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Analysis on current and future capabilities requirements of Key Enabling Technologies (KETs) in Advanced manufacturing

REPORT

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Introduction

The development of Advanced Manufacturing becomes the industry answer to the changes of trends and high-impact global changes within the industrial sector. PROVET 4.0 project is designed from the basis of a lack of specific training in KETs for Advanced manufacturing. The new European industrial revolution marked by the advancement of technologies applicable to the industry, demands high R&D intensity, rapid innovation cycles and more skilled jobs.

PROVET 4.0 contributes to this need, by helping industrial workers and VET learners to be qualified, acquiring skills and competences for KETs for Advanced manufacturing in:

- additive manufacturing;
- collaborative robotics;
- cyber-physical systems;
- augmented reality;
- cloud computing;
- big data.

The report summarises the results of a short survey carried out among companies, mainly SMEs, in three regions across Europe, Basque Country (Spain), Auvergne-Rhône-Alpes (France), Veneto (Italy). The survey aims to identify current experiences and future competences requirements of Key Enabling Technologies (KETs) in Advanced manufacturing.

32 questionnaires were collected from enterprises. Given the limited scope of the survey, **qualitative results will be highlighted**, although it will be necessary to carry out a more extensive research which could be also statistically relevant.

Methodology

Scope

32 Companies, mainly SMEs in three regions across Europe, Basque Country (Spain), Auvergne-Rhône-Alpes (France), Veneto (Italy)

Definition of Survey Questionnaire (EN, ES, IT, FR)

The Questionnaire was designed by Confindustria Veneto SIAV in English and then translated into the three national languages of each country involved. Answers were clustered according to four macro-issues:

Cluster 1 “Respondents features” (Basic data about the company)
Cluster 2 “Previous knowledge /organizational readiness” (Q1-Q6)
Cluster 3 “Technologies” (Q7-Q8)
Cluster 4 “Trends and Human resources” (Q9-Q10)

Data collection's methodology and Respondents' rates

Data were collected in March 2016 through two channels Online and Face-to-face. The choice of the channel and the country-specific digital readiness influenced the respondent's ratio. Spain and France choose to send the questionnaire via email, each email included the link to a dedicated Google module in national language. Italian companies filled the questionnaire face to face, supported by two researchers which eventually clarified questions and concepts.

Spain: online collection among 800 companies – 1,5%
Italy: face to face collection among 33 companies – 90%
France: online collection among 50 companies – 22%

Results

Cluster 1 "Respondents features" (Basic data about the companies)

Sectors

SPAIN: 10 Metal/ components – 1 Engineering
ITALY: 8 Metal/ Electronics/ Lighting – 1 Food – 1 Engineering
FRANCE: 7 Metal/ Electronics – 1 Chemical – 3 Engineering/ Technology

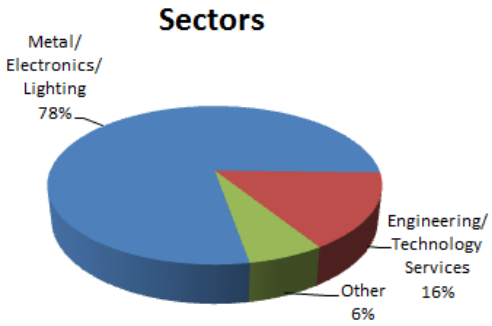

Fig. 1

Companies Size

SPAIN: 2 Large enterprises, 4 Medium, 5 Small
ITALY: 2 Medium, 6 Small, 2 Micro
FRANCE: 4 Large, 4 Medium, 3 Small

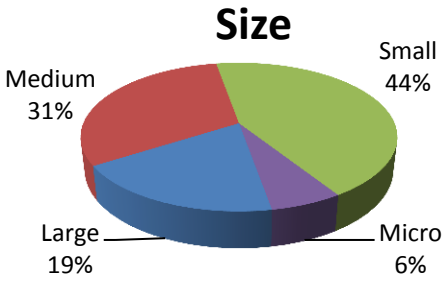

Fig. 2

Position in the Supply Chain

SPAIN: 10 B2B, 1 (small) B2C
ITALY: 5 B2B, 8 B2C (3 companies are both B2B and B2C)
FRANCE: 8 B2B, 3 B2C

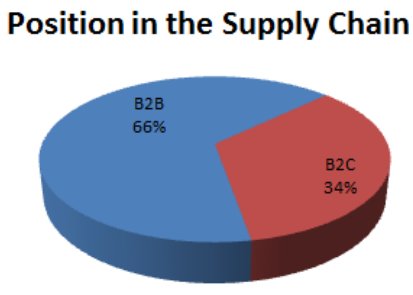

Fig. 3

Cluster 2 "Previous knowledge /organizational readiness" (Q1-Q6)

Advanced Manufacturing: Concepts & applications

Most of the companies heard about the **Industry 4.0 concept**, reflecting their relationship (either as customers or suppliers) of German-based enterprises. Smart Factory is also a recognized term related to Advanced manufacturing. The Digitalisation issue is particularly relevant in Spain, mainly pushed by policy actions.

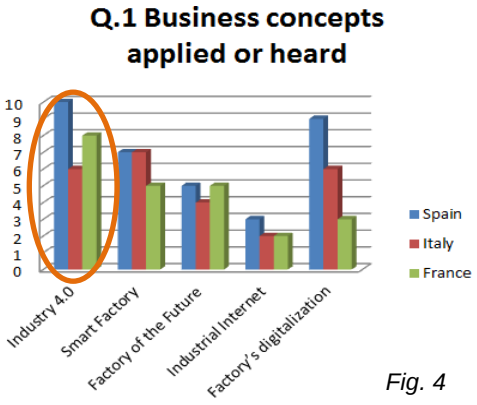

Fig. 4

Industry 4.0's **main application** is currently **Additive Manufacturing**, while Augmented Reality is barely applied in France and unexploited in Spain and Italy.

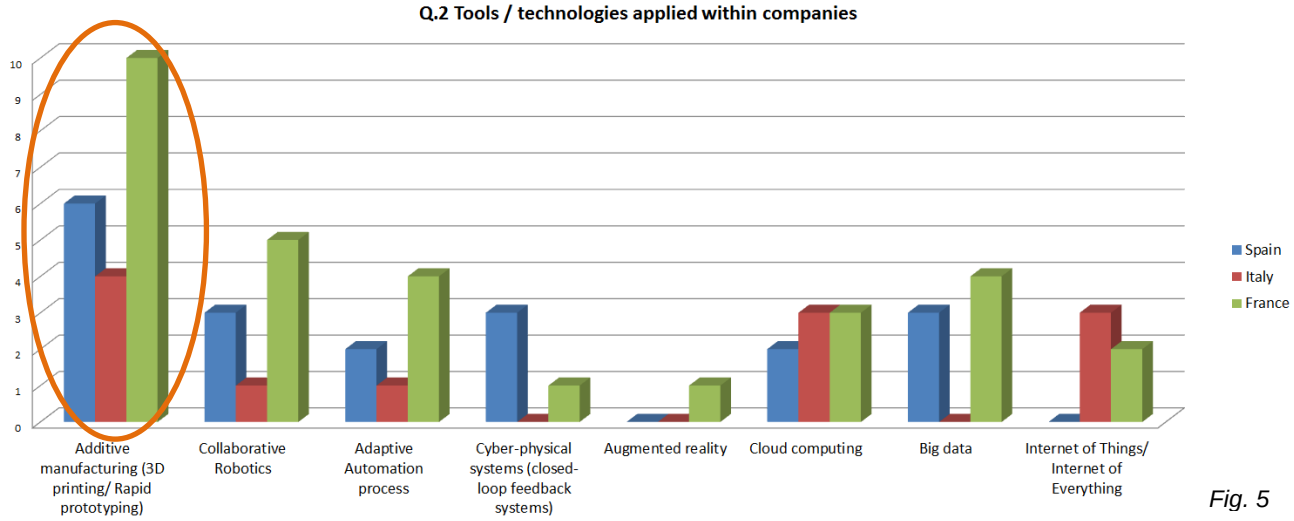

Fig. 5

Process and Product's Digitalisation

Companies where asked to define to what extent they applied digitalization to the manufacturing processes (Q.3) as well as into their product design and delivery to the market (Q.4).

Results show how French companies already strongly or partially applied digitalization to their process management and product development and delivery, Italian companies apply it only partially or weakly, while Spanish companies implement it only partially or not at all.

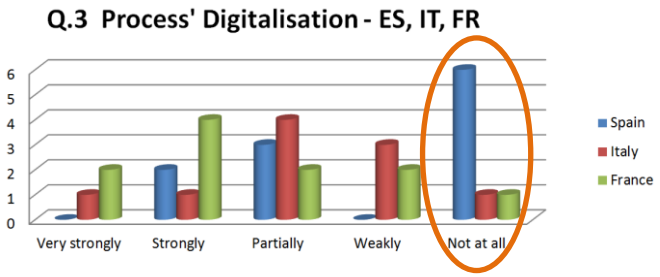

Fig. 6

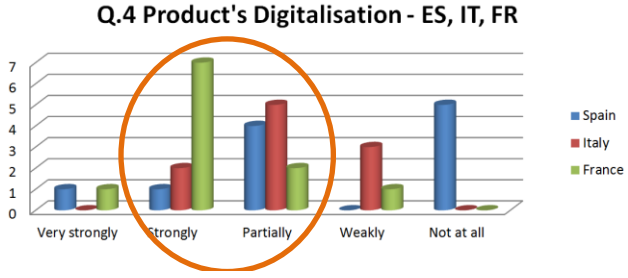

Fig. 7

As a general trend, the **digitalization of product** is applied (strongly or partially) by 65% of the companies interviewed, while process digitalization is applied by 50%.

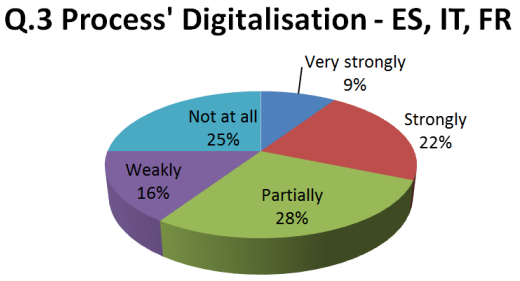

Fig. 8

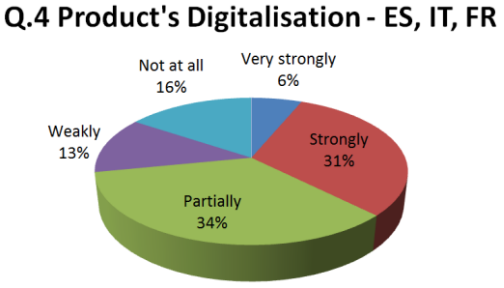

Fig. 9

<u>Expected Impact of Technologies</u>

Companies where asked to estimate the impact of the technologies applied in each unit /area. Seven areas were considered:

1. Research and Development (R&D)
2. Production
3. Logistics / Warehouse
4. Administration / HR management
5. Service
6. Sales
7. Purchases/ Procurement

According to companies, the most relevant effects are expected on R&D, as 68% of interviewees foreseen a very strong or strong impact, on production (63%) and on sales (54%). Expected impact on production is particularly relevant in Spain and Italy, while impact on sales is relevant for Spanish and French companies. On the other end of the scale, weak or no impact is foreseen in Administration and HR management, as shown by the figures 10-13 below.

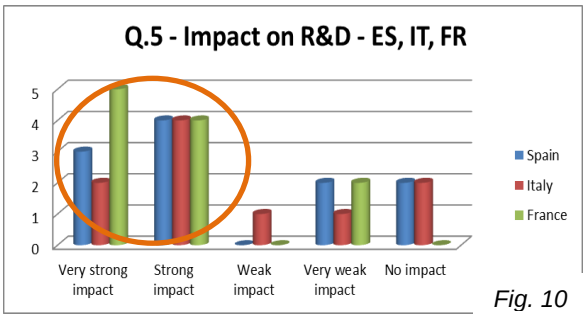

Fig. 10

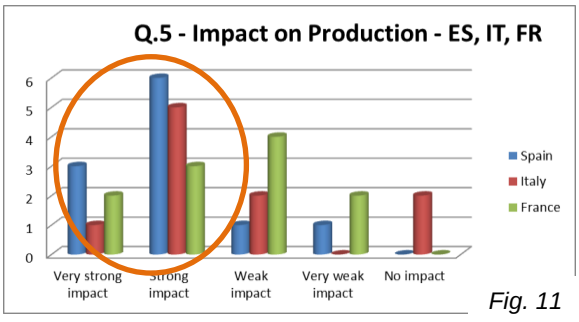

Fig. 11

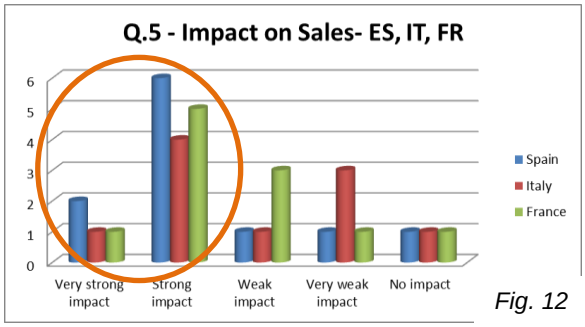

Fig. 12

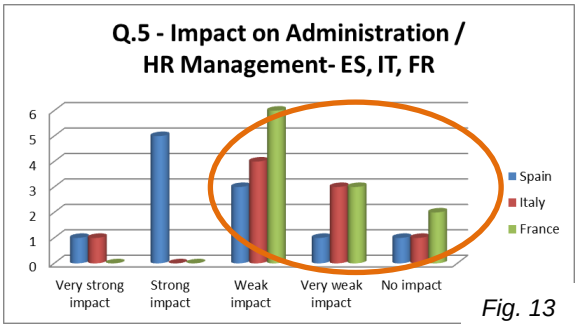

Fig. 13

Expected influence on competitive factors

The survey also questioned the influence of Industry 4.0 technologies on the following competitive advantage factors:

1. Flexibility
2. Delivery reliability
3. Quality of service
4. Quality of product
5. Costs
6. Product range/ variety

Most companies, with minor national differences, agree technologies will strongly or very strongly influence the Quality of Product (88%), the Quality of Service (78%), the Flexibility and the Costs (both 75%), as depicted in Figures 14 and 15 below. Therefore, Industry 4.0 is expected to strongly stimulate core competitive factors!

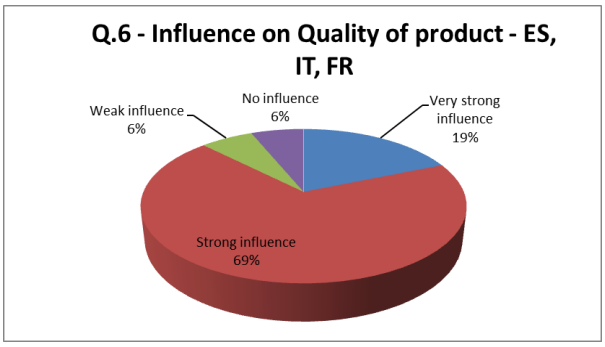

Fig. 14

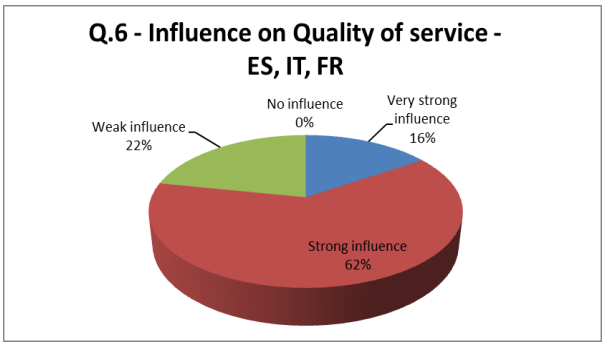

Fig. 15

Cluster 3 "Technologies" (Q7-Q8)

The need for adequate IT and connectivity

On the other hand, the adequacy of IT infrastructure and connectivity is considered only partially appropriate to the planned evolution of the industries.

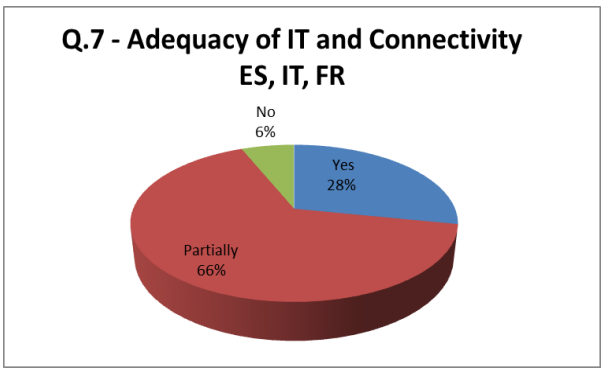

Fig. 16

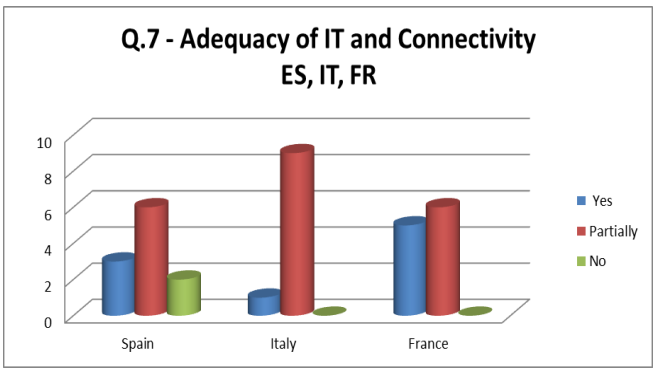

Fig. 17

Introduction and use of technologies and processes for Advanced Manufacturing

Moreover, for each application of Advanced Manufacturing (see question 2), companies were inquired about the Key Enabling Technologies they apply or plan to introduce.

The answers to the question show how fragile is still the planning and the tangible application of Industry 4.0 in manufacture, particularly in Small and Medium Enterprises.

Remarkable differences among countries reflect the composition of the sample: for instance, the French companies included an higher ratio of very large and high tech enterprises compared to SMEs Italy and Spain. National policies and availability/costs of technological applications also influence the use of technology, for instance *Additive manufacturing, Collaborative robotics and Cyber-physical systems* applications are well introduced in France (see figure 18), weakly applied in Spain and almost unknown in Italy.

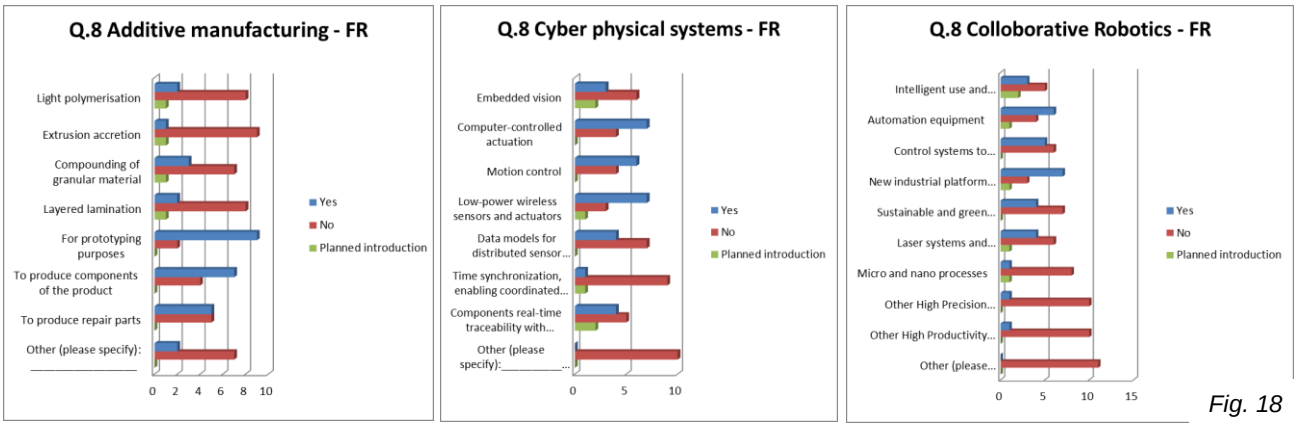

Fig. 18

Among the most *exploited technologies*, companies mainly apply computer–controlled actuation, control systems to monitor processes and Automation equipment. These choices *mirror the expectations about the impact on production* and the expected influence on the quality of product (Figures 19 and 20).

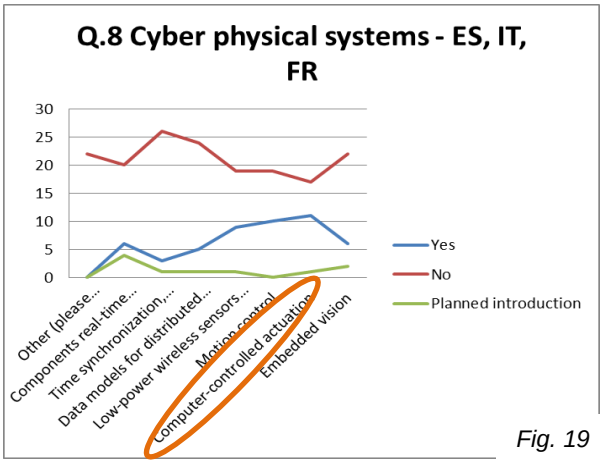

Fig. 19

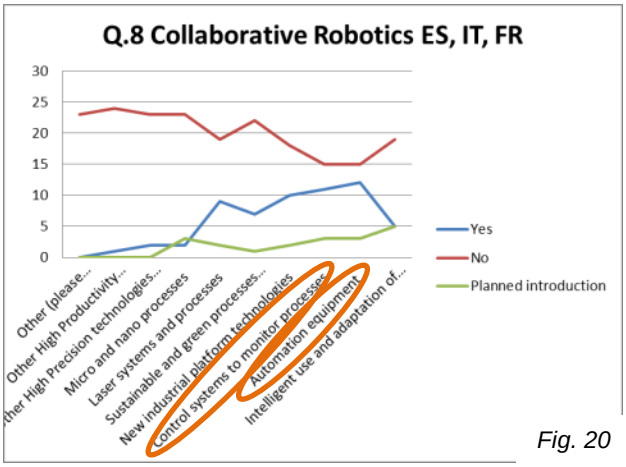

Fig. 20

Although *Additive manufacturing* was declared to be the most used and relevant application, in Italy technologies are mainly employed for prototyping purposes, while in Spain to produce components of the product (Fig. 21).

Cloud computing' applications are widely spread in each country (Fig. 22), particularly Data storage and Distributed applications (i.e. CRM, Business Intelligence, order management, document management).

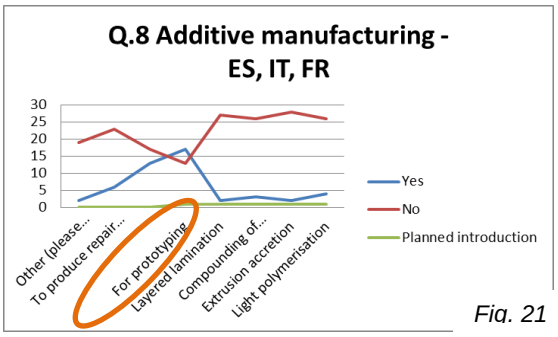

Fig. 21

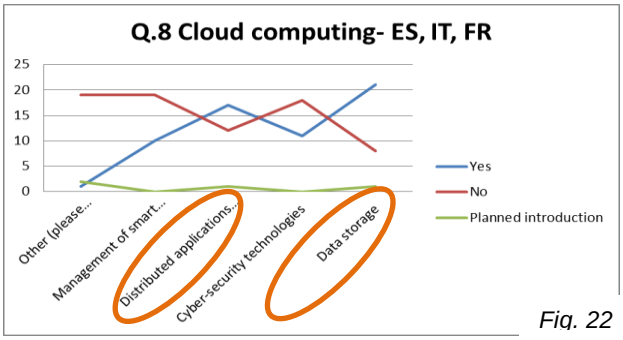

Fig. 22

Big data and Augmented Reality technologies still show a *significant growth potential*, as they are weakly applied in France and Italy and completely ignored in Spain (Figures 23 and 24).

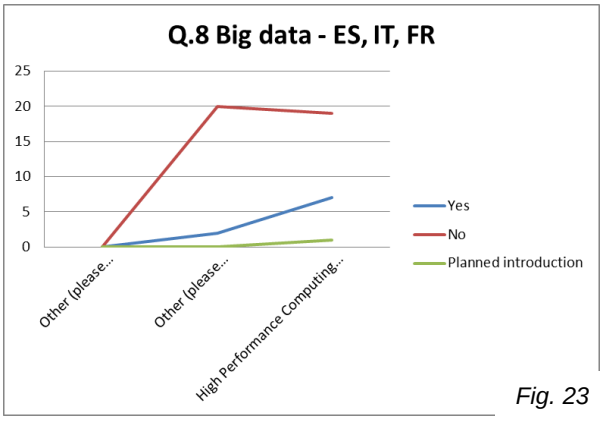

Fig. 23

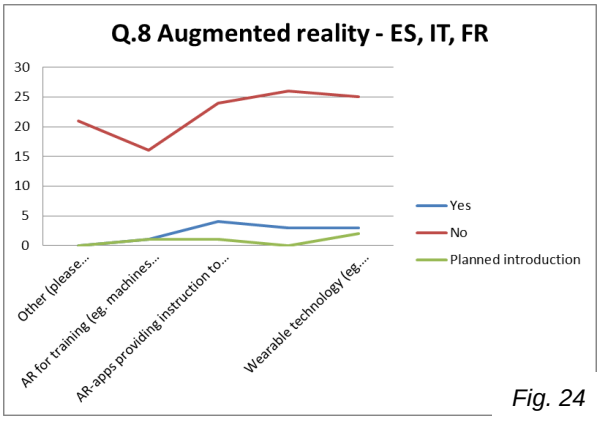

Fig. 24

Cluster 4 "Trends and Human resources" (Q9-Q10)

Trends

Companies were inquired about the foreseen *trends stimulated by Industry 4.0*. Several trends and expectations concerning the benefits were identified (Fig. 25).

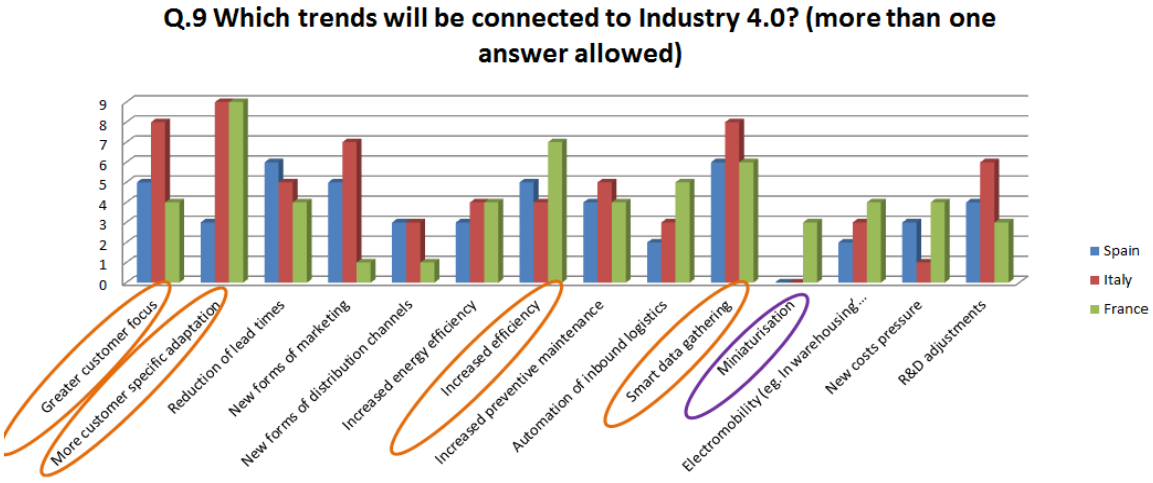

Fig. 25

Consistently with the expectations concerning the impact on production and sales, and the influence of advanced manufacturing technologies on quality of product and services, companies identify as main trends *Enhanced focus on customer*, *More customer-specific adaptation*, *Increased efficiency* and *Smart data gathering*.

Quite interestingly, only large / high tech French companies consider *Miniaturisation* as an opportunity to be exploited. It might be worthy to launch a dedicated debate among Spanish and Italian enterprises to widespread some knowledge about valuable applications and technology providers.

Moreover, in Spain and Italy *Reduction of lead times* and *New forms of marketing* seem to be a prospective benefit of Industry 4.0.

Human resources

Finally, the adequacy of skills and occupations of involved Human resources was investigated. According to results, although companies recognize the future impact and current influence of Industry 4.0, their awareness about technologies, organisational readiness and employees' skills are not aligned.

Satisfactory working knowledge is perceived and planned training is consistently foreseen only for Production and Sales workforces (53%) as shown in Figures 26 and 27. Dedicated training is provided directly by companies to a limited number of R&D staff (12% - Fig. 28).

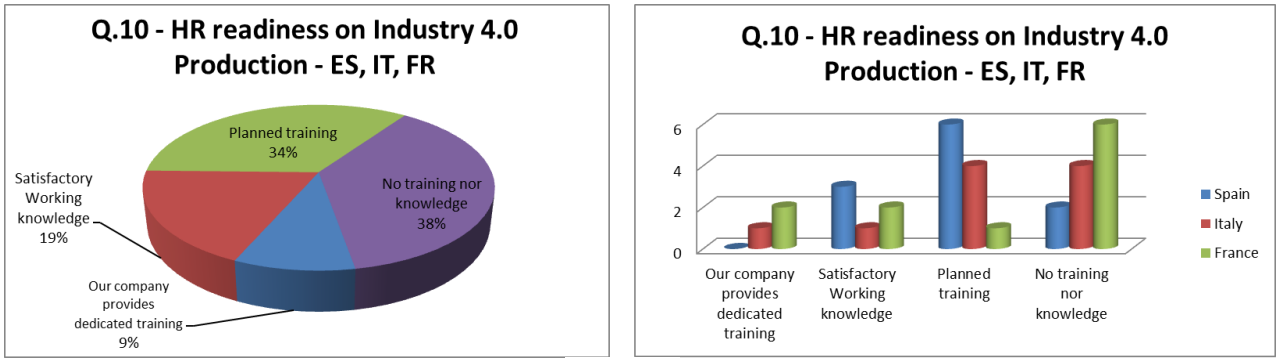

Fig. 26

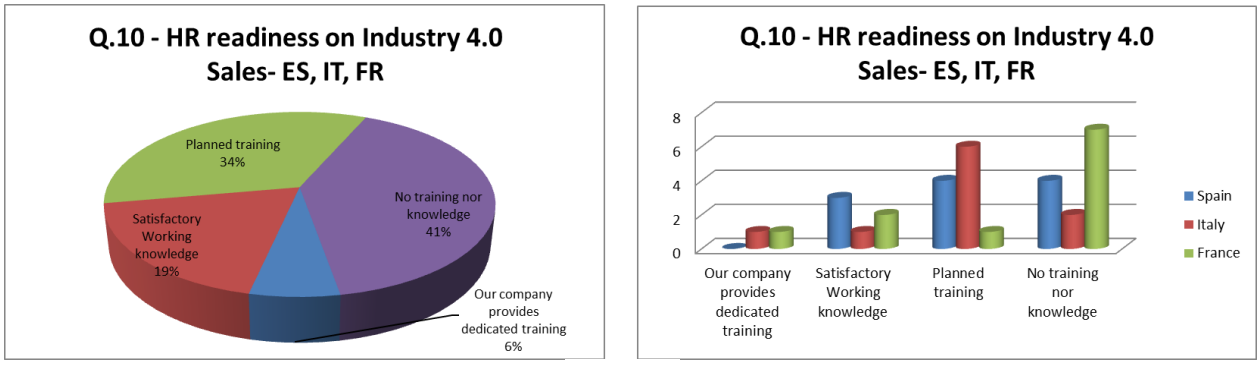

Fig. 27

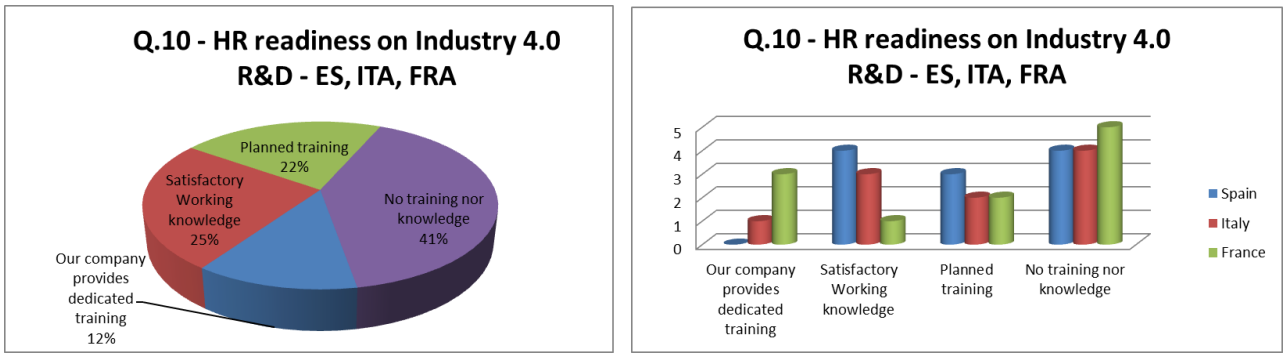

Fig. 28

Logistics, Administration, HR, Service and Purchases staff, according to their employers, have little or no knowledge about Industry 4.0 and Advanced manufacturing technologies. The so–called Fourth Revolution of Industry currently looks as a giant with feet of clay: enterprises are aware of the impact and influence of new technologies on their work organisation, nonetheless only a minority already adopted pro-active and anticipatory actions to prepare the personnel. It is worthy to be noted the high ratio of HR staff (82%) with little or no knowledge, which is supposed to be in charge of the management and delivery of dedicated training to their colleagues in other departments/areas/units. Out of this ratio only 16% planned some training (Fig. 29).

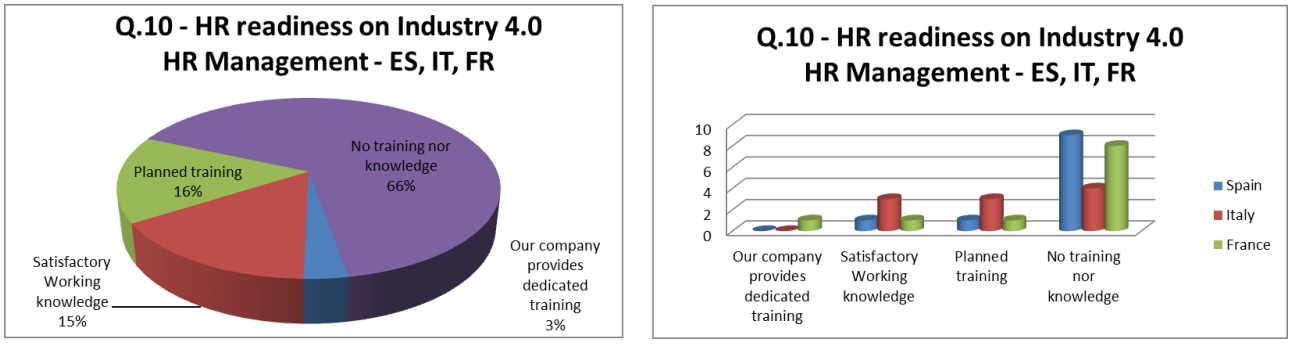

Fig. 29

The *role of PROVET 4.0* could therefore include specific training activities to increase the awareness of managers and employees about Industry 4.0's opportunities independently from their role in the company, in order they could more efficiently support colleagues in Production and Sales, where the main impacts and benefits are expected.

Conclusions

More than the half of the surveyed companies are implementing Industry 4.0 related activities only partially or not at all.

The suppliers are more active than the Final manufacturers. This due to the awareness that as competition is on costs, either the company increase the volume of production either the production's cost shall decrease.

The results highlight how the impact and planning of Industry 4.0 development is dependent from the size of the enterprises: the larger the company, the higher the automation efforts. Moreover, high tech and engineering services are aware they shall provide up-to-date and advanced knowledge services in order to remain competitive.

Industry 4.0 related concepts and language are not yet standardized nor widespread. In some cases it is perceived as digitalisation (even office digitalisation!!), in other cases it is perceived as the impact of automation.

The Industry 4.0 "buzz" is slowing down after the initial hype.

Pragmatic recommendations from larger researches[1]
Five added value application of Industry 4.0:

- Digital performance management
- Predictive maintenance
- Yield, energy and throughput optimization
- Next-level automation
- Digital quality management.

[1] McKinsey Digital (2016) - https://www.mckinsey.de/sites/mck_files/files/mckinsey_industry_40_2016.pdf; Holger-Schmidt (2016) - http://www.elektronikpraxis.vogel.de/iot/industrie40/articles/526849/.

Annex 1: the Questionnaire

Analysis on current and future capabilities requirements of Key Enabling Technologies (KETs) in Advanced manufacturing

The development of Advanced Manufacturing becomes the industry answer to the changes of trends and high-impact global changes within the industrial sector. PROVET 4.0 project is designed from the basis of a lack of specific training in KETs for Advanced manufacturing. The new European industrial revolution marked by the advancement of technologies applicable to the industry, demands high R&D intensity, rapid innovation cycles and more skilled jobs.

PROVET 4.0 contributes to this need, by helping industrial workers and VET learners to be qualified, acquiring skills and competences for KETs for Advanced manufacturing in additive manufacturing, collaborative robotics, cyber-physical systems, augmented reality, cloud computing and big data.

Basic data about the company

1. Location:
2. Sector:
3. Type of products (final product, component within supply chain..):
4. Size (number of employees):
5. Turnover:

Questionnaire

1. Did you heard or applied the following concepts within your business ?
(more than one answer allowed)

- ☐ Industry 4.0
- ☐ Smart Factory
- ☐ Factory of the Future
- ☐ Industrial Internet
- ☐ Factory's digitalization

2. Is your company developing or exploiting activities by applying the following tools/ technologies? *(more than one answer allowed)*

- ☐ Additive manufacturing (3D printing/ Rapid prototyping)
- ☐ Collaborative Robotics
- ☐ Adaptive Automation process
- ☐ Cyber-physical systems (closed-loop feedback systems)
- ☐ Augmented reality
- ☐ Cloud computing

- ☐ Big data
- ☐ Internet of Things/ Internet of Everything

3. To what extent is your company already using digitalization to **control** the manufacturing process (eg. analyse machine data to avoid defects in the production process)?

- ☐ Very strongly
- ☐ Strongly
- ☐ Partially
- ☐ Weakly
- ☐ Not at all

4. To what extent is your company already using digitalization to **design** the product and manage the delivery to the market (eg. warehousing, logistics, marketing, sales…)?

- ☐ Very strongly
- ☐ Strongly
- ☐ Partially
- ☐ Weakly
- ☐ Not at all

5. Which business units could receive the strongest impact from the tools mentioned in Q.2? *(more than one answer allowed)*

Professional profiles	Very strong impact	Strong impact	Weak impact	Very weak impact	No impact
1.Research and Development					
2.Production					
3.Logistics / Warehouse					
4.Administration / HR management					
5.Service					
6.Sales					
7.Purchases/ Procurement					

6. Which issues will be mostly influenced by the introduction of the tools mentioned in Q.2? *(more than one answer allowed)*

Issues	Very strong influence	Strong influence	Weak influence	No influence
1. Flexibility				
2. Delivery				

reliability				
3. Quality of service				
4. Quality of product				
5. Costs				
6. Product range/ variety				

7. Is your IT infrastructure and connectivity appropriate to the evolution of your company' sector / industry?

- ☐ Yes
- ☐ Partially
- ☐ No

8. Is your company making use of or planning to introduce the following technologies/ processes? *(more than one answer allowed)*

Additive manufacturing - 3D printing/ Rapid prototyping	Yes	No	Planned introduction
Light polymerisation			
Extrusion accretion			
Compounding of granular material			
Layered lamination			
For prototyping purposes			
To produce components of the product			
To produce repair parts			
Other (please specify): _____			

Collaborative Robotics and Adaptive Automation process	Yes	No	Planned introduction
Intelligent use and adaptation of robots			
Automation equipment			
Control systems to monitor processes			
New industrial platform technologies			
Sustainable and green processes and technologies			
Laser systems and processes			
Micro and nano processes			
Other High Precision technologies (please specify):_____			
Other High Productivity technologies (please specify):_____			
Other (please specify):_____			

Cyber physical systems (closed-loop feedback systems) for improved anomaly detection /supply chain management	Yes	No	Planned introduction
Embedded vision			
Computer-controlled actuation			
Motion control			
Low-power wireless sensors and actuators			
Data models for distributed sensor data			
Time synchronization, enabling coordinated sleep and wakeup times, and enabling time-stamping of sensor data with globally meaningful time stamps			
Components real-time traceability with RFID, UID			
Other (please specify):_____			

Augmented reality	Yes	No	Planned introduction
Wearable technology (eg. Eyewear for industry)			
AR-enabled print activating information or instructions for workers			
AR-apps providing instruction to customers			
AR for training (eg. machines training)			
Other (please specify):_____			

Cloud computing	Yes	No	Planned introduction
Data storage			
Cyber-security technologies			
Distributed applications (ie. CRM, Business Intelligence, order management, document management)			
Management of smart devices			
Other (please specify):_____			

Big data	Yes	No	Planned introduction
High Performance Computing (HPC) for modeling, simulation and analysis			
Other (please specify):_____			
Other (please specify):_____			

9. Which trends will be connected to Industry 4.0 (a definition is available below/ here)? (*more than one answer allowed*)

- ☐ Greater customer focus
- ☐ More customer specific adaptation
- ☐ Reduction of lead times
- ☐ New forms of marketing
- ☐ New forms of distribution channels
- ☐ Increased energy efficiency
- ☐ Increased efficiency
- ☐ Increased preventive maintenance
- ☐ Automation of inbound logistics
- ☐ Smart data gathering
- ☐ Miniaturisation
- ☐ Electromobility (eg. In warehousing' management)
- ☐ New costs pressure
- ☐ R&D adjustments

10. Are your Human resources prepared to the introduction of Industry 4.0 ?

Professional profiles	Our company provides dedicated training	Satisfactory Working knowledge	Planned training	No training nor knowledge
1. Research and Development				
2. Production				
3. Logistics / Warehouse				
4. Administration				
5. HR management				
6. Service				
7. Sales				
8. Purchases/ Procurement				

Concepts and Definitions

The term "**Industry 4.0**" was first introduced by the German Industry-Science Research Alliance (Forschungsunion) in 2011 and involves cooperation among industry associations, enterprises, universities and government. It refers to digitising industrial production. The concept outlines the vision of a Smart Factory, which is characterized by the interconnection of all production parts and processes (physical assets, people and information), internal to the factory and distributed throughout the value chain. Smart manufacturing technologies refer to Information Technology (Internet of Things, Big data, Cloud Computing) and to Operational Technology (Advanced Automation, Advanced Human machine Interface and Additive Manufacturing).

Companies are already working toward solutions for the so-called "innovative factory", "smart factory", "smart industry", "industry 4.0" where the breakthrough concept is the integration between the physical industrial plant and virtual systems, defining cyber-physical systems and allowing objects and workers to interact.

Additive Manufacturing refers to a process by which digital 3D design data is used to build up a component in layers by depositing material. The term "3D printing" is increasingly used as a synonym for Additive Manufacturing. However, the latter is more accurate in that it describes a professional production technique which is clearly distinguished from conventional methods of material removal. Instead of milling a work piece from solid block, for example, Additive Manufacturing builds up components layer by layer using materials which are available in fine powder form. A range of different metals, plastics and composite materials may be used.

A **cobot or "collaborative robot"** is a robot designed to assist human beings as a guide or assistor in a specific task. A regular robot is designed to be programmed to work more or less autonomously. In one approach to cobot design, the cobot allows a human to perform certain operations successfully if they fit within the scope of the task and to steer the human on a correct path when the human begins to stray from or exceed the scope of the task.

A **cyber-physical system (CPS)** is a system of collaborating computational elements controlling physical entities. Today, a precursor generation of cyber-physical systems can be found in areas as diverse as aerospace, automotive, chemical processes, civil infrastructure, energy, healthcare, manufacturing, transportation, entertainment, and consumer appliances. This generation is often referred to as embedded systems. In embedded systems the emphasis tends to be more on the computational elements, and less on an intense link between the computational and physical elements.

Cloud computing is a kind of Internet-based computing, where shared resources, data and information are provided to computers and other devices on-demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources. Cloud

computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centers.

Big data is a broad term for data sets so large or complex that traditional data processing applications are inadequate. Challenges include analysis, capture, data curation, search, sharing, storage, transfer, visualization, querying and information privacy. Accuracy in big data may lead to more confident decision making, and better decisions can result in greater operational efficiency, cost reduction and reduced risk.

Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. As a result, the technology functions by enhancing one's current perception of reality. Augmentation is conventionally in real-time and in semantic context with environmental elements, such as sports scores on TV during a match. With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the surrounding real world of the user becomes interactive and digitally manipulable.

Adaptive Automation process is a novel neuroergonomic concept, refers to a human-machine system that uses real-time assessment of the operator's workload to make the necessary changes to enhance performance. For adaptive automation to work, the system must utilize an accurate operator-state classifier for the real-time assessment. Operator-state classifiers such as discriminant analysis and artificial neural networks show an accuracy of 70% to 85% in real-time.