of it being successfully commercialised. It looks at whether the product satisfies a market sector and if there is a potential customer base. With respect to the supply side, it assesses whether there are potential barriers, e.g. regulatory frameworks or existing IPR issues, which could weaken the commercial exploitation of an innovation. In the current undertaking, the focus is placed on the supply side. This is mostly because information on markets for individual innovations is not available. Market potential is measured by the **Market Potential Indicator (MPI)**.

The three indicators described above, i.e. IRI, IMI and MPI, are used to construct the final **Innovation Potential Indicator (IPI)**. As all three elements are considered equally important for the successful commercialization of an innovation, equal weighting is applied, see Figure 1.

Figure 1: Construction of the Innovation Potential Indicator



Source: JRC

2.2 Innovator capacity assessment framework and indicators

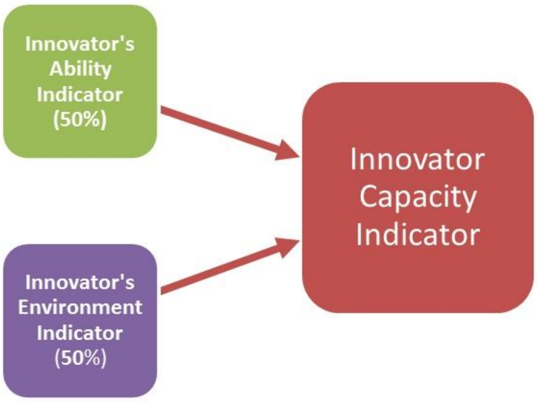
The second assessment framework of the Innovation Radar ranks innovators. It concentrates on two issues. First, how well do organizations, seen as key innovators, perform as regards innovation? Second, in what kind of environment are these organizations located? It includes a set of criteria and indicators which assess the capacity of organizations identified as key deliverers of innovations.

Innovator's ability: This relates to the innovation performance of an individual organization that is seen as the key organization behind an innovation. The ability of an organization is measured mainly by its innovative output within the FP7 activities. By output, we mean the number of innovations each organization contributes to and the potential of these innovations, where the innovation potential is a product of the innovation potential assessment, as defined above. In addition, when assessing an innovator's ability, factors such as a reviewer's opinion about the innovator's potential or independence in realising the market potential of an innovation are taken into account. Innovator's ability is measured by **Innovator's Ability Indicator (IAI)**.

Innovator's environment: this criterion aims to capture the overall conditions that an innovator faces. It is mainly related to the overall composition and activities of partner organizations, the performance of the project in terms of innovation and the commitment of relevant partners to exploiting the innovation. Moreover, it also takes into account the presence of organizations that are directly interested in applying or exploiting the innovations, e.g. end-users. It is assumed that a positive environment overall will have a positive spill over effect on the innovator and vice-versa. Innovator's environment is measured by **Innovator's Environment Indicator (IEI)**.

Both indicators, IAI and IEI, are used to construct the **Innovator Capacity Indicator (ICI)**. The value of the ICI is an arithmetic aggregate of the values of the IAI and IEI (see Figure 2).

Figure 2: Construction of the Innovation Capacity Indicator



Source: JRC

2.3 Normalization of indicator values

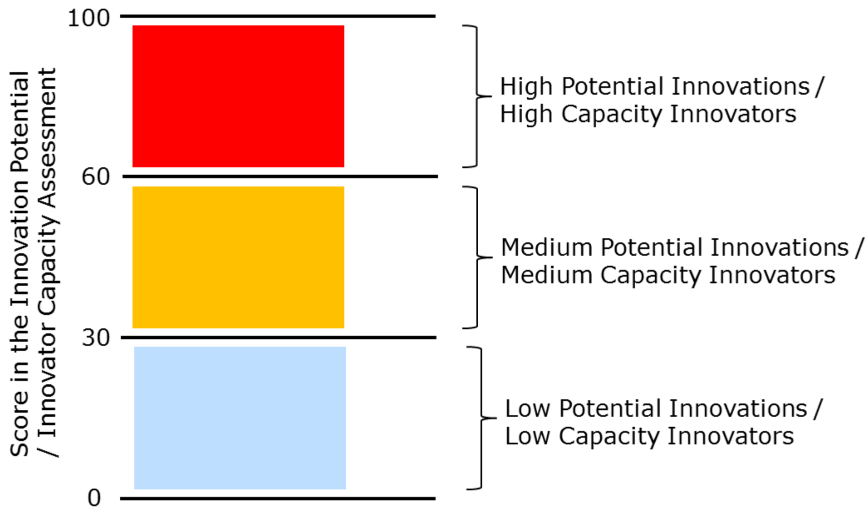
In order to make the values of each indicator for different innovations and innovators as easily comparable as possible, a normalisation procedure is applied. Observed values for each indicator are brought to the scale between 0 and 100 in the following way:

$$Indicator_{Normalized\,Score} = \frac{Indicator_{Observed\,Score}}{Indicator_{Max\,Score}} \times 100. \qquad (1)$$

2.4 Categories of innovations and innovators

In order to facilitate the interpretation of the results, the IR study introduces three categories of innovations, i.e. low, medium and high potential, and also of innovators, i.e. low, medium and high capacity. Figure 3 shows how innovations and innovators are assigned to each of the three categories based on their score on the IPI for innovations and ICI for innovators.

Figure 3: Innovation potential and innovator capacity scoring system



Calculations: JRC

Data: European Commission DG Connect

Note: The figure presents average scores across all four innovation potential assessment indicators, i.e. IRI, IMI, MPI and IPI, as defined in section **2.1**. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

2.5 Data

The Innovation Radar initiative is an ongoing process that was launched in August 2013. The data collection process started in May 2014 and the data used in the current report was collected during periodic reviews of ICT FP7/CIP of 603 projects. The reviews, which took place between October 2014 and January 2016, were based on the IR Questionnaire and were conducted by external experts commissioned by DG Connect. In addition to the standard review procedure, DG Connect deployed the Innovation Radar questionnaire during the same period to spot innovations originating from the FP7 projects and the key organizations behind them. For a detailed description of data collection, please see the first Innovation Radar report (De Prato, et al., 2015).

3 Innovations in EC-funded Research Projects

This section presents the innovation potential assessment results. It covers the following points:

- The overall and average innovative output of ICT FP7/Horizon2020 projects
- Overview of the innovation performance of innovations,
- Presentation of innovations with high potential and their characteristics, including the main organizations behind them,
- Categorisation of innovations by their type, e.g. product, process or service innovations,
- Presentation of plans to commercialise and exploit innovations,
- Presentation of the structure of innovation ownership,
- Overview of innovations by review type.

3.1 In a nutshell

The main findings of the innovation potential assessment can be summarised as follows:

- A typical ICT FP7/Horizon2020 project produces 1.87 innovations,
- There are 1.9 innovators per innovation, on average,
- Market potential and innovation readiness are among the strongest dimensions of the ICT FP7/Horizon2020 innovations, while the most room for improvement is found in innovation management.
- Most of the innovations are in data processing or software development and only a few innovations are in hardware development.
- 50% of key organizations behind the top 10 innovations are SMEs.
- 12% of all innovations are already being exploited, either on the market or within a partner organization. However, 28% of innovations that are already mature are not being exploited yet.
- 58% of innovations that have already been developed or are being exploited are either new products or significantly improved products.
- Commercial exploitation is planned for over 63% of all innovations and almost all those Innovations that have high potential,
- Although 55% of the innovations have multiple owners, 67% of those with high potential, or 11.4% of all the innovations, have a clearly defined owner.
- 74% of innovations with high potential belong to projects that have been through their final review and are therefore in their final stages. Thus, it can be assumed that new ideas and technologies developed during EU-financed projects mature and increase their potential as projects advance.

3.2 Innovations in the reviewed ICT FP7/Horizon2020 projects

According to

Table **1**, between October 2014 and January 2016, 603 projects were reviewed using the IR Questionnaire. As a result, 1,128 innovations were identified. This means that, on average, an ICT FP7/Horizon2020 project produces nearly 2 innovations. 1,036 distinct organizations could be considered as key organisations in delivering these innovations. The average number of innovators per innovation was 1.9.

Table 1: Innovations in ICT FP7/Horizon2020 projects – key facts

Review period	01.10.2014 and 18.01.2016
Number of reviewed projects	603
Number of innovations	1128
Number of distinct innovators	1036
Average number of innovations per project	1.87
Average number of innovators per innovation	1.9

Source: JRC

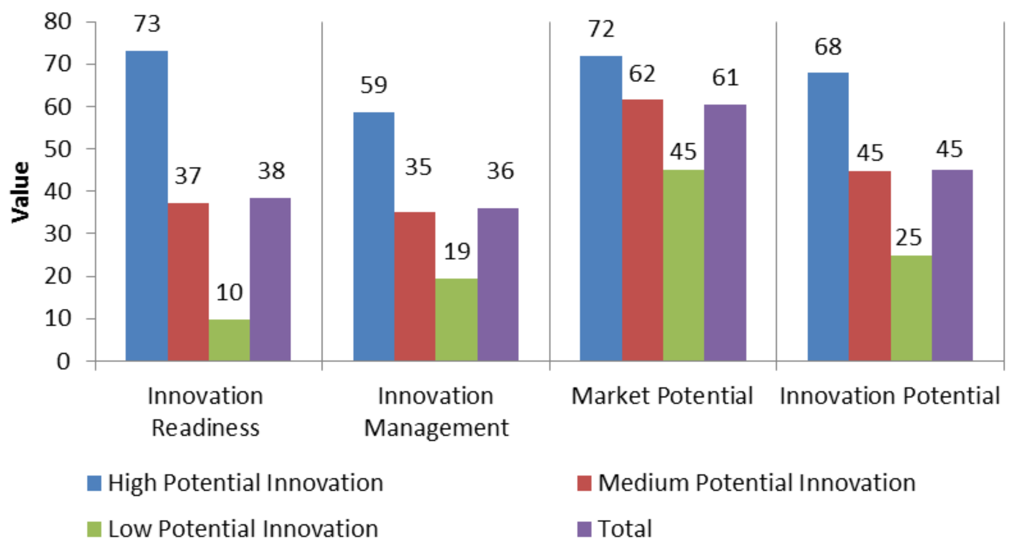
Data: European Commission DG Connect

3.3 Overview of innovation performance

Figure 4 presents the summary statistics of the three innovation potential assessment sub-indicators, i.e. Innovation Readiness (IRI), Innovation Management (IMI), Market Potential (MPI) and the composite Innovation Potential (IPI), for all the innovations analysed by innovation potential category. Figure 4 presents the average values of the indicators across innovation potential categories and shows the distribution of the IPI values.

The average value of the IPI among all the innovations is 44.97 out of the total 100 points. This number varies between 24.71 and 67.82 for innovations in the low and high potential categories. The innovation with the highest score obtained 88.33 points, while the lowest-ranked innovation only 12.5 points. When looking at the individual sub-indicators, one can observe that MPI has the highest and the IMI has the lowest average value. The average MPI score is 60.54 and the average IMP score is 36.04 points. The average score of the IRI is 38.34 points.

Figure 4: Average values of indicators by innovation potential category



Calculations: JRC

Data: European Commission DG Connect

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Based on the presented evidence, it can be concluded that, on average, market potential and innovation readiness are among the strongest dimensions of innovations from the reviewed ICT FP7/Horizon2020 projects. In contrast, innovation management represents the weakest dimension of these innovations. Hence, in order to increase the potential of these innovations, steps such as clarifying the ownership of the innovation, preparing a business plan, carrying out a market study or securing investment must be taken.

3.4 Innovations with high potential

Table **2** shows detailed descriptions of 10 innovations with the highest IPI score, together with the name and organization type of the key organizations behind them. Most of the innovations are in data processing or software development. Altogether, there are 12 entities behind the top innovations. Only in one case – that of RELEASE_B – is more than one organization identified as the key organizations behind an innovation. For the remaining innovations, only one innovator was identified. Interestingly, SMEs and higher education and schools and research centres (HES/REC) account for 42% of all organizations. Only 2 of the organizations are large companies.

Table 2: Description of the top 10 innovations and the key organizations behind them

Rank by IPI	Innovation	Innovation description	Key Organisations	Organisation type
1	GET HOME SAFE_A	Affordable and professional driving simulation tool. Main USP: separation between driving tasks and core part of the system.	DEUTSCHES FORSCHUNGSZENTRUM FUER KUENSTLICHE INTELLIGENZ GMBH	REC
2	RELEASE_A	The Wombat OAM system is a broker layer able to deploy ERLANG applications on top of cloud or super-clusters of smaller heterogeneous clusters managing dynamically scaling on the base of capability profile matching.	ERLANG SOLUTIONS LIMITED	SME
3	RELEASE_B	The scalable Erlang Virtual Machine is able to provide improved load balancing mechanism and to interrupt long running garbage collection thus making the language more responsive and scalable. The Virtual machine also provides more concurrent access to shared data held in ETS tables.	UPPSALA UNIVERSITET	HES
			ERICSSON AB	PRC
			INSTITUTE OF COMMUNICATION AND COMPUTER SYSTEMS	REC
4	SCI-BUS_A	CloudBroker Platform: one point of connection - unified interface to different commercial clouds, enables users to provide their self-developed applications, workflows, data products and other software to be exploited commercially.	CLOUDBROKER GMBH	SME
5	CUBRIK_B	The Gamification Framework (GF) enables organizations to add game elements to business applications, to boost customer engagement, activity and loyalty.	WEBRATIO SRL	SME
6	LiMoSINe_A	The innovation is about self-learning search and recommendation systems, able to learn to optimize themselves while people are interacting with them. Self-learning search and recommendation systems add value to businesses because they improve user engagement, which correlates with increase in revenue.	UNIVERSITEIT VAN AMSTERDAM	HES
7	Trilogy 2_A	The Federated Market is a market-place for the buying and selling of VM resources across distributed cloud provider Data Centres.	ONAPP LIMITED	SME
8	GREEN@Hospital_C	Web-EMCS is a software platform that simplifies the integration among subsystems at the field layer realized with heterogeneous standards.	AEA s.r.l.	PRC
9	MateCat_A	The MateCat tool is a Web-based open source computer-assisted translation (CAT) tool, which puts together the best environment for post-editing and translation and a marketplace for outsourcing translation projects.	TRANSLATED SRL	SME
10	COMPASS_A	Novel test strategy for automated equivalence class partition testing of complex systems with guaranteed error detection capabilities.	UNIVERSITAET BREMEN	HES

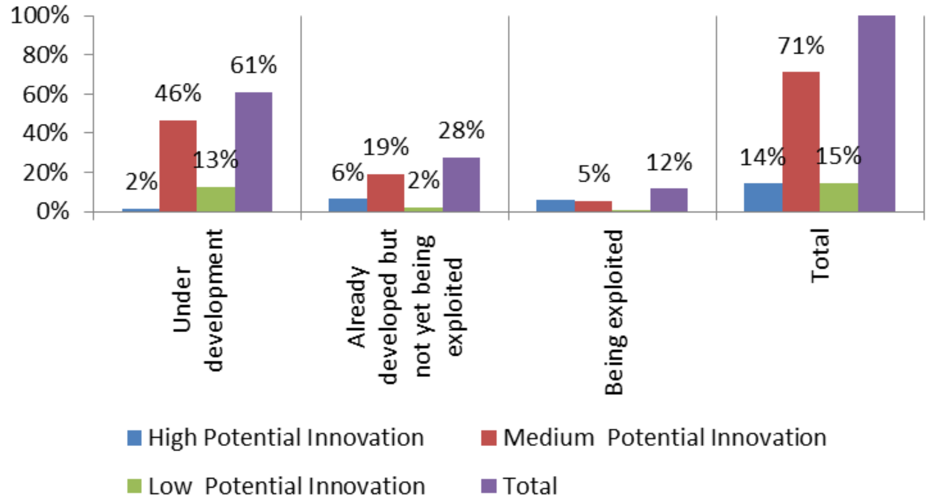
Calculations: JRC; Data: European Commission DG Connect

Note: The table presents the list of 10 innovations with high potential with the highest IPI score as defined in Section 2.1. Organization classes: HES/REC (Higher Education and Schools and Research Centres); PUB (Public Bodies); SMEs (Small Medium Enterprise); PRC (Large companies), OTHER (Other organisations). Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and

3.5 Development stage of innovations

Figure 5 shows the distribution of innovations by stage of development and innovation potential category. According to this information, 61% of the innovations are under development and 12% of are already being exploited: they are either on the market or are being used within a partner organization. However, more than 25% of innovations are already developed, but not being exploited. About 45% of innovations with high potential belong to this category. The other 43% with the highest IPI scores are already being exploited and the remaining 12% are under development.

Figure 5: Development stage of innovations



Calculations: JRC

Data: European Commission DG Connect

Note: The computations were based on the responses to question 3 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

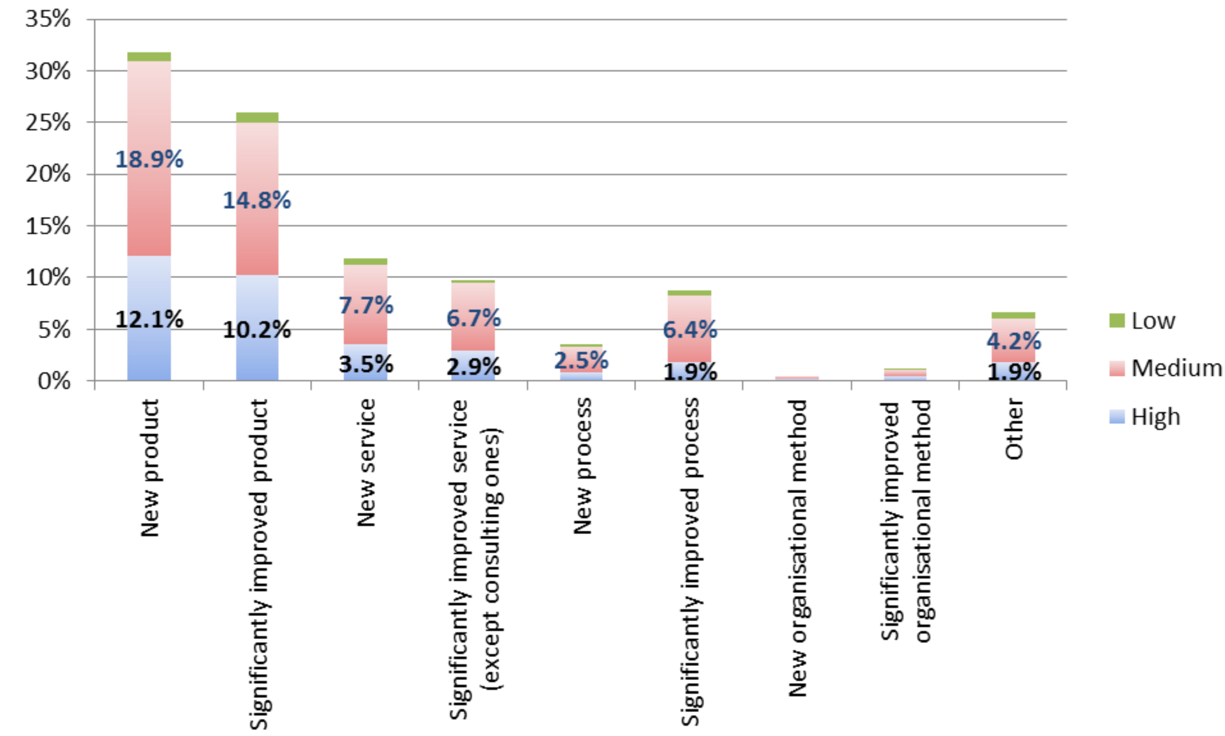
3.6 Type of innovations

Figure 6 shows the types of innovations that are developed or being exploited and Figure 7 shows types of innovations that are still under development. In both cases, a breakdown by innovation potential category is given. According to Figure 6, most of the innovations that are already developed or being exploited are either new products or significantly improved existing products. Altogether, these two types account for around 58% of all developed innovations. The second largest group of innovation types represent new services or significantly improved services. These two categories account for 22% of all developed innovations.

Of the different types of innovation, one can see that the new products or significantly improved products include a relatively large share of innovations with high potential. Innovations in these two groups account for 22.3% of all developed innovations.

According to Figure 7, most of the innovations that are still under development (53.1%) are product innovations. A very large share of innovations in this group, i.e. 78%, is made up of innovations with medium potential. Thus, this is the group of innovations that requires further nurturing, in order to exploit its potential.

Figure 6: Innovations developed or being exploited by type and innovation potential category

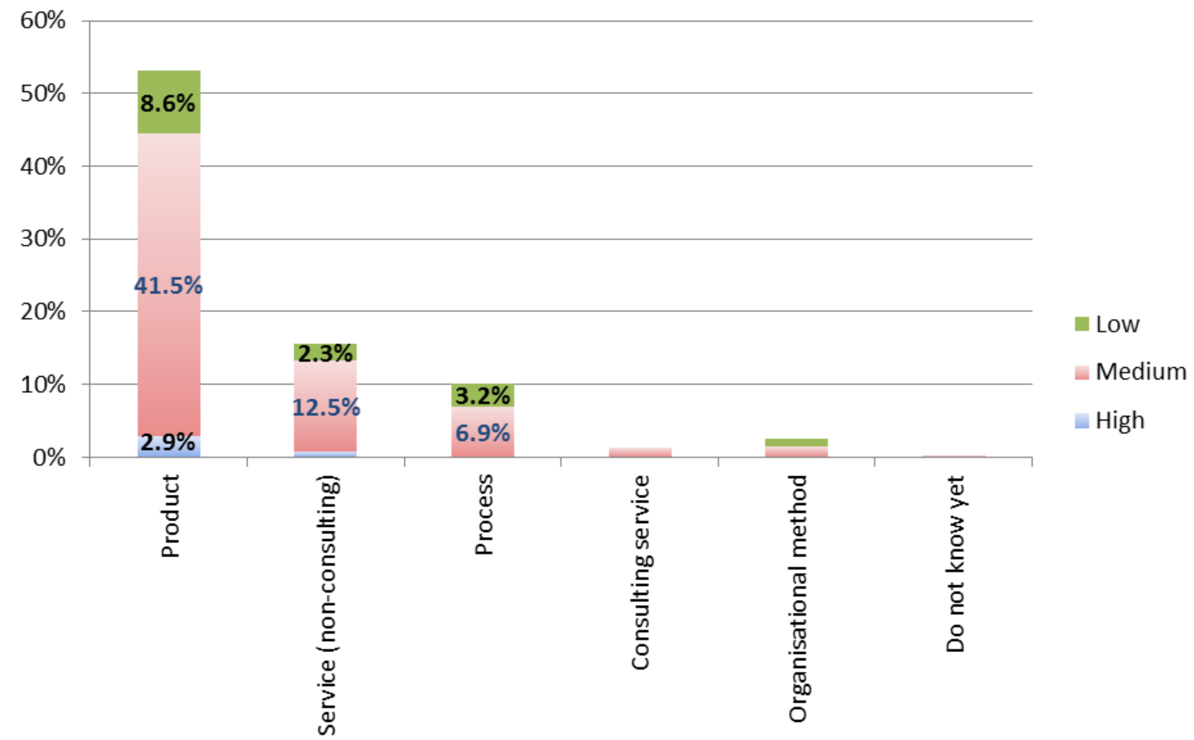


Calculations: JRC

Data: European Commission DG Connect

Note: The computations were based on the responses to question 4 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

Figure 7: Innovations under development by type and innovation potential category



Calculations: JRC

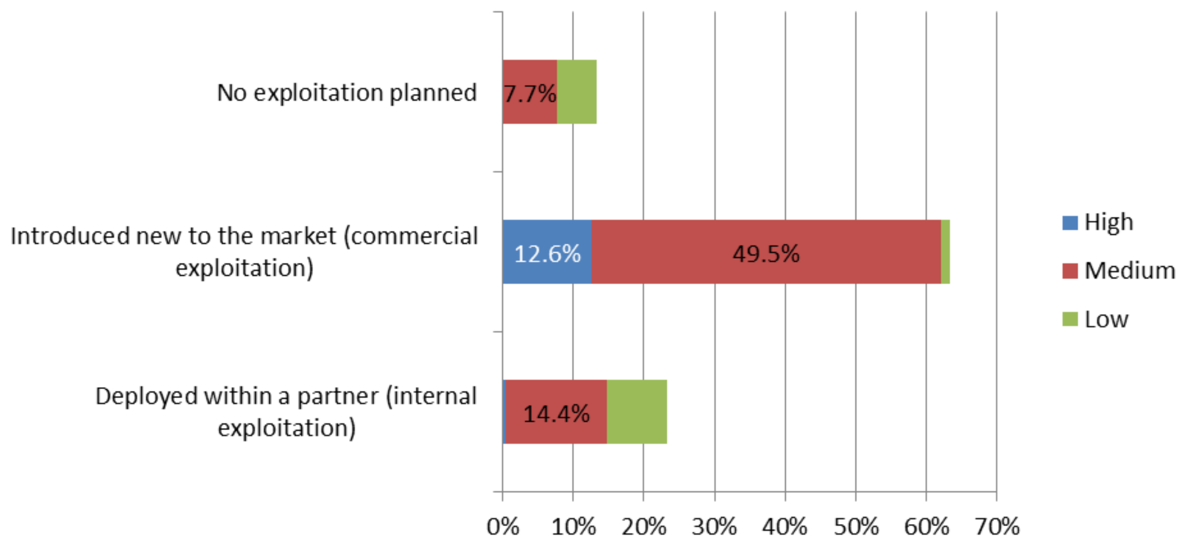
Data: European Commission DG Connect

Note: The computations were based on the responses to question 4 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

3.7 Exploitation and commercialisation of innovations

Figure 8 shows the breakdown of innovations by exploitation and innovation potential category. A distinction between commercial and internal exploitation is made. According to this information, commercial exploitation is planned for 63% of all innovations and for almost all innovations with high potential. Only 0.5% of innovations with high potential are exploited internally, whereas over 23% of all innovations are. Internal exploitation is expected to take place through changes in organization, new internal process implementation, etc. The remaining innovations, i.e. 13% are not planned to be introduced to the market or exploited internally.

Figure 8: External vs. internal exploitation by innovation potential category



Calculations: JRC

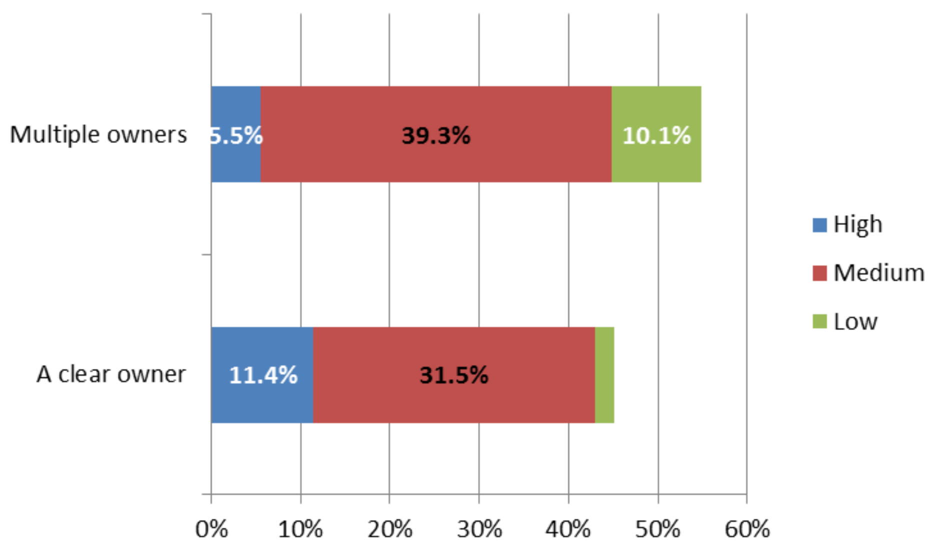
Data: European Commission DG Connect

Note: The computations were based on the responses to question 6 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

3.8 Innovation ownership

Figure 9 presents the information on innovation ownership and innovation potential category. A distinction between innovations with one clear owner and multiple owners is made. 45% of all innovations have a clear owner, while the ownership rights of the remaining innovations belong to multiple owners. The majority innovations with high potential (i.e. 67%) have clearly defined ownership, whereas only 11.4% of the total number of innovations do

Figure 9: Innovation ownership by innovation potential category



Calculations: JRC

Data: European Commission DG Connect

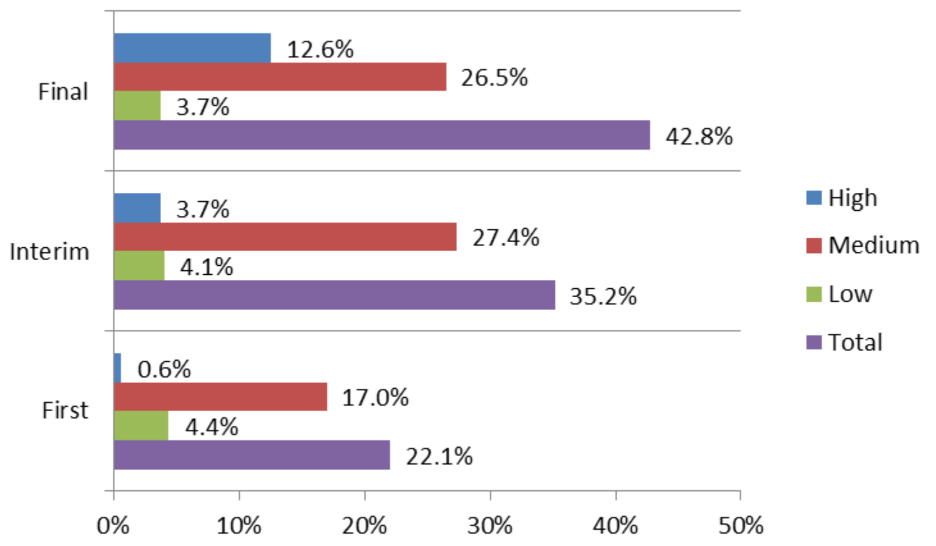
Note: The computations were based on the responses to question 8 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

3.9 Innovations by review time

During their lifecycle, ICT FP7/Horizon2020 projects go through three review rounds. The reviews are conducted by a panel of independent evaluators, who are recognized specialists in the relevant fields. In addition to the standard reviews, the Innovation Radar Questionnaire was applied to ongoing projects. Hence, the IR covers and assesses innovations and innovators that belong to projects at different stages of their lifecycle. Figure 10 presents a breakdown of innovations by review time and innovation potential category. 22% of all innovations belong to projects that were reviewed for the first time. 35% of innovations were produced within projects that were reviewed for the second time and the remaining 42.8% of innovations originate from projects in their final stages.

Regarding innovation potential and review time, 4.4% of all innovations are classified as innovations with low potential and belong to projects that were reviewed for the first time. This percentage goes down to 3.7% for innovations with low potential in projects in their final stages. By the same token, only 0.6% of all innovations are classified as innovations with high potential and they originate from projects that were reviewed for the first time. However, the percentage of innovations with high potential rises to 12.6% of all innovations for projects in their final stages. Thus, one can observe a relatively clear pattern: while the share of innovations with low potential decreases, as projects mature, the reverse is true innovations with high potential.

Figure 10: Number of innovations by innovation potential category and review time



Calculations: JRC

Data: European Commission DG Connect.

Note: The figure includes the count of innovations based on the project review time and innovation performance according to the IPI as defined in Section 2.1 Review type concerns one of the three reviews each FP7 project is subject to during its lifecycle. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

4 Innovators in EC-funded Research Projects

This section presents the innovator capacity assessment results. The analysis addresses the following points:

- Summary of innovator capacity performance,
- Presentation of high capacity Innovators and SMEs that are high capacity innovators,
- Overview of organizations by their type and innovations,
- Location of innovators,
- Relationship between the scores for innovator capacity and innovation potential.

4.1 In a nutshell

The main findings of the innovator capacity assessment can be summarised as follows:

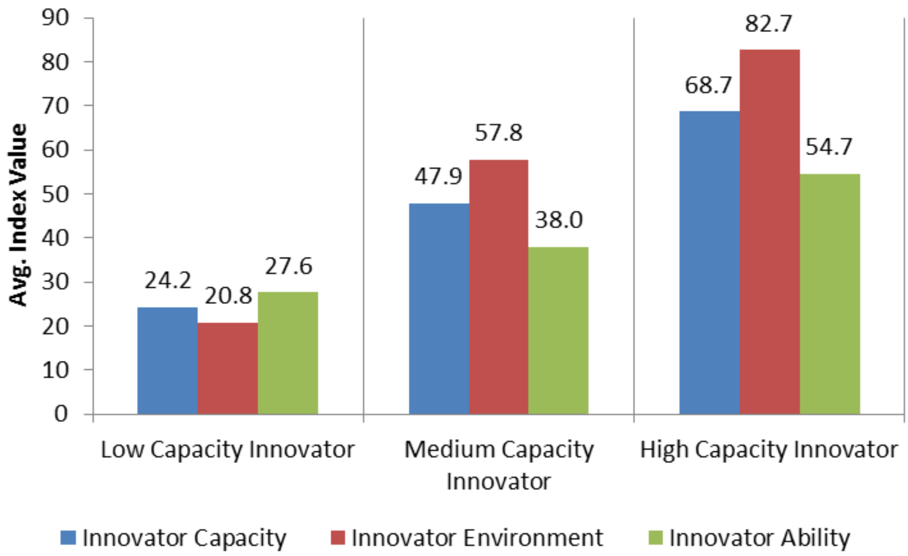
- On average, innovators profit from an innovation-favourable environment. However, the quality of an innovation environment is not equal for all innovators. The reason for this is that some projects do not engage end-users in the consortium, or relevant partners may lack the necessary commitment to exploiting the innovation.
- 44% of all organizations behind innovations with high potential are SMEs and, in general, there is a positive link between an innovation's potential and an SME being involved in its development. Hence, it can be assumed, that SMEs are important vehicles for co-creating and commercialising innovative technologies developed within ICT FP7 projects.
- The countries with the most organizations identified as key players in delivering the innovations are Germany (15.66%), the UK (13.51%), Italy (11.79%) and Spain (11.74%).
- There is a positive relationship between an organisation's innovator capacity score and the innovation potential score of the innovation, the development of which this organisation is contributing to. However, a high score in one indicator does not automatically translate into a high performance in the other. Often, high capacity innovators participate in delivering innovations with low or medium potential and low capacity innovators are identified as key organizations in developing innovations with medium potential. Thus, improving the overall performance of innovative output requires a focus on both innovations and the organizations behind them.
- Among over 1000 participants identified as key innovators, Nr 1 is Arduino SA, a global leader in Open Source Software and Hardware development. Arduino is a European-based technology platform which sets the standards of global collaborative development of future technologies.

4.2 Overview of innovator performance

Figure 11 summarises the statistics on the two sub-innovator capacity assessment indicators, i.e. Innovator's Ability (IAI), Innovator's Environment (IEI) and a composite Innovator Capacity Indicator (ICI), for all key organizations in delivering the innovations and by innovator capacity category. Figure 11 shows the distribution of the ICI average values across innovator capacity categories.

The average value of the ICI among all 1,128 innovators is 53.4 out of 100 points. This number varies from 24.2 to 68.7 for low to high capacity innovators. The innovator with the highest score obtained 94.41 points, while the lowest-ranking innovator obtained only 12 points. Looking at the individual sub-indicators, one can observe that IEI has the highest average value among high and medium capacity innovators. The average IEI score is 63.9 and the average IAI score is 42.9 points. However, looking at the standard deviation values of both indicators (respectively 22.1 and 15), one can see that IEI scores are much more volatile than those of IAI. In other words, the quality of the innovation environment is not equal for all innovators. This happens as some projects do not engage end-users in the consortium or because the relevant partners are not sufficiently committed to exploiting the innovation.

Figure 11: Average values of indicators by innovator capacity category



Calculations: JRC

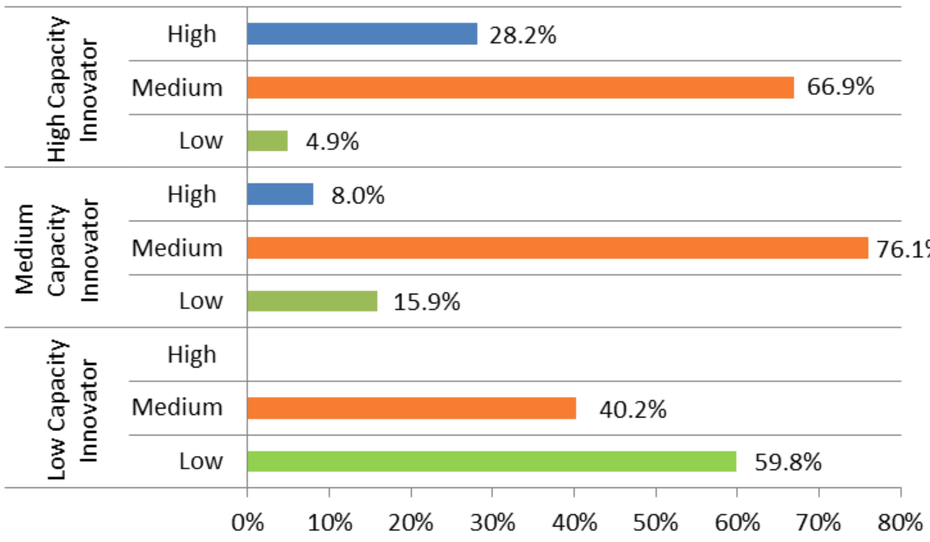
Data: European Commission DG Connect

Note: The figure shows the average scores of innovators across three assessment indicators, IAI, IEI and ICI, defined in section **0**. Innovators are defined as key organization behind the innovation according to the answers to the question 12 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

4.3 Innovators and their innovations

Figure 12 shows the distribution of innovators by innovator capacity and innovation potential category. It can be seen that 28.2% of high capacity innovators were identified as key organizations in delivering innovations with high potential. 66.9% of innovators in this category participate in developing innovations with medium potential and only 4.9% innovations with low potential. Regarding the medium capacity innovators category, 8% of organizations were responsible for the development of innovations with high potential and 76.1% for those with medium potential. The distribution patterns in the last category, i.e. low capacity innovators, are consistent. Indeed the majority of innovators in this category participate in delivering innovations with low potential (59.8%). The remaining 40.2% deliver innovations with medium potential, while none of the Low Capacity innovators delivers innovations with high potential.

Figure 12: % of innovators by innovator and innovation categories



Calculations: JRC

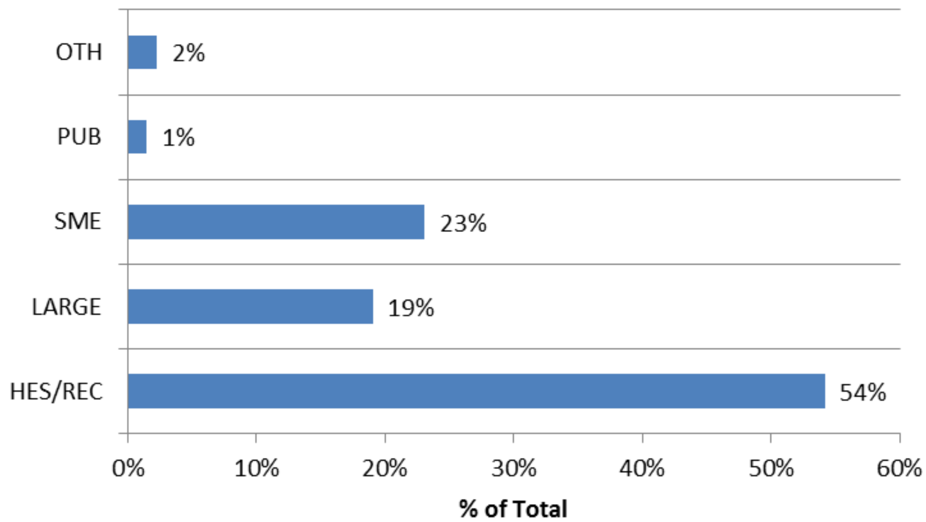
Data: European Commission DG Connect

Note: The figure shows breakdown of innovators by Innovator Capacity and Innovation Potential category. Innovators are defined as key organization behind the innovation according to the answers to the question 12 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

4.4 Type of organizations and their innovations

Figure 13 presents the distribution of key organizations in delivering innovations that were identified during the reviews by organization type. 54% of innovators are Higher Education and Schools and Research Centres (HES/REC), 23% are SMEs and 19% are large enterprises.

Figure 13: % of innovators by organization type



Calculations: JRC

Data: European Commission DG Connect

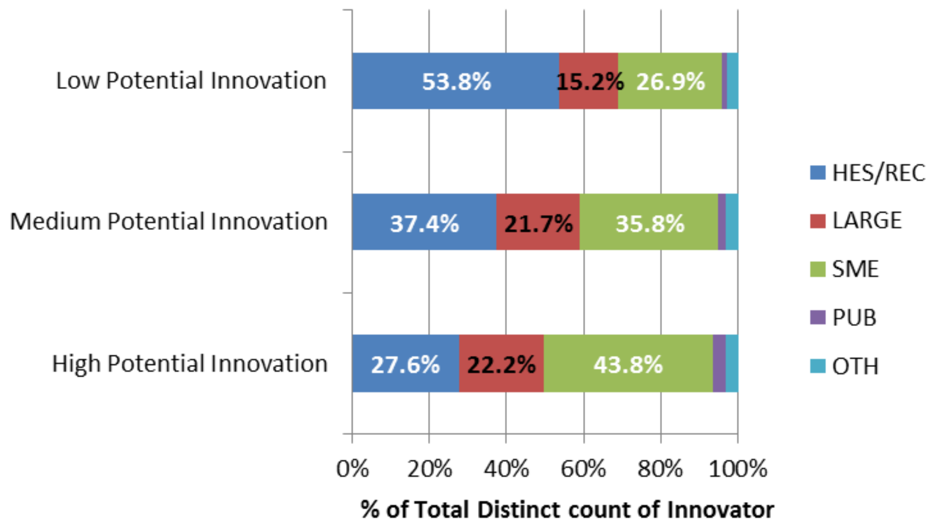
Note: The figure presents the breakdown of innovators by organization type. Innovators are defined as key organization behind the innovation according to the question 12 of the Innovation Radar Questionnaire. Organization types: HES/REC (Higher Education and Schools and Research Centres); PUB (Public Bodies); SMEs (Small Medium Enterprise); LARGE (Large companies), OTH (Other organisations). Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

Figure 14 presents the distribution of key organization type for each innovation potential category. 44% of the key organisations behind innovations with high potential are SMEs.. This is more than three times the share of SMEs in total participation. SMEs accounted in FP7 for 16% of total participations and 15% of total EC funding (EC-CONNECT, 2013). Second in this comparison is the category including HES/REC. Altogether, about 28% of all key organizations behind innovations with high potential are universities or research centres, whereas 22% of them are large companies.

In innovations with low and medium potential, the situation is reversed: HES/REC is the largest group of organizations behind these innovations and SMEs are the second largest group. In both categories, large companies remain in third position. For example, HES/RECs account for 37% and SMEs for 35% of all organizations participating in the development of innovations with medium potential.

In general, there is a positive link between an innovation's potential and an SME being involved in its development. Hence, it can be assumed, that SMEs are important vehicles for co-creating and commercialising innovative technologies developed within ICT FP7 projects.

Figure 14: % of innovators by organization type and innovation potential category



Calculations: JRC

Data: European Commission DG Connect

Note: The figures presents the breakdown of innovators by organization type and innovation potential of their innovations. Innovators are defined as key organization behind the innovation according to the answers to the question 12 of the Innovation Radar Questionnaire. Organization types: HES/REC (Higher Education and Schools and Research Centres); PUB (Public Bodies); SMEs (Small Medium Enterprise); LARGE (Large companies), OTH (Other organisations). Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

4.5 High Capacity Innovators

Table 3 presents the top 10 innovators from the IR sample with the highest ICI scores, together with their names, organization type, place of origin and innovations in which they were identified as being key organizations. The organization with the highest ICI score is Arduino SA, directly followed by Native Instruments GMBH. Both are private organizations: the first is an SME, while the second is a large enterprise. Altogether, the top 10 high capacity innovators participated in the development of 24 innovations. Regarding the potential of the innovations of the top 10 innovators, 13 (54%) are innovations with high potential, 10 (42%) have medium potential and only 1 (4%) has low potential. In other words, high capacity innovators are also associated with innovations with higher potential.

The majority of the top 10 high capacity innovators (50%) are SMEs. The remaining 50% is equally distributed between large companies and higher education and schools and research centres.

Table 3: Top 10 High capacity innovators and their innovations

Rank by ICI	Organistaion name	Organisation type	Country	Region	Project innovation	Nr	Innovation Potential
1	ARDUINO SA	SME	SWITZERLAND	TICINO	SOCIAL&SMART_A	1	High
					SOCIAL&SMART_B	2	High
					PELARS_A	3	Medium
2	NATIVE INSTRUMENTS GMBH	PRC	GERMANY	BERLIN	GiantSteps_B	4	High
					GiantSteps_A	5	Medium
3	PERVOICE SPA	PRC	ITALY		EU-BRIDGE_A	6	High
					EU-BRIDGE_B	7	High
4	HELIATEK GMBH	SME	GERMANY	DRESDEN, KREISFREIE STADT	X10D_A	8	High
5	UNIVERSITAET BREMEN	HES	GERMANY	BREMEN, KREISFREIE STADT	SAPHARI_A	9	High
					COMPASS_A	10	High
6	SIEMENS AKTIENGESELLSCHAFT	PRC	GERMANY	MÜNCHEN, KREISFREIE STADT	MD PAEDIGREE_A	11	Medium
					MD PAEDIGREE_C	12	Medium
					MD PAEDIGREE_B	13	Medium
					CONCERTO_B	14	Medium
					MSP_A	15	Medium
					STREETLIFE_C	16	Medium
7	ERLANG SOLUTIONS LIMITED	SME	UNITED KINGDOM	BERKSHIRE	RELEASE_A	17	High
					PROWESS_A	18	High
8	THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE	HES	UNITED KINGDOM	ESSEX CC	PARLANCE_B	19	High
					ASC-Inclusion_A	20	High
					AP@home_A	21	Low
					BrainScaleS_B	22	Medium
9	EPIGAN BVBA	SME	BELGIUM	ARR. LEUVEN	HiPoSwitch_A	23	High
10	WORLDSENSING S.L.N.E.	SME	SPAIN	BARCELONA	RELYonIT_A	24	Medium

Calculations: JRC

Data: European Commission DG Connect

Note: The table presents the list and characteristics of High Capacity Innovators as defined in section 2.4 and their innovations. Innovators are defined as key organization behind the innovation according to the answers to the question 12 of the Innovation Radar Questionnaire. Organization types: HES/REC (Higher Education and Schools and Research Centres); PUB (Public Bodies); SMEs (Small Medium Enterprise); PRC (Large companies), OTH (Other organisations). Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

4.6 High Capacity SME Innovators

Table 4 presents the top 10 SME innovators with the highest ICI score, together with their names, place of origin and innovations in which they were identified as key organizations. These organizations were identified as key organizations in the development of a total of 11 innovations.

The SME with the highest ICI score is Arduino. Arduino is an open-source electronics platform based on easy-to-use hardware and software[2]. Arduino was identified as a key organization in the SOCIAL&SMART project whose goal was to build up a physical and computational networked infrastructure which allowed household appliances to better meet the needs of their owners. Launched in 2005, Arduino's electronic prototyping platform became a major technological platforms which enabled users to create interactive electronic objects. Between October 2014 and January 2016, the IR identified 3 innovations for which Arduino was identified as a key

[2] https://www.arduino.cc/

organization. For example, together with partners like Gorenje, a leading European manufacturer of home appliances, Arduino was involved in the development of a new WiFi controlling platform for home IoT. As a result, Gorenje's advanced fridge has been enhanced with a WiFi enabled solution, which is expected to be put on the market within the next two years.

Box **1** provides an overview of the development of Arduino and its global community, which is becoming one of the major global technological platforms of software and hardware development.

Regarding the potential of the innovations of the top 10 SME nnovators, 4 were recognised as innovations with high potential. The remaining six are innovations with medium potential.

Table 4: Top 10 SMEs and their innovations

Rank by ICI	Organisation name	Country	Region	Project Innovation	Innovation Potential
1	ARDUINO SA	SWITZERLAND	TICINO	SOCIAL&SMART_A	High Innovation Potential
5	HELIATEK GMBH	GERMANY	DRESDEN, KREISFREIE STADT	X10D_A	High Innovation Potential
8	ERLANG SOLUTIONS LIMITED	UNITED KINGDOM	BERKSHIRE	RELEASE_A	High Innovation Potential
10	EPIGAN BVBA	BELGIUM	ARR. LEUVEN	HiPoSwitch_A	High Innovation Potential
11	DATALASE LTD	UNITED KINGDOM		UV-Marking_B	Medium Innovation Potential
12	WORLDSENSING S.L.N.E.	SPAIN	BARCELONA	RELYonIT_A	Medium Innovation Potential
14	2ND QUADRANT LIMITED	UNITED KINGDOM	KENT CC	AXLE_A	Medium Innovation Potential
17	ONTOTEXT AD	BULGARIA	SOFIA	PHEME_B	Medium Innovation Potential
21	STICHTING EUROPEANA	THE NETHERLANDS	AGGLOMERATIE 'S-GRAVENHAGE	EAwareness_C EAwareness_B	Medium Innovation Potential
24	SPARSITY SL	SPAIN	BARCELONA	LDBC_C	Medium Innovation Potential

Calculations: JRC

Data: European Commission DG Connect

Note: The table presents the list and characteristics of SMEs High Capacity Innovators as defined in section 2.4 and their innovations. Innovators are defined as key organization behind the innovation according to the answers the question 12 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

Box 1: Arduino – Nr 1 innovator among 1,000 organizations participating in the EC-funded research projects

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs (e.g. light on a sensor, a finger on a button, or a Twitter message) and turn them into outputs (e.g. activating a motor, turning on an LED, publishing something online). Users can tell their boards what to do by sending a set of instructions to the microcontroller on the board. To do so they use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Arduino was developed at the Ivrea Interaction Design Institute, Italy, as an easy tool for fast prototyping, and was aimed at students without electronics and programming backgrounds. Soon afterwards, it was released under a Creative Commons licence. As it gained popularity and acceptance among user-innovators, the Arduino board started changing to adapt to new needs and challenges. It differentiated its offer from simple 8-bit boards to products for IoT applications, wearables, 3D printing, and embedded environments. All Arduino boards are open-source, which empower users to build them independently and eventually adapt them to their particular needs. The software is also open-source, and is growing through the contributions of users worldwide (Evans, 2011).

The key element of the Arduino ecosystem is the community around it (Evans, 2011). The community of makers has contributed to the Arduino ecosystem by developing code and libraries, designing new hardware, teaching workshops and classes, and sharing what they have made. Arduino is now being taught in high schools, colleges, and universities everywhere around the world. It is assumed that the number of Arduino members increases by 100,000 per month (SJTU, 2015). A large share of the users and developers come from developing countries. In China, for example, a large part of the community is made up of teachers. They play a critical role in the development of the Arduino ecosystem. They publish documents that can be used to teach Arduino technology in schools and educate new generations of Arduino community members.

When we look at the Arduino case, we see that the technological networks that work on these issues include growing numbers of organizations and individuals. Moreover, the concept of Arduino opens up possibilities that go clearly far beyond hobby activities and have real economic impacts. Today, there is already a range of open source hardware products including synthesizers, MP3 players, amplifiers, high-end voice-over-IP phone routers, mobile phones and laptops (Thompson, 2008). The Arduino ecosystem allows the creation of infrastructure for large technological projects like smart homes or IoT.

There are already a number of companies that have built their business models around the Arduino ecosystem. For example, most of the 13 largest open source hardware companies that, in 2010, earned approximately $50 Mln in revenues, operate within the Arduino community (Torrone & Fried, 2010). By 2010, all of them earned at least $1 Mln in revenues and most of them earned nearer $5 Mln and were involved in hundreds of projects.

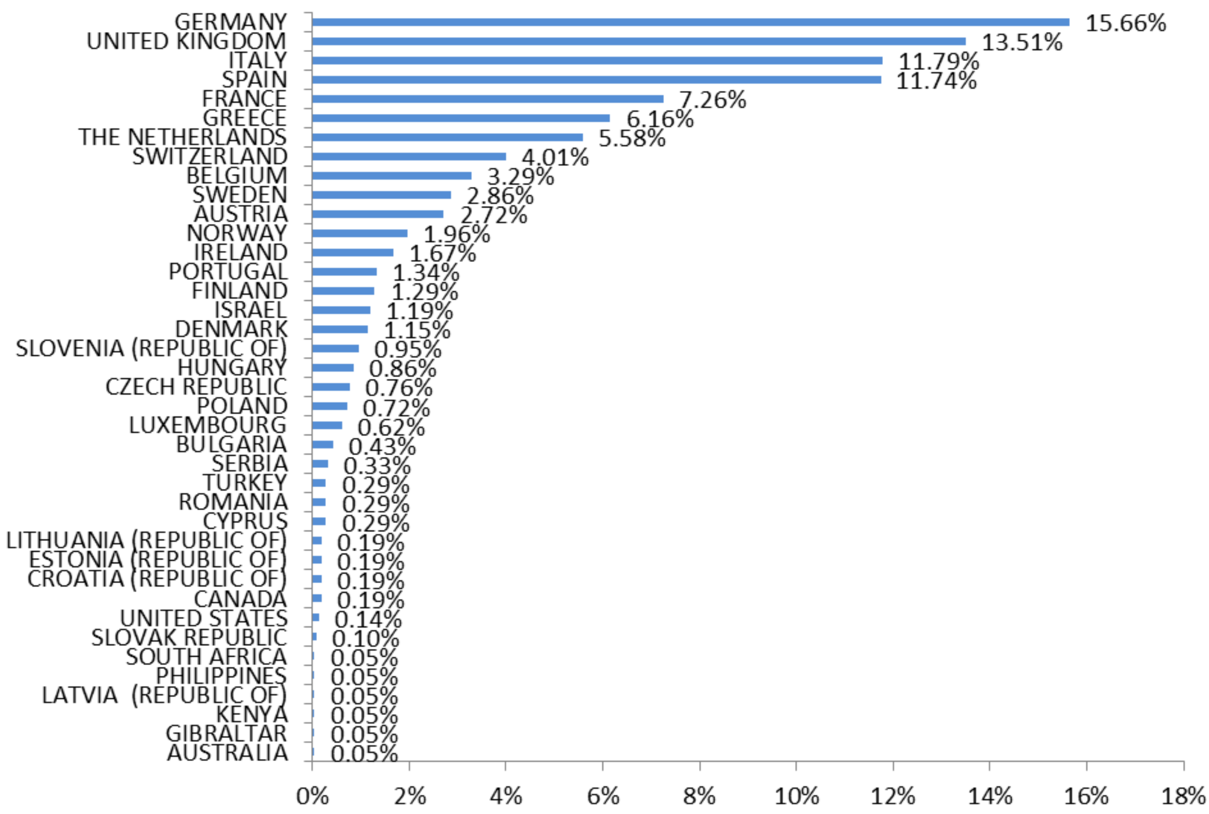
Like Linux for software, Arduino is an example of how the process of innovation has evolved over the last few decades. The development and production of advanced technological products is increasingly taking place within collaborative user communities, rather than within a single, integrated, hierarchical organization.

4.7 Location of innovators

Figure 15 provides a list of countries with the total number of innovators for each. Germany has the most: over 15% of all the key organizations involved in delivering the innovations are from Germany. The UK has 13.51% of the total number of innovators; Italy has 11.79% and Spain

(11.74%). Innovators located outside the EU, are from Switzerland, Norway, Israel, Turkey, Australia, South Africa, Kenya, Philippines, Canada and the US.

Figure 15: Locations of innovators by country



Calculations: JRC

Data: European Commission DG Connect

Note: The figure includes locations of innovators by country of origin, i.e. key organizations in delivering innovations identified in the answers to the question the question 12 of the Innovation Radar Questionnaire. Average IPI score, as defined in section **2.1**, corresponds to the innovations to which innovators from relevant location contribute. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

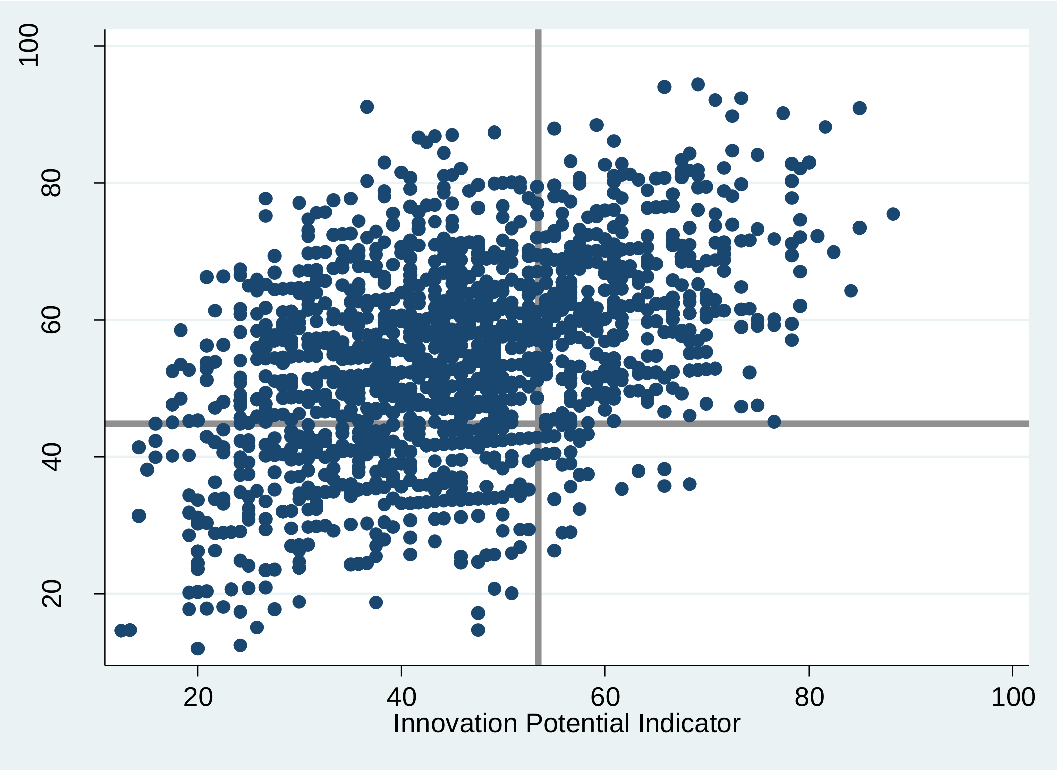
4.8 Innovator capacity and innovation potential

Figure 16 shows the relationship between the innovation potential indicator and innovator capacity indicator values. The correlation coefficient of the two indicators is 0.45. Thus, although overall it can be said that there is a positive relationship between the two indicators, a high score in one indicator does not translate into high performance in the other. In other words, as demonstrated in Section 4.3, there are high capacity innovators that participate in delivering innovations with low or medium potential. By the same token, there are low capacity innovators that were identified as key organizations in developing innovations with high potential.

The best illustration of the fact that there is no clear-cut relationship between innovator and innovation performance is that innovations with medium potential dominate in all categories of innovator capacity. For example, as shown in Figure 12, more than half of all the high capacity innovators (66.9%) were identified as key organizations in delivering innovations with medium potential. This number is even higher for medium capacity innovators (76. 1%).

The above observation leads to the conclusion that improving the overall performance of innovative output requires a focus on both the innovations and the organizations behind them. In the case of innovations, the focus is on increasing their market potential or improving their management. In turn, expanding innovators capacity requires efforts by individual organizations to increase their performance. However, this also depends on their environment, which can positively or negatively affect their innovative outputs.

Figure 16: Relationship between the innovation potential indicator and innovator capacity indicator values



Calculations: JRC

Data: European Commission DG Connect

Note: The figure presents the relationship between innovation IPI score as defined in section 2.1, and the ICI score of the key organization behind the innovation. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

5 Universities as Co-innovators in EC-funded Research Projects

This section tackles questions related to the involvement of different types of organizations in innovation activities, the results of these collaborations, and the role of universities as co-inventors in EC-funded research projects by:

- Looking at the relationship between innovation potential and various types of organizations identified as key innovators (Section 5.2).
- Reporting on the type of innovations developed by different combinations of organizations (Section 5.3).
- Analysing whether the type of organizations has implications for the innovation development stage and their exploitation plans (section 5.4).

This is complemented by an analysis of whether different types of organizations exhibit different needs with respect to innovation commercialisation (Section 7.3).

5.1 In a nutshell

The main findings of the analysis of universities as co-innovators are that:

- Of the innovations with high potential, universities and research centres deliver about 28% whereas SMEs deliver about 44%. However, universities are identified as key co-innovators in over 70% of all the innovations with high potential.
- Collaboration between universities and SMEs delivers the largest share of innovations with high potential (approx. 31%), followed by collaboration between private organisations.
- Collaboration between universities and SMEs seems to be more fruitful than between universities and large firms.
- New products are considerably more often co-developed in the course of collaboration involving universities. Although private-private partnerships are also an important source of new products, they show equal interest in developing new processes and organizational methods. This may suggest that universities are the source of new products that are then channelled through private organizations to the market.
- Innovations co-developed with universities have equal chances of commercial exploitation as those introduced by private-private collaborations.

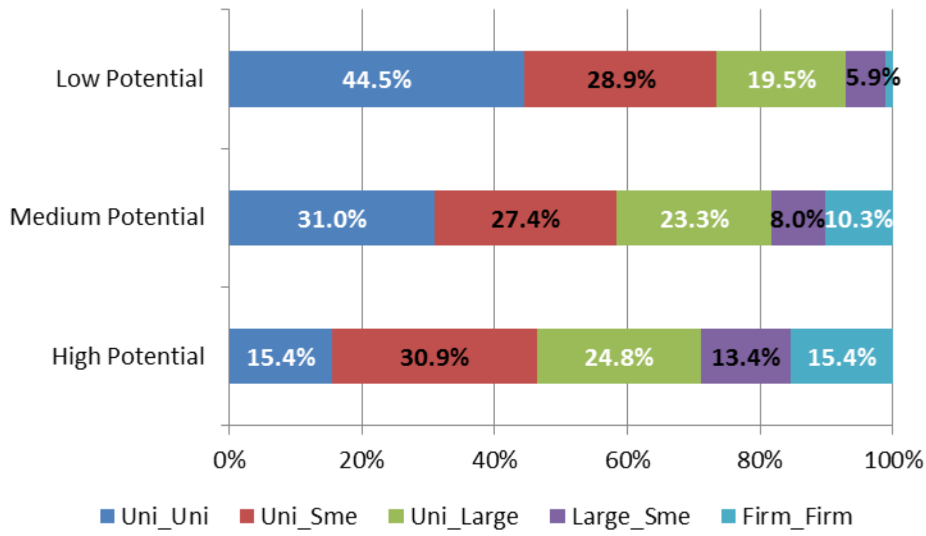
5.2 Collaboration with universities and innovation performance

This section looks at the relationship between innovation potential and the type of organizations involved in its development. In particular, it looks at the question of whether there is a difference in the potential of innovations that were (co-) developed by universities and private organizations, i.e. SMEs and large enterprises.

Figure 13 and Figure 14 present the distribution of the different organisation types by innovation potential. Higher education and schools and research centres (HES/REC) make up the lion's share of the organisations sample (54%). However, they only deliver about 28% of innovations with high potential - less than SMEs which deliver about 44%.

When focussing on cooperation, SMEs are still the pull for the development of innovations with high potential. Figure 17 shows the distribution of pairwise cooperation by innovation potential for all the innovations reviewed. Collaboration between higher education and schools and research centres and SMEs (Uni_Sme) delivers the highest share of innovations with high potential (around 31%). This is followed by collaboration between HES/REC and large organisations (Uni_Large) with 24.8%. The innovation resulting from these two types of collaboration, and the collaboration between private organisations (Firm_Firm[3]) are increasing in innovation potential. On the other hand, when higher education and schools and research centres collaborate among themselves, (Uni_Uni), the innovation potential of the innovative outcome decreasesl, as shown by the 15.4% innovations with high potential and the 44.5% innovations with low potential. However, it has to be taken into account that the Innovation Radar targets innovations that have the potential to be brought to the market in the near future. As discussed above, consistent with their status and mission, the main reason universities participate in EU-funded research projects is to develop research and technology. Therefore, the critical issue is collaboration between private organizations aiming at commercialisation of the research results.

Figure 17: % of innovators by collaboration type and innovation potential category



Calculations: JRC

Data: European Commission DG Connect

Note: Innovators are defined as key organization behind the innovation according to the answers to the question 12 of the Innovation Radar Questionnaire. Collaboration types: Uni_Uni (Higher Education and Schools and Research Centres); Uni_Sme (Higher Education and Schools and Research Centres and SMEs); Uni_Large (Higher Education and Schools and Research Centres and Large companies); Large_Sme (Large companies and SMEs); Firm_Firm (private organisations of the same entity, i.e. Large_Large or Sme_Sme). Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

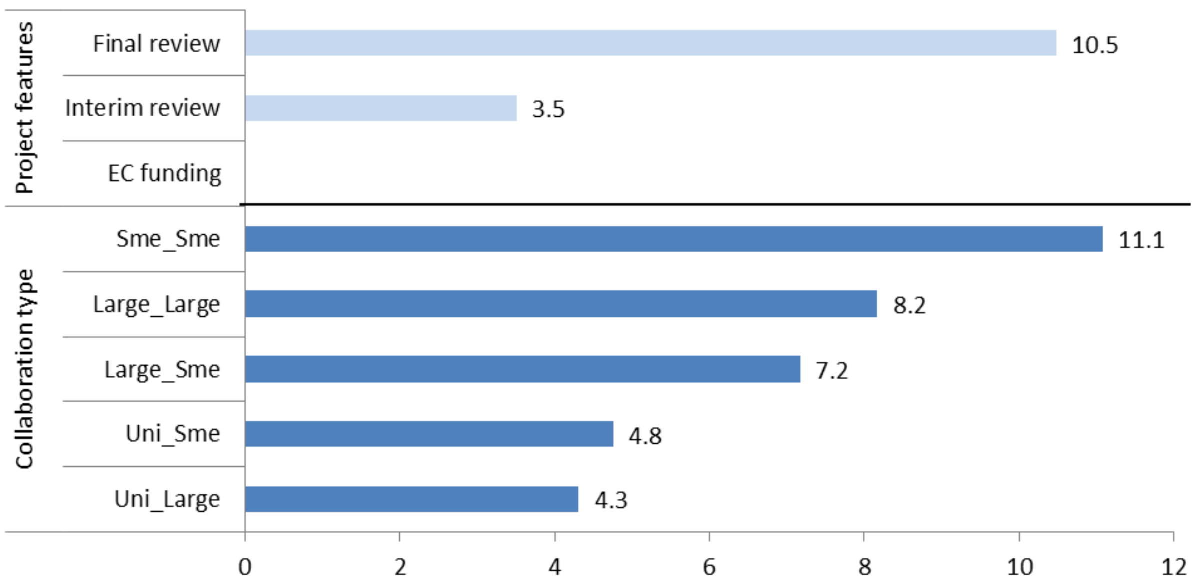
Taking into account the above, and in order to see what type of collaboration increases the innovation potential and commercialization of innovations developed in EU-funded research project, an additional analysis was performed. Figure 18 presents the coefficient estimated by a linear regression model which investigates the impact of different types of collaboration and project characteristics, i.e. the time of the review (when the project was evaluated) and the EC contribution to the project, on innovation potential. The reference baseline of the regression model is collaboration between HES/REC (Uni_Uni) and first project review. Regarding the collaboration type, the collaboration between private organizations (Sme_Smes, Large_Large and Large_Sme) had the strongest effect on innovation potential. On average, the potential score of innovation co-developed by at least two private firms is about 10 points higher than it is when an innovation is co-developed by universities. Collaboration between SMEs has the highest coefficient. Again, this does not come as a surprise, as firms have stronger incentives and capacities to bring technology to the market. Therefore, what is considerably more interesting is the effect of collaboration between universities and different types of private firms. There one can observe that innovations

[3] The category Firm_Firm is built taking into account all the collaborations between private organisations of the same entity. That is, either Large_Large or Sme_Sme.

co-developed by universities and SMEs have, on average, higher innovation potential scores than those co-developed by universities and large firms. Whereas innovations co-developed between universities and SMEs have a 4.8 point higher score, as compared to the reference point, those that are co-developed by universities and large firms have a score of only 4.3. This observation is consistent with previous findings that indicate that SMEs benefit more than large firms from collaboration with universities in publicly-funded research projects (Okamuro, 2007).

As expected, a review later in the life of the project finds that the average value of the innovations developed has increased. This confirms previous observations, which suggest that ideas and technologies developed during EU-funded research projects mature and increase their potential as projects advance. On the other hand, the amount of EC funding allocated to the project does not seem to affect the potential of the innovation.

Figure 18: Linear estimates of innovation potential indicators and innovation partnerships



Calculations: JRC

Data: European Commission DG Connect

Note: OLS robust standard errors, number of observation: 1,426; R-squared: 0.14 . Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

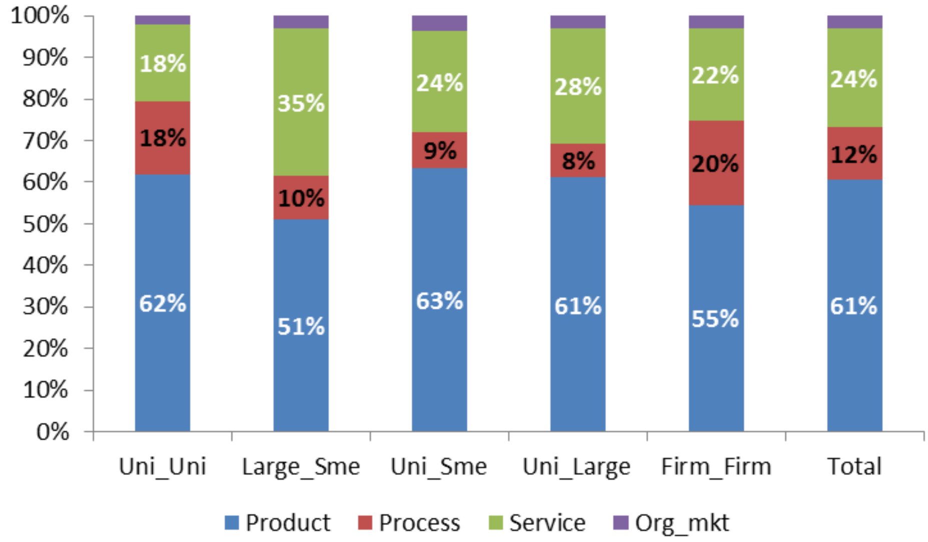
To conclude, the importance of SMEs in delivering innovations with high potential is observed also when looking at the different type of collaboration between projects. Interestingly enough, when private organisations pair together they increase their probability of delivering innovations with high potential while the same is not true for HES/REC. This may suggest the need for support for HES/REC to increase the market potential of the innovations developed.

5.3 Innovation type and collaboration type

The Innovation Radar characterises the types of innovation by distinguishing between new or significantly improved product, process, service, marketing and organisational method. Based on this information, Figure 19 presents the relationship between the mix of organizations involved in innovation (co-) development and the type of innovation.

Over 50% of the innovations are product innovations, followed by service and process. At the same time, very few innovations belong to organisational and marketing method that accounts for only 3% of the total innovation output.[4] As shown by the figure, the distribution of the innovation type is relatively stable across the different organisation composition. However, new products are considerably more often co-developed in the course of collaboration involving universities. For example, 63% of innovations developed by university and SMEs are new product. In contrast, only 51% of innovations delivered as a result of collaboration between SMEs and large firms are new products. The remaining half represents innovations that can be described as new processes, services or organizational methods. This can suggest that universities are a source of novel technologies that are channelled through private organizations to the market.

Figure 19: % of innovators by collaboration and innovation type



Calculations: JRC

Data: European Commission DG Connect

Note: Innovators are defined as key organization behind the innovation according to the answers to the question 12 of the Innovation Radar Questionnaire. Collaboration types: Uni_Uni (Higher Education and Schools and Research Centres); Uni_Sme (Higher Education and Schools and Research Centres and SMEs); Uni_Large (Higher Education and Schools and Research Centres and Large companies); Large_Sme (Large companies and SMEs); Firm_Firm (private organisations of the same entity, i.e. Large_Large or Sme_Sme). Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

5.4 Innovation stage and exploitation plans

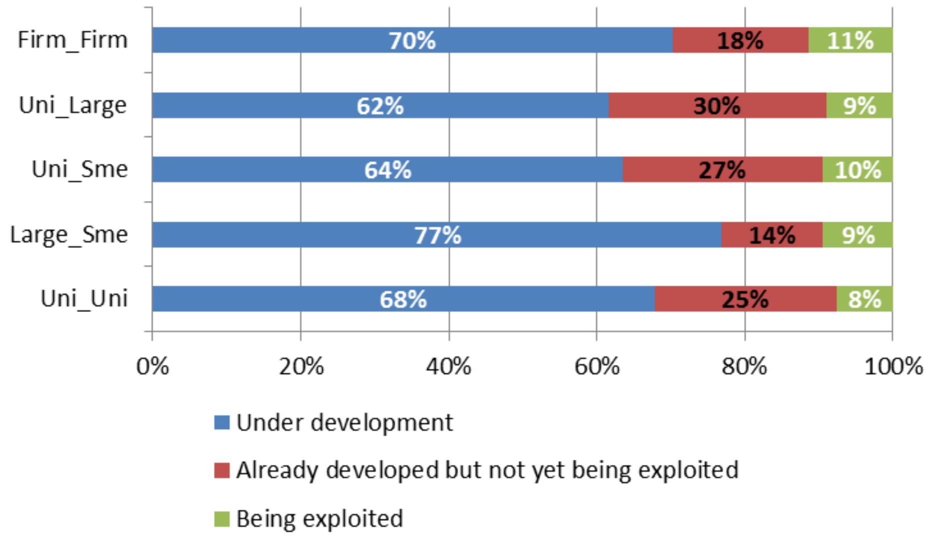
This section deals with the question of whether there is a pattern in the innovation development stage and exploitation plans depending on the type of organizations involved in its (co-) development. The idea is that organisations of different types may apply for EC projects at different stages of their innovation development. Indeed, one could expect that private organisations may apply for public funding after having already initiated the development of the innovation, while universities are more likely to start innovation development after having been granted public funding.

Figure 20 shows the percentage of innovators by cooperation type and innovation development. Figure 20 shows there is no clear pattern. Even when focussing on collaboration between organisations of same type, the relative differences between innovation stages are negligible and do not bring additional information on the exploitation plans deployed by the distinct organisations.

[4] For simplicity of presentation, possible innovation output was grouped into four categories, combining organisational and marketing method.

In order to ensure the results were not influenced by when the review took place, we also analysed jointly the different types of collaboration at the different stages of the review process. The results didn't show any major differences across organisation type, apart from a general trend for all organisations towards a higher percentage of innovations "Already developed but not yet being exploited" and innovations "Being exploited" in the final period of the project.

Figure 20: % of innovators by collaboration type and innovation development



Calculations: JRC

Data: European Commission DG Connect

Note: Innovators are defined as key organization behind the innovation according to the answers to the question 12 of the Innovation Radar Questionnaire. Collaboration types: Uni_Uni (Higher Education and Schools and Research Centres); Uni_Sme (Higher Education and Schools and Research Centres and SMEs); Uni_Large (Higher Education and Schools and Research Centres and Large companies); Large_Sme (Large companies and SMEs); Firm_Firm (private organisations of the same entity, i.e. Large_Large or Sme_Sme). Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

6 The role of end user engagement for innovation potential

In the past decades, the innovation model has shifted from a linear model where end-users intervene only at the very end of the process to a more collaborative model where end-users actively contribute to the innovation process. The increasing importance of the role of end-users in innovation processes has been highlighted in the work of Chesbrough (2003) and von Hippel (2005), who both recognize end-users as important sources of valuable ideas for firms. The Innovation Radar recognises the importance of end-users being close to the innovation process and reports on the engagement of end-users in the project consortium. Below, we show how the engagement of end-users affects the innovation potential of the projects.

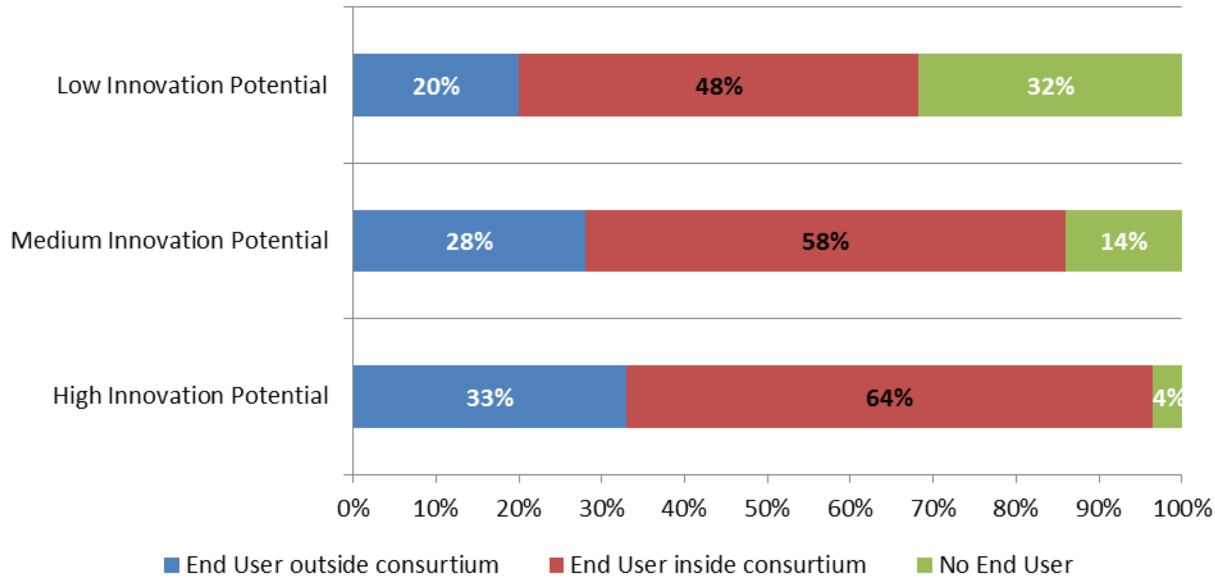
6.1 In a nutshell

The analysis of end user engagement in the project consortium produced the following main findings:

- There is a positive relation between the engagement of end-users and innovation potential. High Innovation potential projects report the highest share of end-users engagement. The share of end-users engagement inside the consortium is 64%, and 33% for end-users outside the consortium.
- End-users engagement– both internal and external to the consortium- positively affects the level of commitment of relevant partner in exploiting the innovation. Projects with high shares of end-users engagement (32% when end-users are inside the consortium and 16% when outside the consortium) show a "High" level of partners' commitment.

Figure **21** shows the distribution of end-users across projects by innovation potential. End-users could either belong to the consortium or be external to the project. High innovation potential projects report the overall highest share of end-user engagement: 64% (part of the consortium) and 33% (outside the consortium). Interestingly the low innovation potential projects account for the lowest rate of end-user engagement. Indeed, the percentage of low innovation potential projects that declare no end-user engagement is above 30%. We do not have the necessary information for assessing whether a causal relation between end-user engagement and innovation potential exists. However, the data confirms a positive relation between the engagement of end-users and innovation potential.

Figure 21: End user engagement by innovation potential



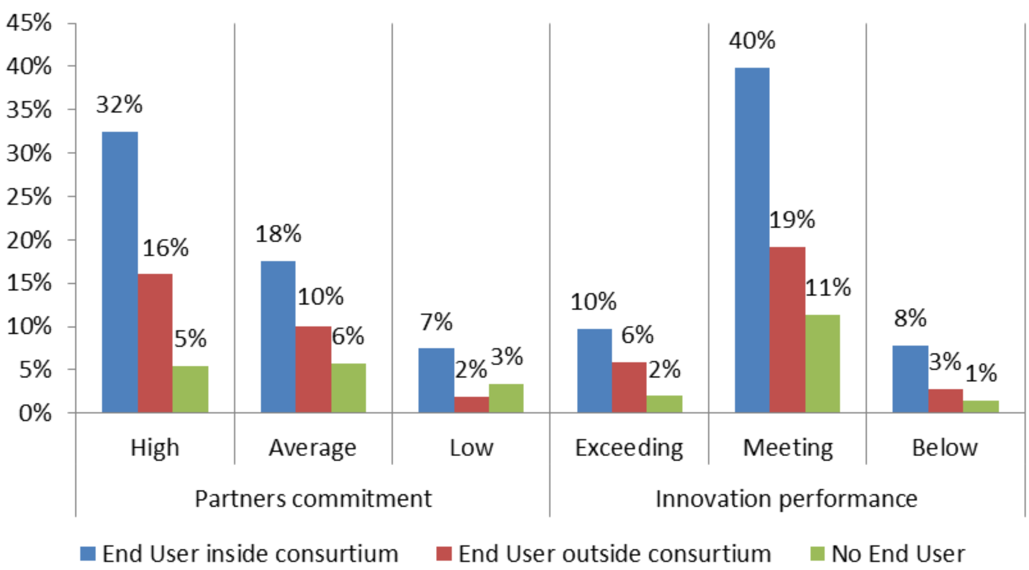
Calculations: JRC

Data: European Commission DG Connect

Note: The computations were based on the responses to general question 1 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

End-user engagement may also affect the overall innovation performance of the project and the level of commitment of relevant partners in exploiting the innovation. Figure **22** presents data on the project partners' commitment and innovation performance. The data suggest that end-user engagement – both internal and external to the consortium - increases the level of commitment of relevant partners in exploiting the innovation. On the other hand, the results in terms of innovation performance do not show that end-user engagement directly improves the project.

Figure 22: End user engagement by partners' commitment and innovation performance



Calculations: JRC

Data: European Commission DG Connect

Note: The computations were based on the responses to general question 1, 6 and 8 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

7 Steps and barriers to innovation commercialisation

This section deals with three issues concerning innovation commercialisation. First, it presents the responses to the questions on the steps that organizations undertook or plan to undertake in order to bring the innovations to (or closer to) the market. Second, it provides an overview of what innovators need to fulfil the market potential of their innovations and, finally, it shows what the most common bottlenecks to innovation commercialization are.

7.1 In a nutshell

The main findings of the analysis of steps and barriers to innovation commercialisation include:

- When taking innovations to the market, projects focus more on technology-related steps than business-related ones. 66.4% of the projects that plan to commercialise their innovations undertake, or plan to undertake, demonstration or testing activities. In contrast, only 40% of projects have carried out, or plan to carry out, a market study. A business plan is on the agenda of only 36% of projects that plan innovation commercialisation.
- Activities that involve participations or interactions with actors outside of the projects are relatively uncommon. Only 4.5% to 9% of the projects have sought, or are planning to seek, private or public funding.
- Three of the most common needs are partnership with another company (19.5%), business plan development (16.7%) and expanding to more markets (14.9%).
- The least frequently named needs include incubation (6.4%), participation in a start-up accelerator (5.9%) and investor readiness training (5.6%).
- 30.7% of project partners see financing as the major external bottleneck to innovation exploitation.
- Only 2.5% of the project partners consider trade issues between Member States and the rest of the world as a barrier to exploiting their innovative products or services.

7.2 Steps to innovation commercialisation

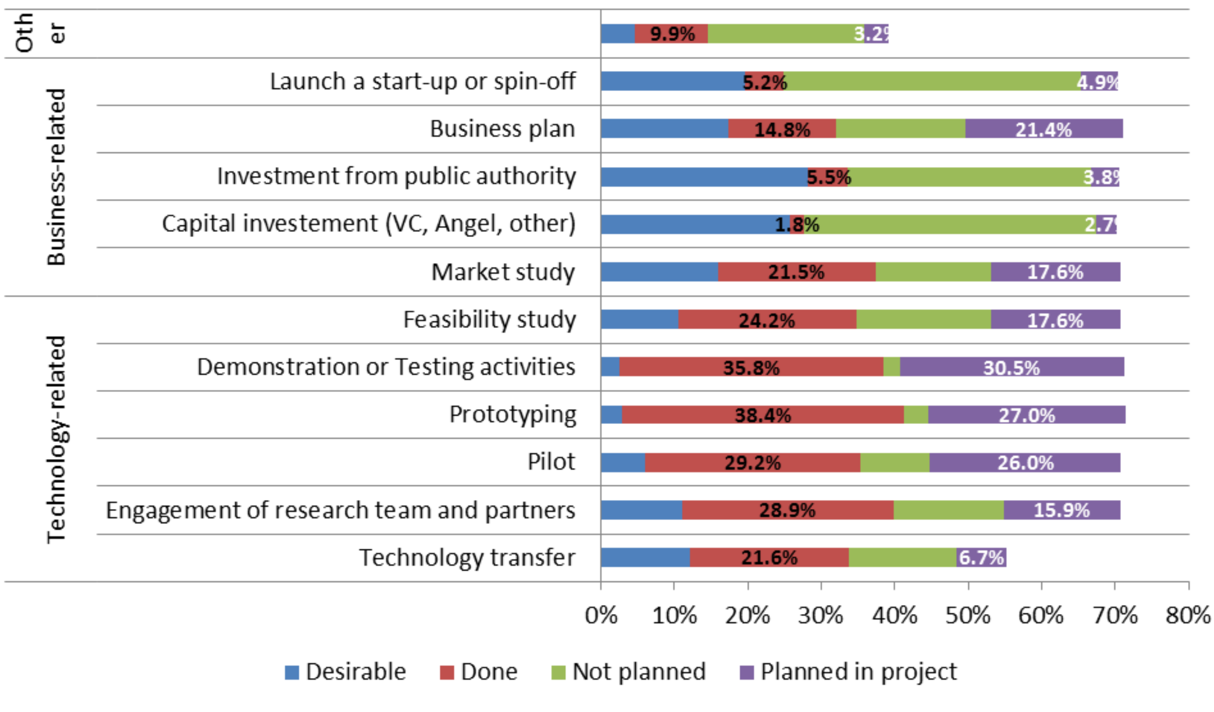
Figure 23 indicates what steps have already been taken or are planned by projects to bring their innovations to (or closer to) the market. This figure distinguishes between technology-related steps (e.g. feasibility study or prototyping) and business-related steps (e.g. business plan or capital investment).

Concerning technology-related steps, prototyping and demonstration or testing activities are the most common measures that projects undertake in order to bring their innovations to the market. Of the projects that are plannng to introduce their innovations to the market, 66.4% is either undertaking or planning demonstration or testing activities. or creating or planning to develop a prototype (65.4%). Developing a pilot (55.2%) is also quite common. Among the most desirable steps that have not been taken or planned, are feasibility studies, engagement by industrial research team of one of their company's business units in project activities and technology transfer. Around 12% of projects that are planning to introduce their innovations to the market perceive that these activities will facilitate innovation commercialisation.

With respect to business-related steps, Figure 23 shows that carrying out a market study and writing a business plan are among the most common steps that help to commercialise innovations. Around 40% and 36% of projects have carried out or plan to carry out a market study and write a business plan. At the same time, around 16% of the projects see these steps as desirable and between 16% and 18% have not planned them in the course of innovation commercialisation. A significantly smaller number of projects consider undertaking steps like launching a start-up or a spinoff or seeking funding. For example, between 5% and 9% of the projects have sought, or are planning to seek, private or public funding and between 25% and 28% of the projects consider this step as desirable. At the same time, between 40% and 33% of the projects do not plan to seek capital or public investment.

The evidence presented above leads to the following conclusions: First, the technology-related steps to bring innovations to the market are seen as more important than business-related ones. Organizations very often focus on making sure that the innovation they develop is ready to be commercialised from the technological point of view. To this end, projects create a prototype or perform demonstrations or testing activities. Relatively often, organizations do not undertake or plan business-related steps. Second, in both cases, i.e. technology- and business-related activities, the emphasis is on what can be done within the project and among the participants. Activities that involve interactions with actors outside of the projects or participation by them are less common, particularly as regards seeking external funding. Only a few projects see these activities as relevant to the commercialisation of innovations and many of them do not plan to undertake them. This calls for two kinds of support. First, projects should be encouraged to look beyond the technological aspects and introduce business-related elements to their activities. Second, they should be encouraged to increase interaction with external specialised actors, e.g. business coaches or venture capitalists, as this could help them to improve the commercialisation chances of their innovations.

Figure 23: Progress of projects in bringing innovations to the market



Calculations: JRC

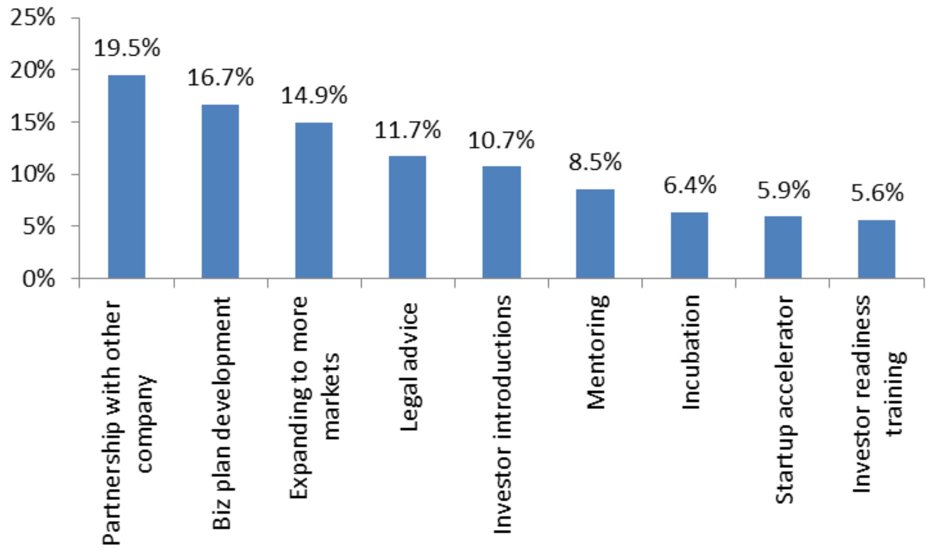
Data: European Commission DG Connect

Note: The computations were based on the responses to question 10 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

7.3 Innovators need to realise the market potential of innovations

Figure 24 presents the responses to the question: what do innovators need to realise the market potential of their innovations? The most common needs are seen as partnerships with other companies, business plan development and expanding to more markets. The least frequently named needs include investor readiness training, participation in a start-up accelerator and incubation.

Figure 24: Innovators' needs to fulfil the market potential of their innovations



Calculations: JRC

Data: European Commission DG Connect

Note: The computations were based on the responses to question 13 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

7.4 Type of organization and need to realise the market potential of innovations

Below, we analyse whether the fact that an innovator is a university or private organizations has any implications for the further support needed to bring its innovation to the market.

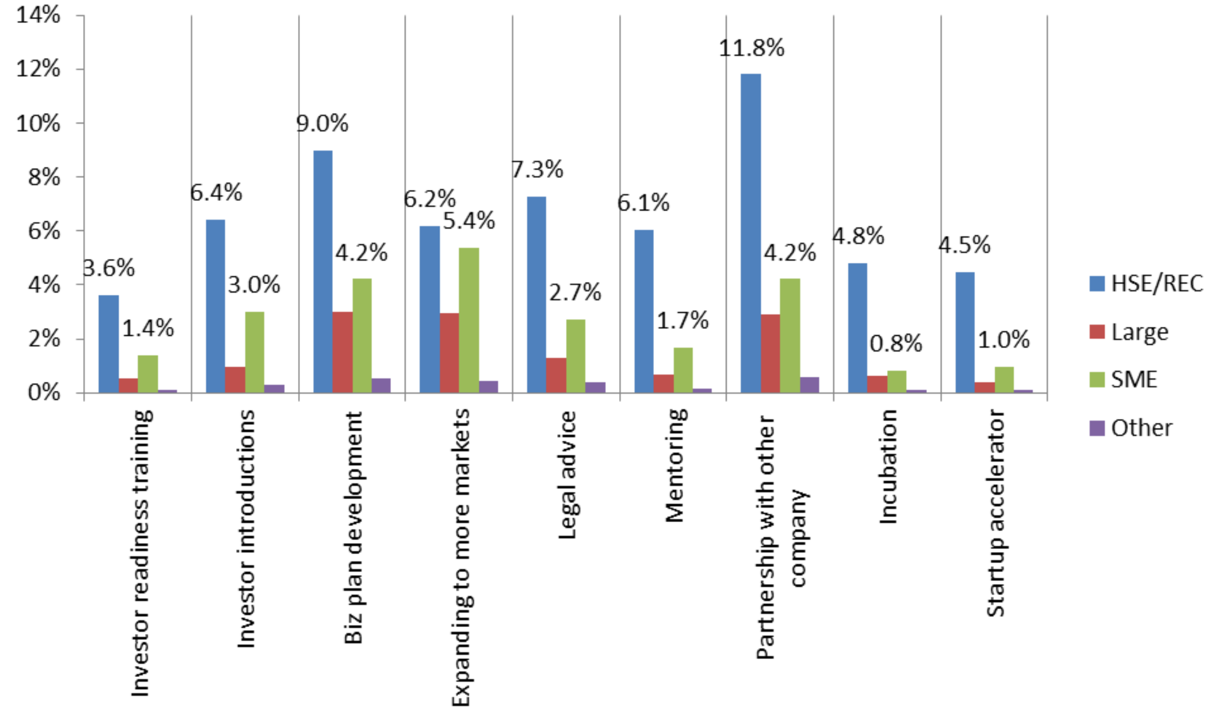
Figure 25 presents innovators' needs to fulfil the market potential by organisation type. As already shown in Figure 24, the most common need reported is partnership with another company (19.5%). The breakdown by organisation type shows that the most common need reported by higher education and schools and research organisations (HSE/REC) is partnership with another company (11.8% of the total needs, or 60.5% of the specific needs), followed by business plan development (9% or 54%) and legal advice (7.3% or 62%). For private organisations, the most common needs reported are expanding to more markets and developing a business plan (between 5% and 3% respectively). Moreover, in general HES/REC seem to report more needs than private organisations.

In order to better analyse the differences between organisations in reporting potential market needs, we ran a multinomial logistic regression and reported the resulting marginal effects in Figure 26. The figure shows that we can identify clearly different patterns for HES/REC and private organisations. The figure also shows the probability of reporting a specific need, all other things remaining constant, for specific organisations.

For HES/REC the probability of reporting needs such as start-up accelerator, incubation, partnership mentoring and legal advice are all positive and range from 10 to 20%. On the other hand, being an HES/REC reduces the probability of reporting needs such as expanding to more markets or developing a business plan. The situation is completely the reserve for private organisations, where both large enterprises and SMEs are more likely to report the latter as their most common needs. Private organisations diverge only with respect to investor introductions, which are more relevant for SMEs and HES/REC than they are for large enterprises.

The results of the analysis suggest that HES/REC tend to report more needs related to the finalisation of the innovation and the subsequent steps to bring it to the market, while private organisations needs are more related to the commercialization of the innovation and the need to create or expand their markets.

Figure 25: Innovators' need to fulfil the market potential by organisation type

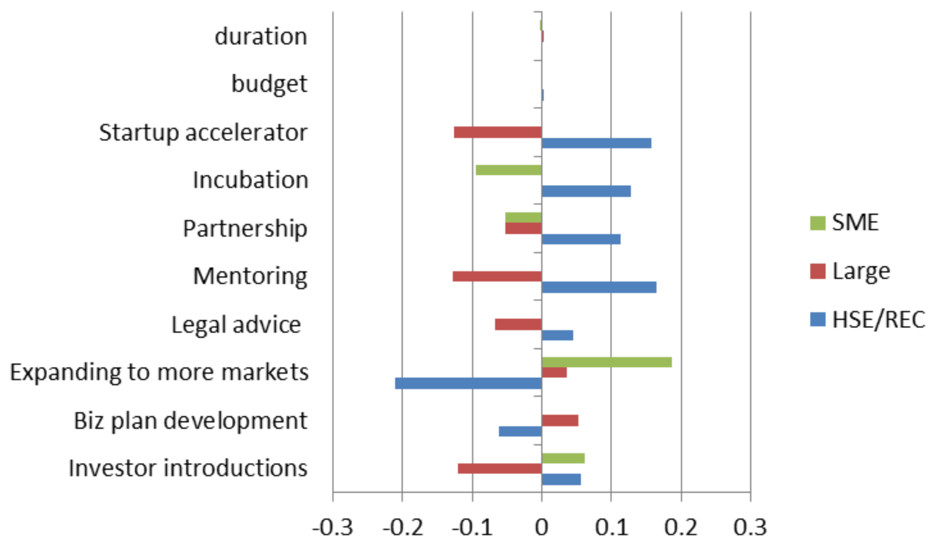


Calculations: JRC

Data: European Commission DG Connect

Note: The computations were based on the responses to question 13 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

Figure 26: Marginal effects of potential market needs by organisation type



Calculations: JRC

Data: European Commission DG Connect

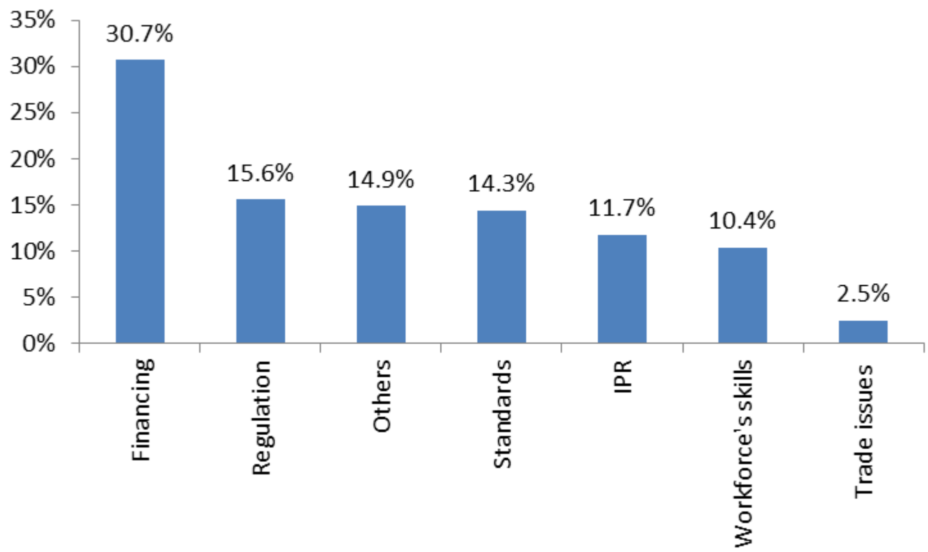
Note: Marginal effects multinomial logistic regression, number of observation:2,095. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

7.5 Bottlenecks to innovation commercialization

Figure 27 presents responses to the question of what are the external bottlenecks that compromise the ability of project partners to exploit new products, solutions or services, internally or in the market place. For the majority of project partners (30.7%), lack of financing is seen as the major external bottleneck to innovation exploitation. Regulation and standards account for 15.6% and 14.3% respectively, together with the generic group "others". IPR and workforce skills are considered as relatively important. Around 10% of the projects perceive at least one of the two issues as an external factor that could threaten the ability of project partners to commercially exploit innovations. Among the bottlenecks seen as least harmful are trade issues between Member States and the rest of the world. Only 2.5% of the project partners consider these as barriers to exploiting their innovative products or services.

Comparing the steps that organizations undertook, or plan to undertake, in order to bring their innovations to (or closer to) the market (see Figure 23) and the information presented in Figure 27 leads us to observe an apparent contradiction between what project organisations claim to be a barrier and their actual behaviour. While 30.7% of project partners see lack of financing as a barrier to exploiting their innovative products or services, only 5% to 9% of the projects have sought, or are planning to seek, private or public funding. Moreover, between 33% and 40% of the projects do not plan to seek capital or public investment. This point is further emphasised by the fact that organizations most commonly declare that they need partnerships with other companies and to expand to more markets in order to realise the market potential of their innovations.

Figure 27: External bottlenecks that compromise the ability of project partners to exploit innovations



Calculations: JRC

Data: European Commission DG Connect

Note: The computations were based on the responses to general question 4 of the Innovation Radar Questionnaire. Total number of reviewed projects: 603. Total number of innovations: 1128. Review period: 01.10.2014 and 18.01.2016.

8 Conclusions

This section summarises the key messages from the analysis of the IR data. These focus specifically on the role of collaboration between universities and private organisations.

Nurturing business culture among innovators

The current analysis shows that the key organizations behind ICT FP7/Horizon2020-related innovations tend to have high levels of technological involvement, but pay less attention to the business-related dimensions of their innovations. It seems that there is a strong need for projects to look beyond the technological aspects and introduce business-related elements into their activities. This can be achieved by providing incentives for increasing interactions between projects and external specialised actors, e.g. business coaches or venture capitalists, who could help to improve the commercialisation chances of innovations.

Another interesting aspect emerging from the IR data is the high participation and active role of SMEs in delivering innovations with high potential. SMEs are an important vehicle for co-creating and commercialising innovative technologies developed within ICT FP7/Horizon2020 projects.

Industry-university collaboration

Collaboration between universities and industry plays a crucial role in driving innovation processes. Universities possess essential skills for innovation supplied to business. They are the basis of the knowledge-based economy. The close collaboration between university and industry poses a series of policy questions on how to foster this collaboration and what kind of policy support should be implemented.

The IR data showed that universities are key co-innovators in over 70% of all innovations with high potential. Collaboration between universities and SMEs delivers the largest share of innovations with high potential and seems to be more fruitful than the collaboration between universities and large firms. This may suggest that universities are a source of innovative products that are channelled through private organizations to the market and that SMEs form a better bridge to universities in this process. Finally, innovations co-developed with universities are as likely to be commercially exploited as those introduced by private-private collaborations.

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