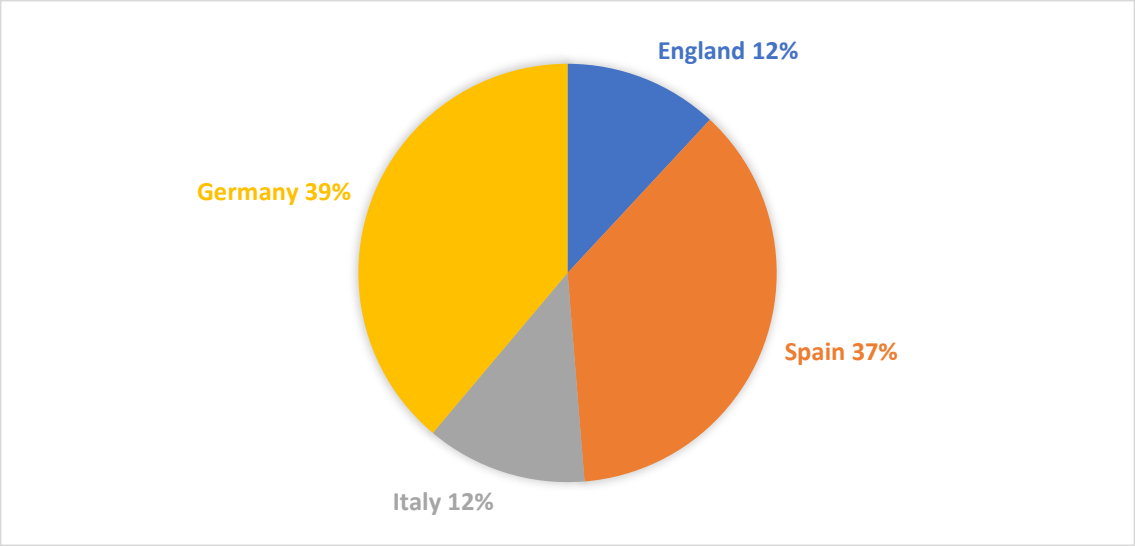
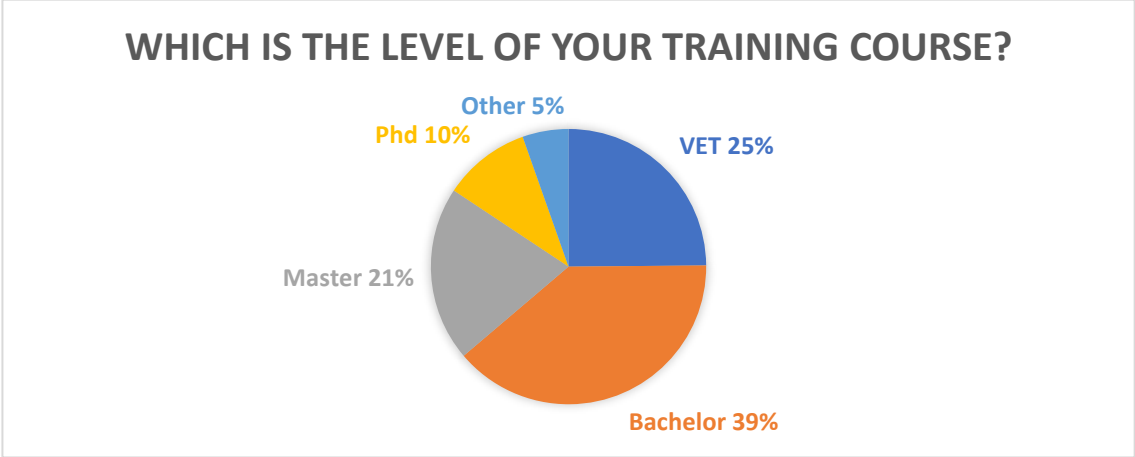
General Information

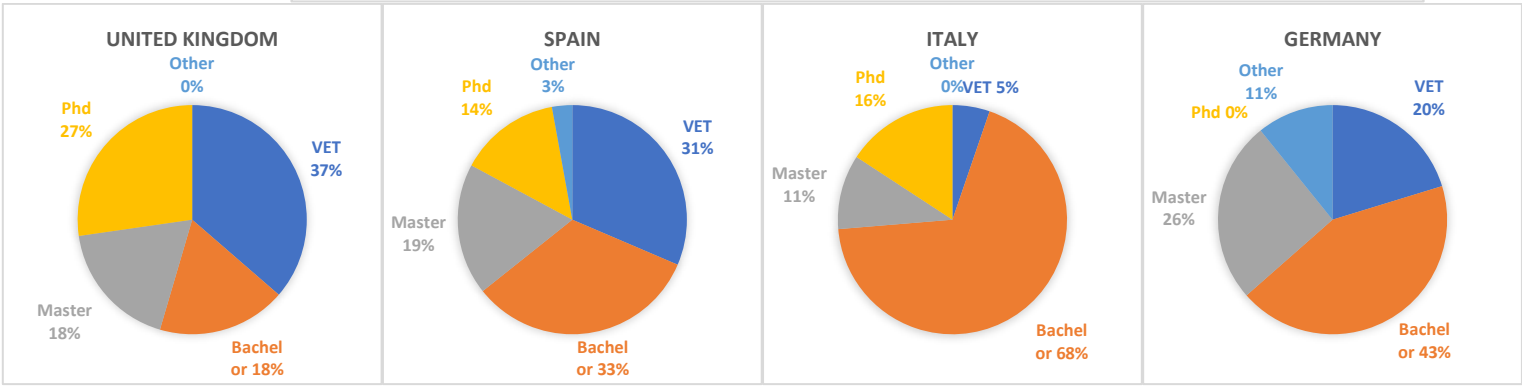
Origin of the respondents



Graphic 1: Origin of the respondents.

Level of Training Course





Graphic 2:Level of Students.

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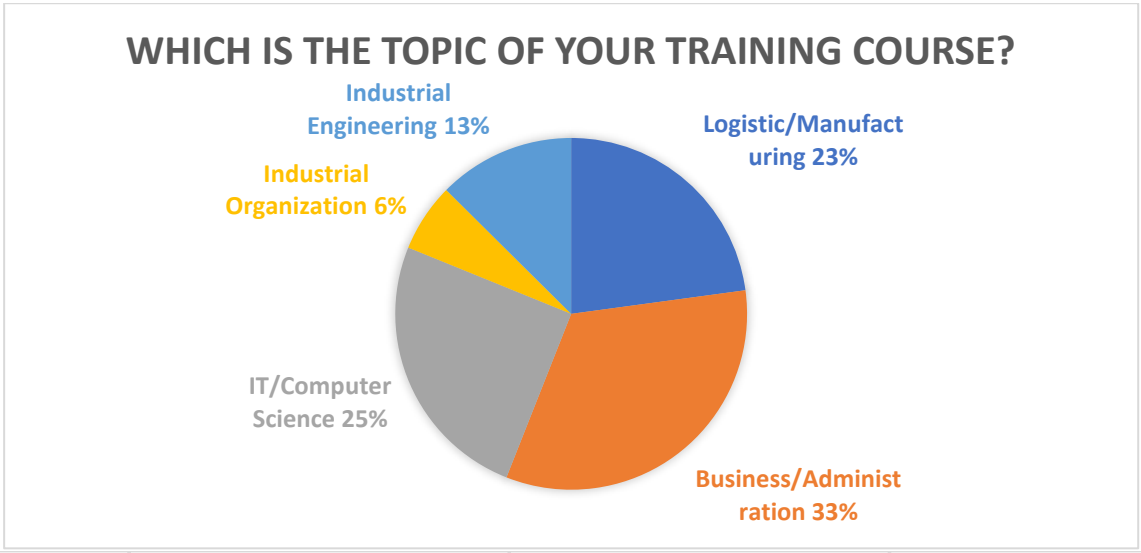
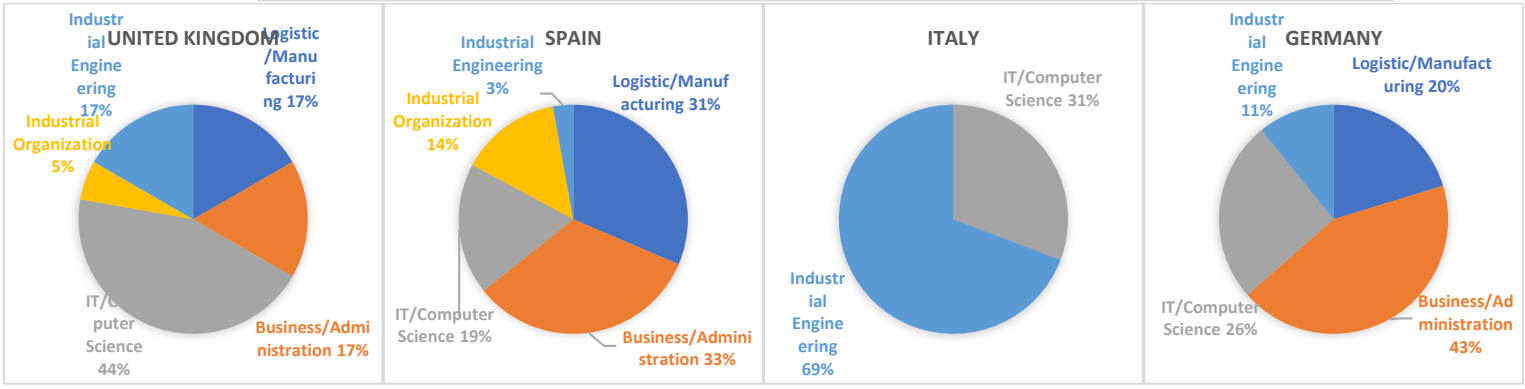
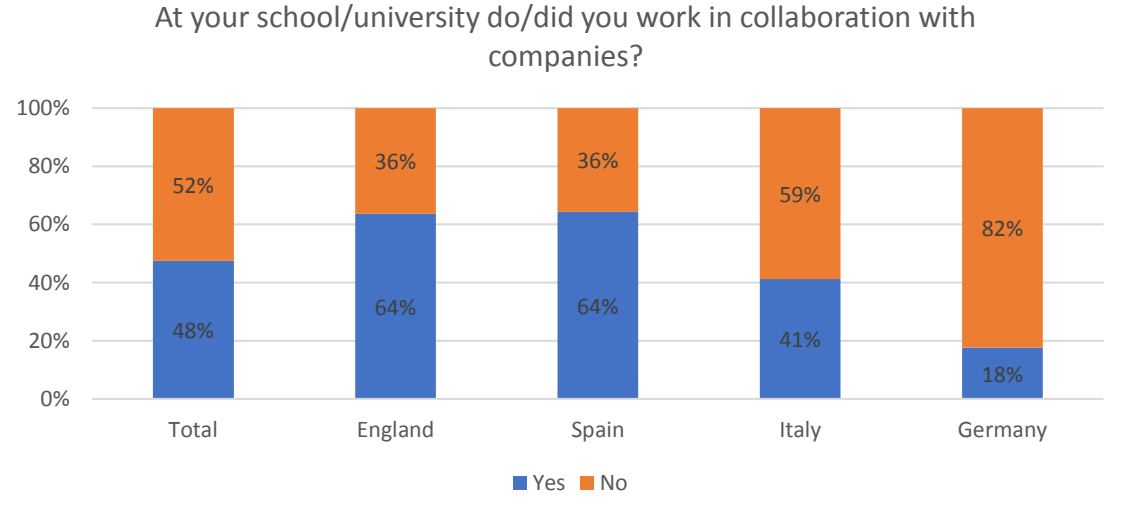
Training Course topic





Graphic 3: Training Course topic.

Collaboration between HE/VET institutions and Companies



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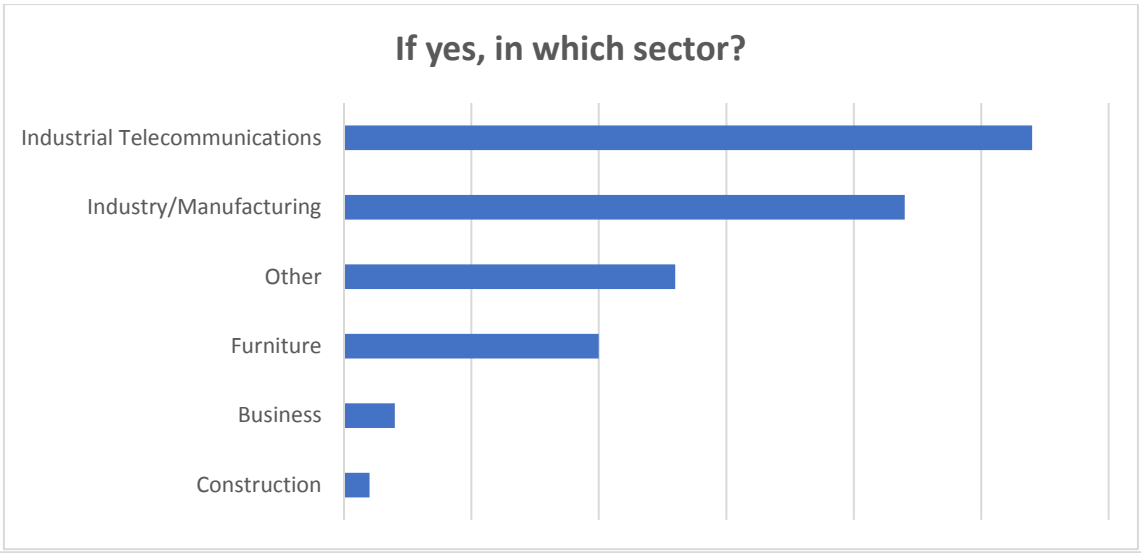

Graphic 4: Collaboration between HE/VET institutions and Companies.

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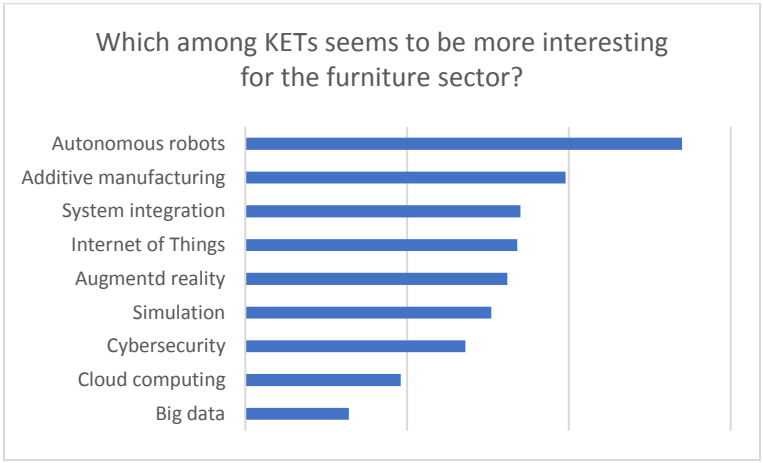
Interesting KETs for the Furniture Sector



Graphic 5: Interesting KETS for the furniture sector by Students.

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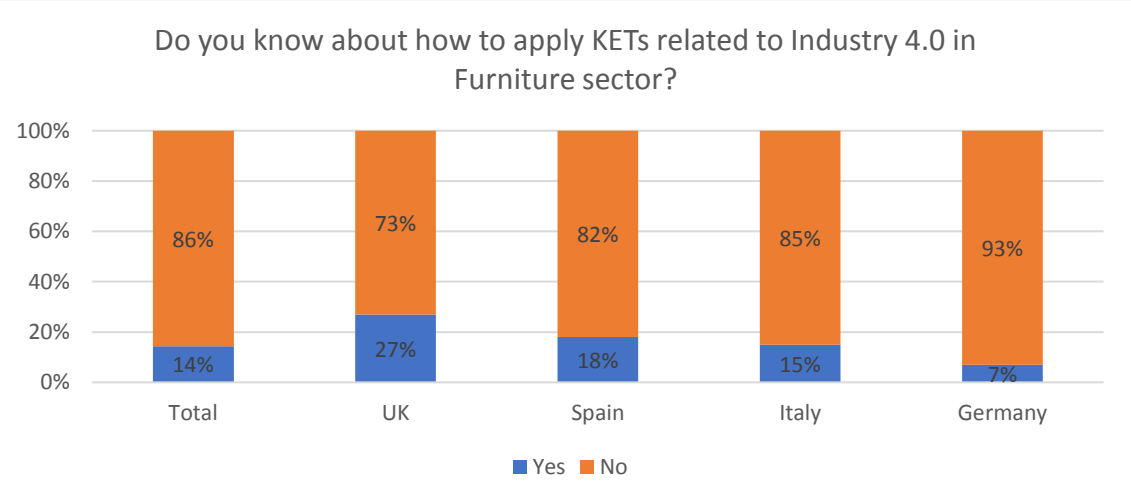
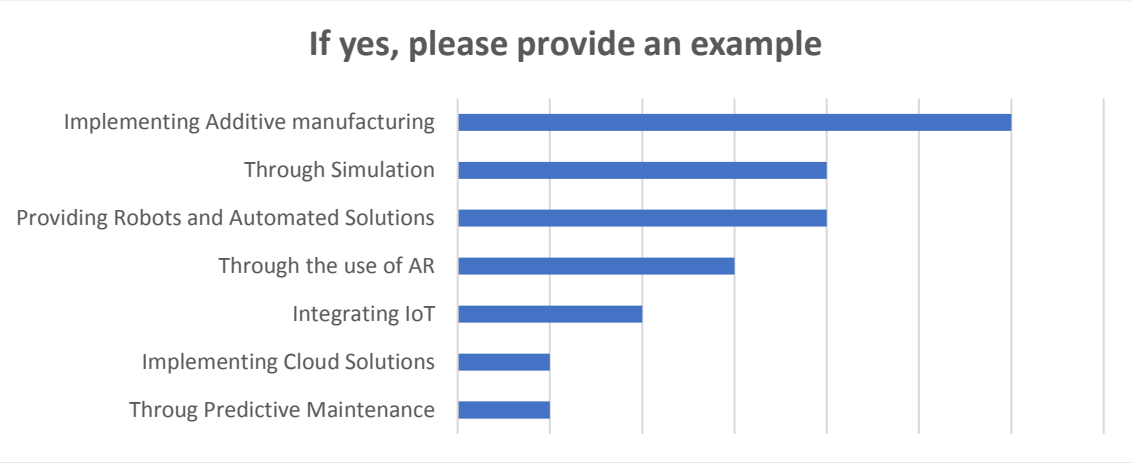
Student´s knowledge about implementing KETs in the Furniture sector.





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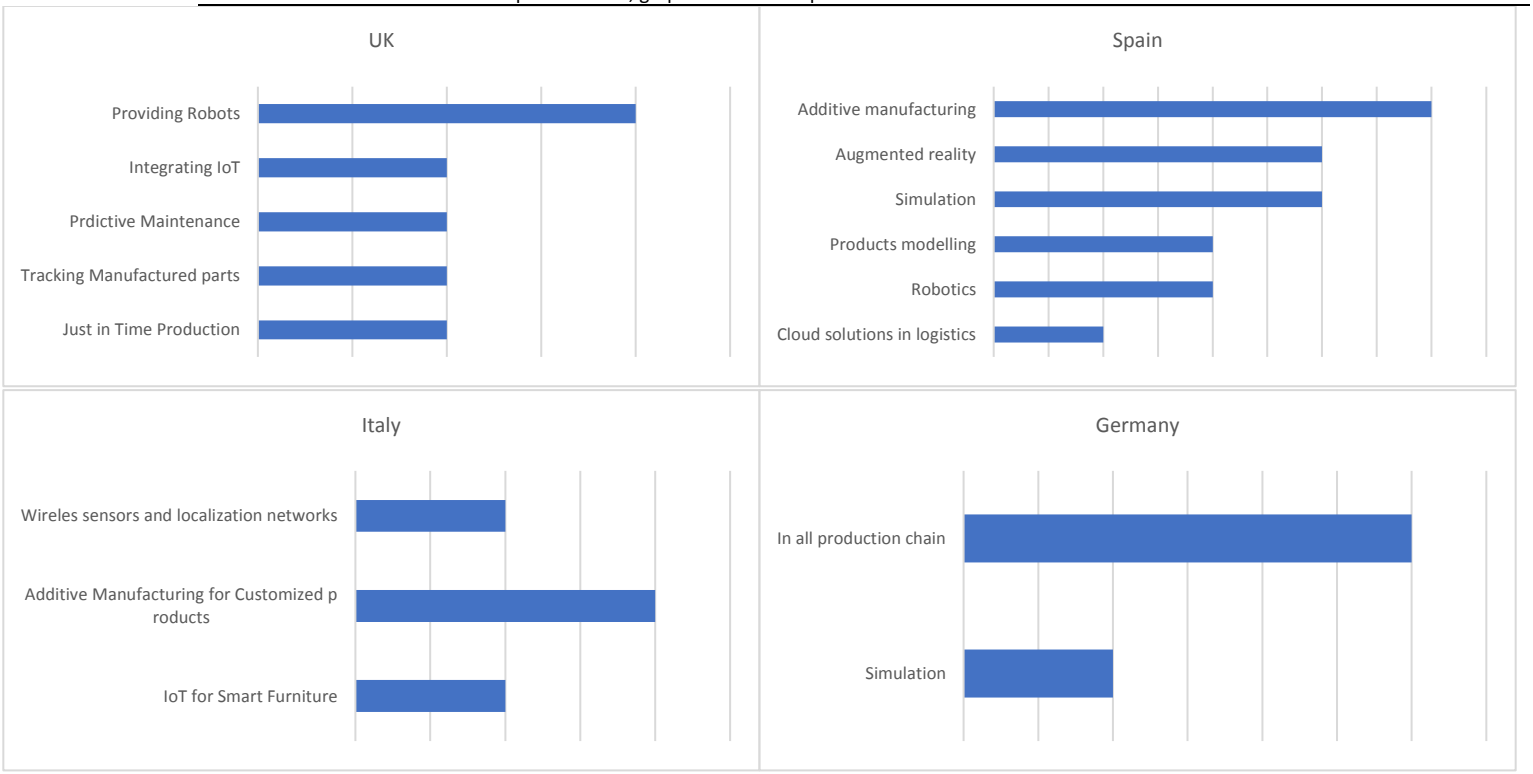

Graphic 6:Student´s knowledge about implementing KETs in the Furniture sector.

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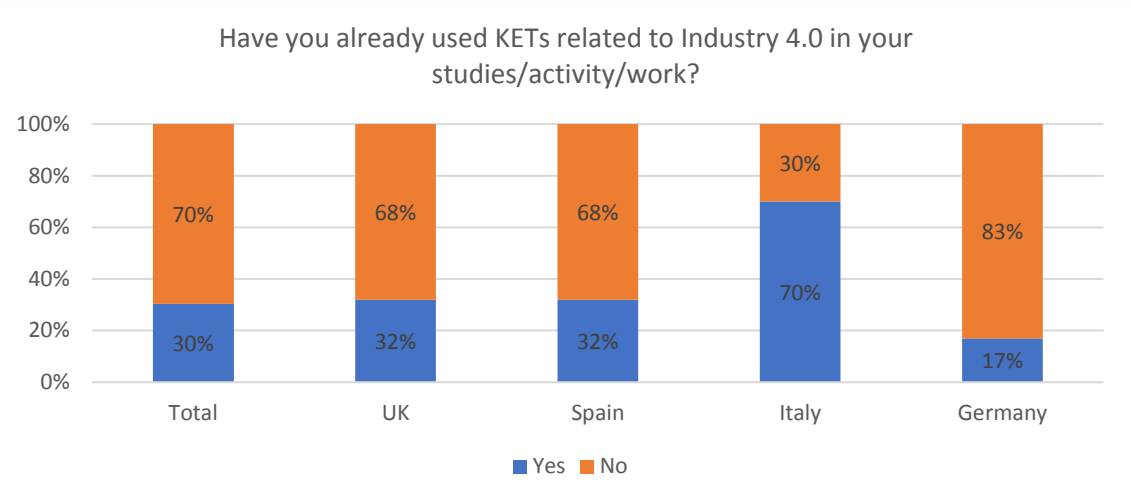
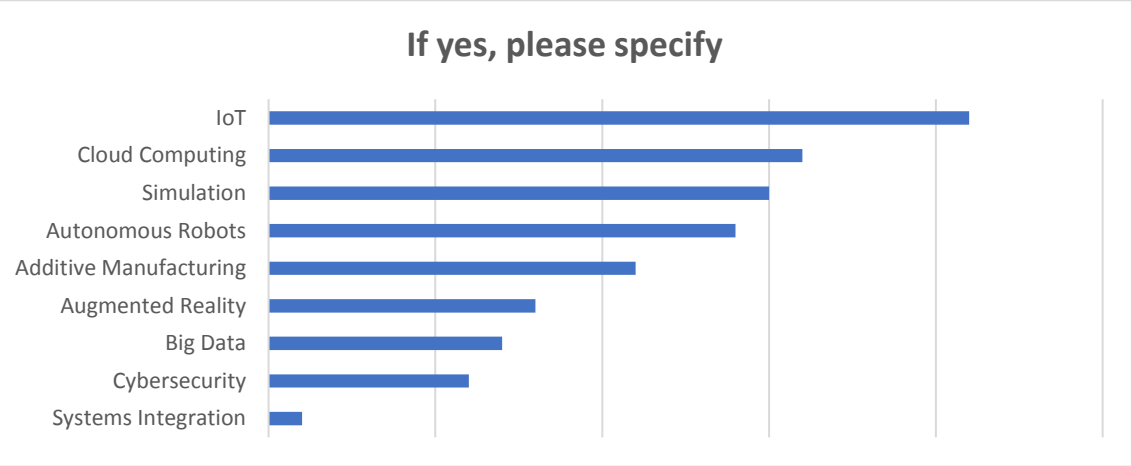
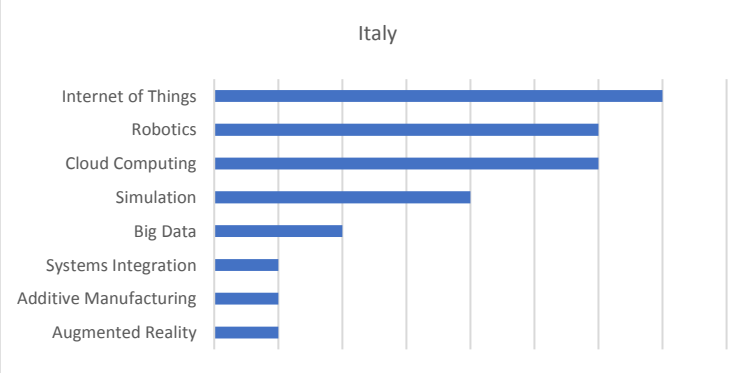
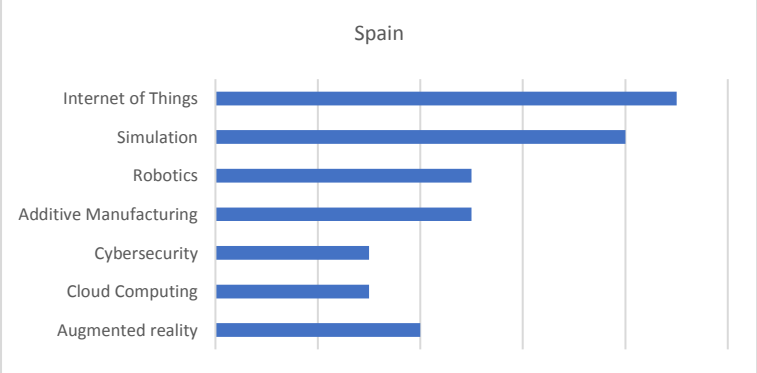
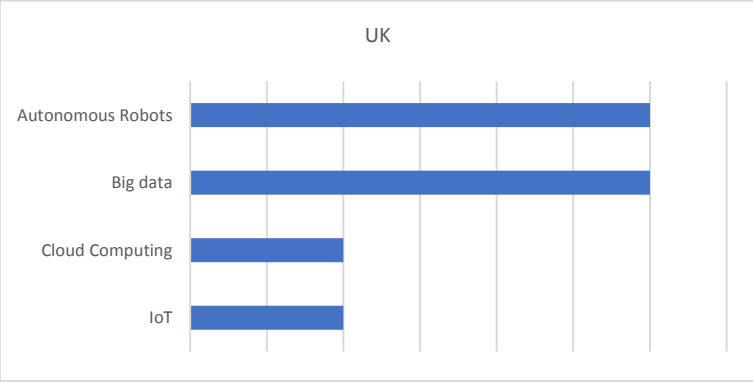
I4.0 KETs in VET/HE programmes.

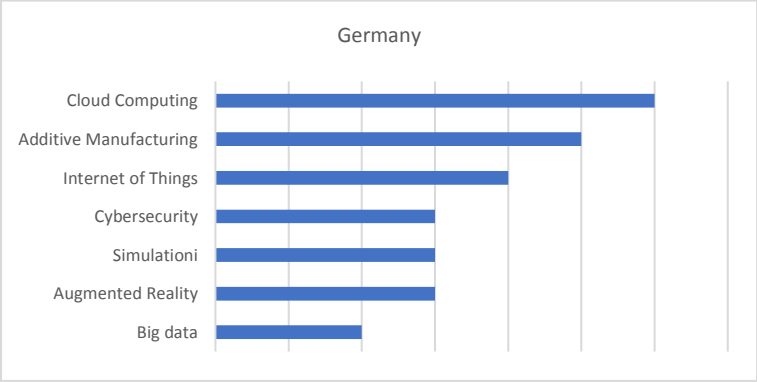












Graphic 7: I4.0 KETs in VET/HE programmes.

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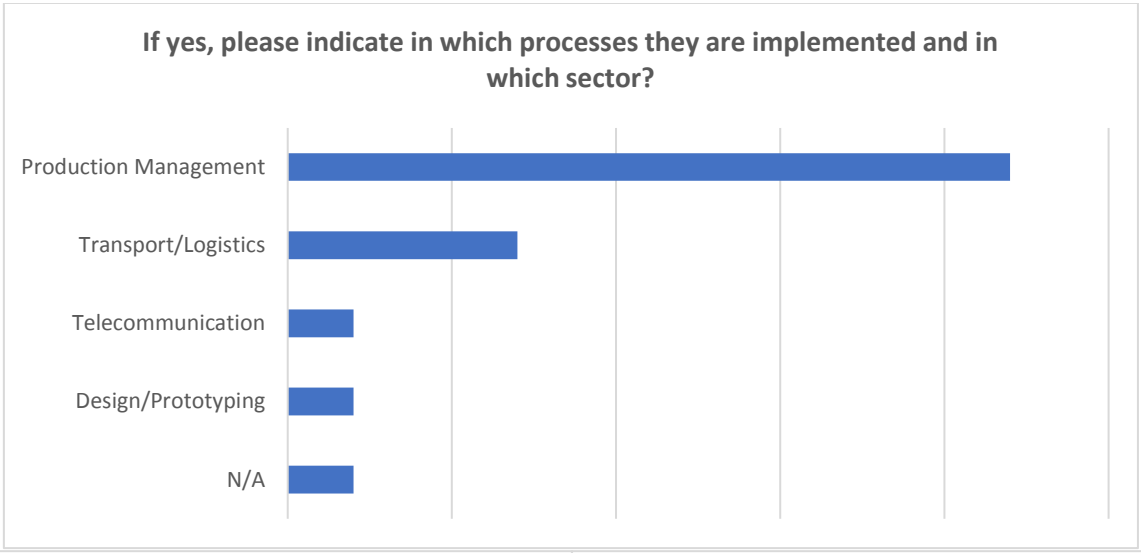

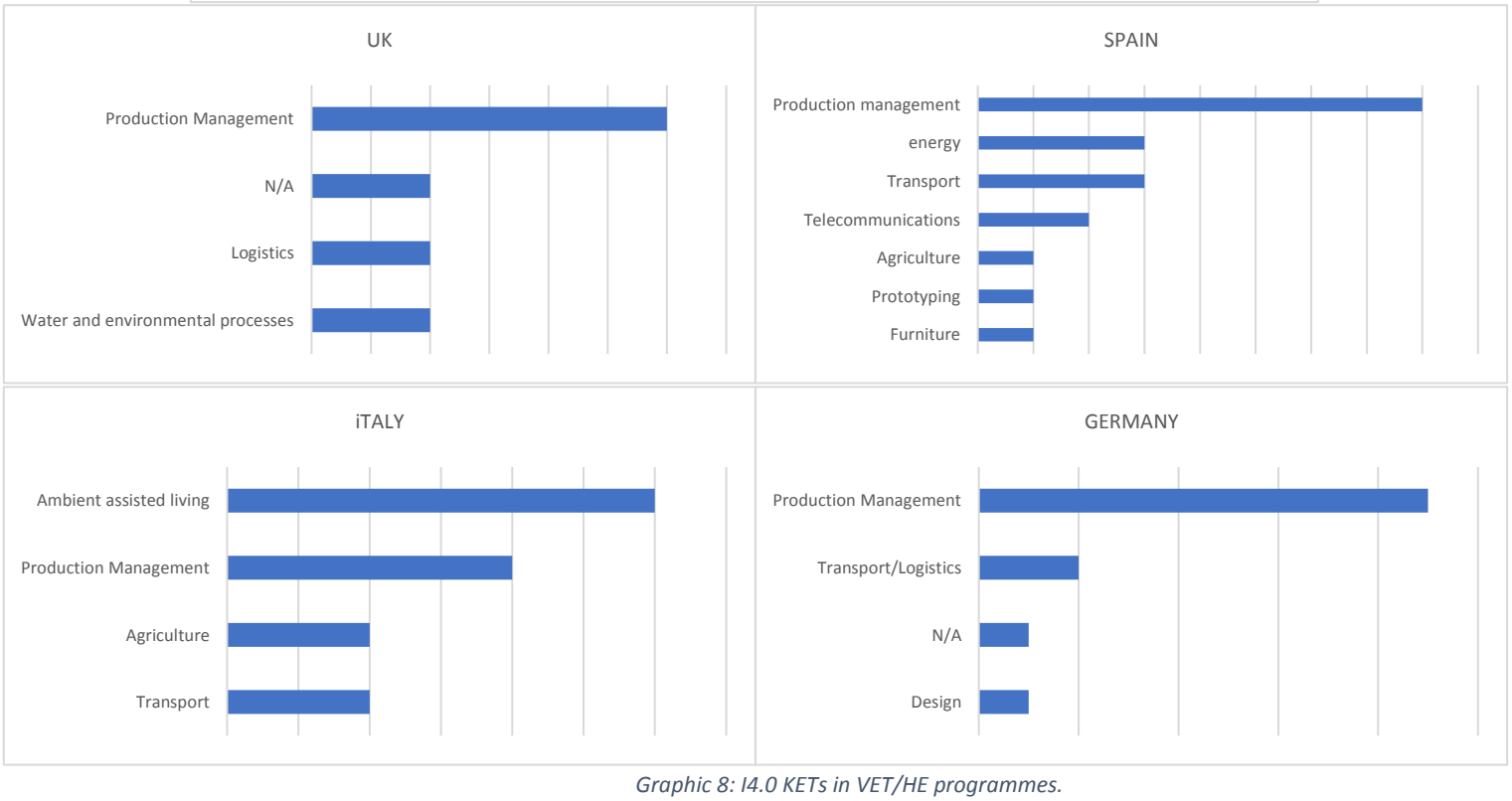

Graphic 8: I4.0 KETs in VET/HE programmes.

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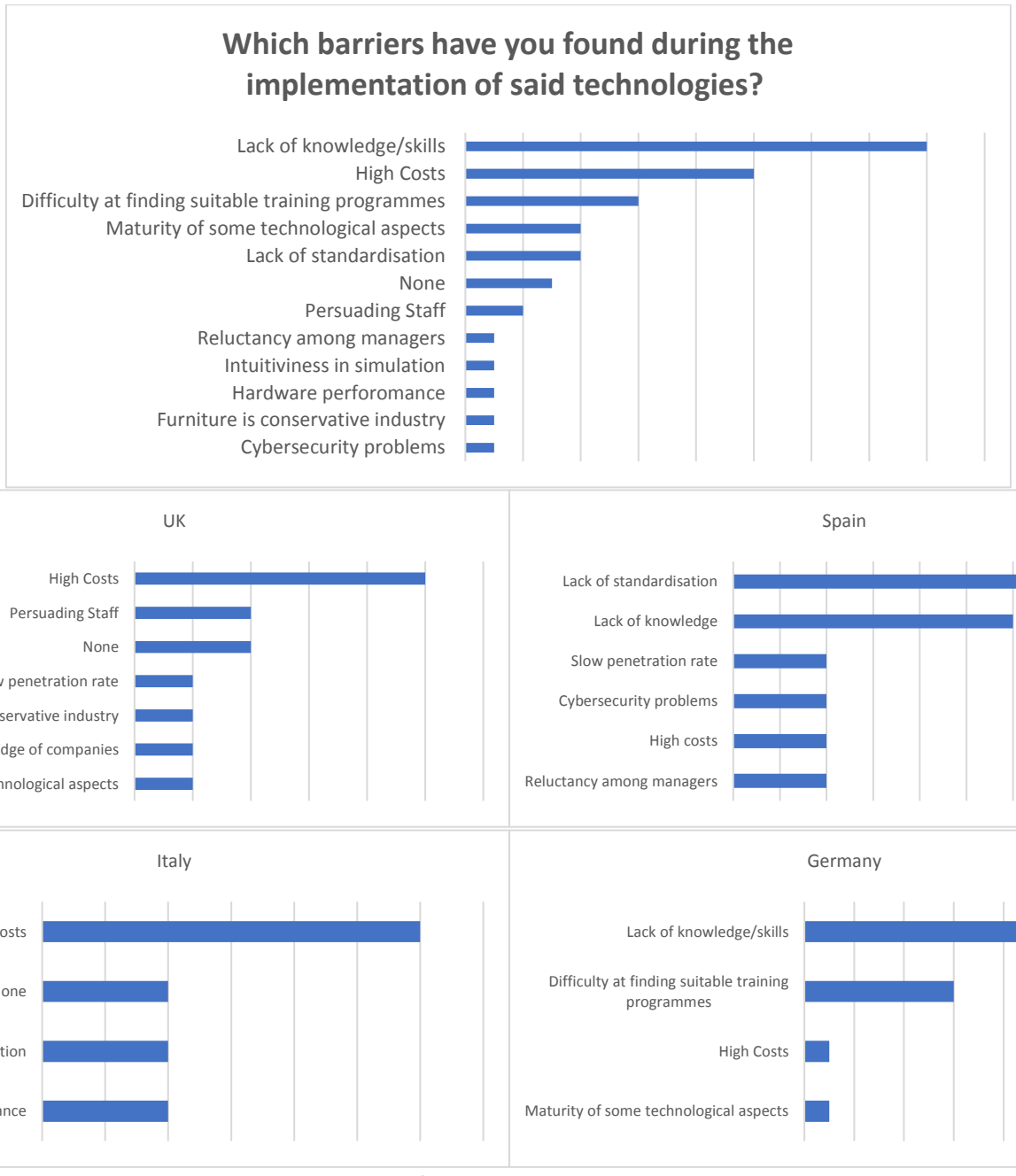
Barriers at implementing KETs



Graphic 9: Barriers in VET/HE Communities during the Implementation of KETs in Companies.

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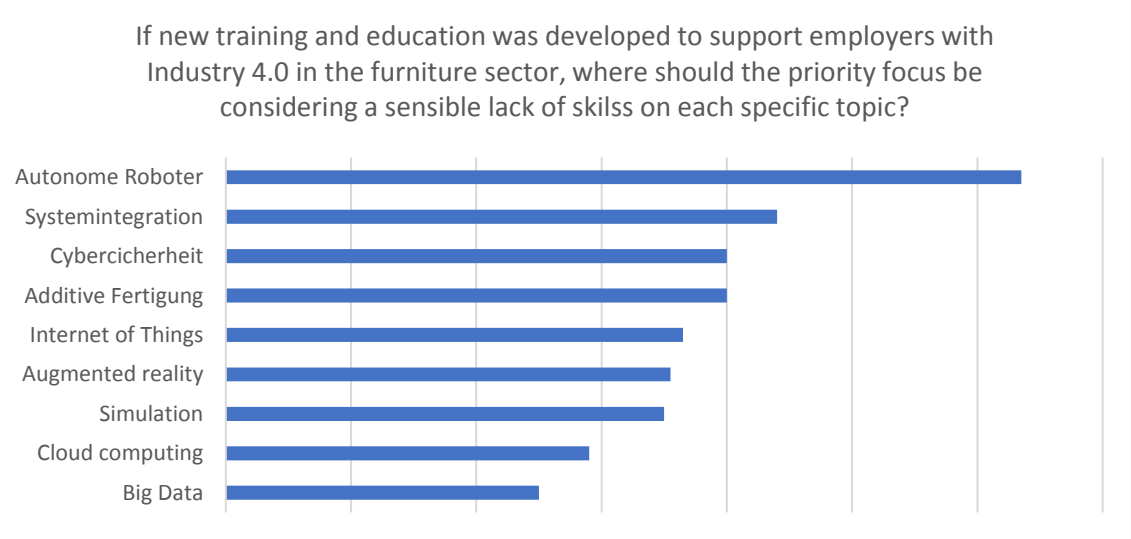
Skills on KETs within HE/VET programmes

Graphic 10: Skills on KETs within HE/VET programmes.

Priorities in KET training within the furniture industry



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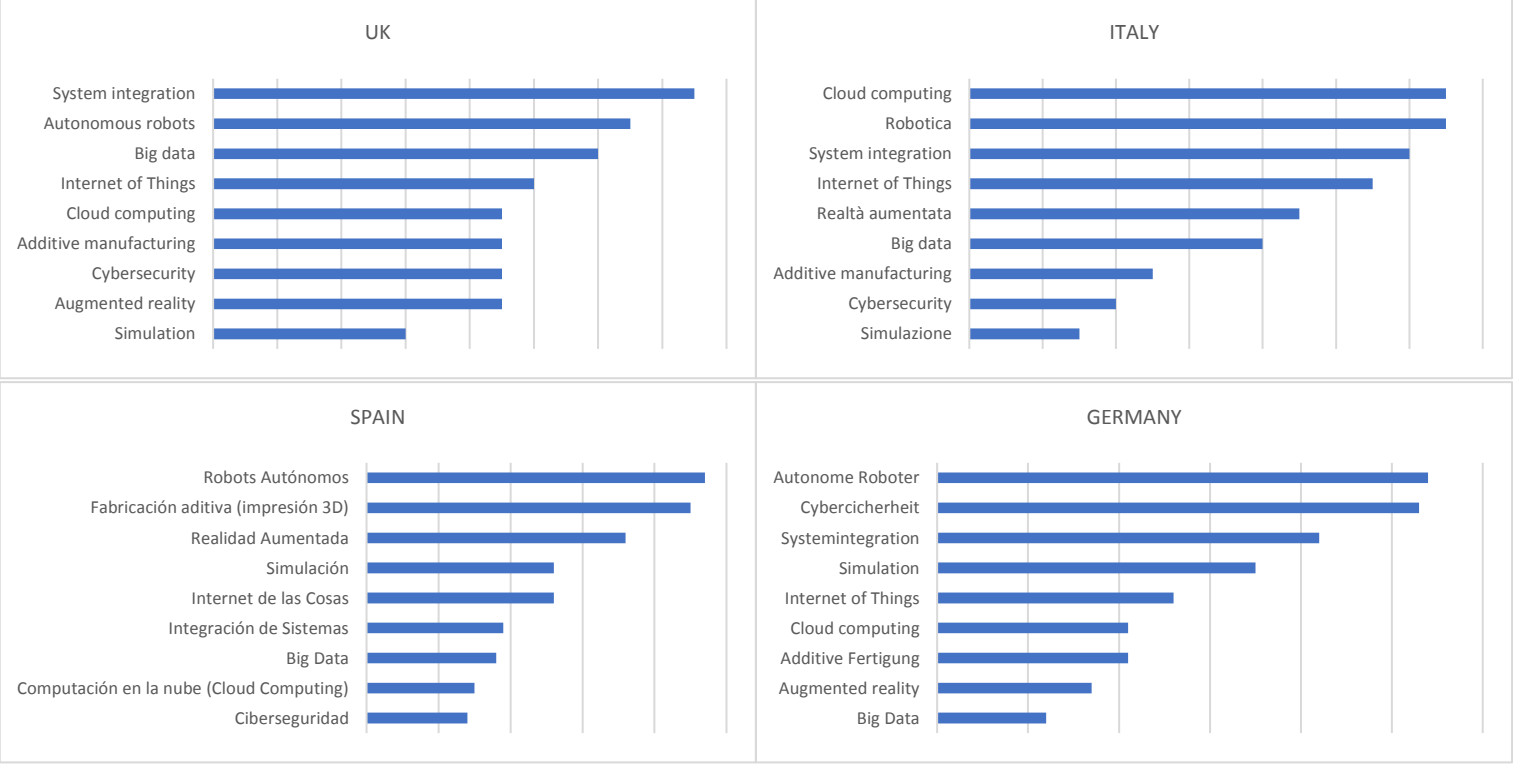
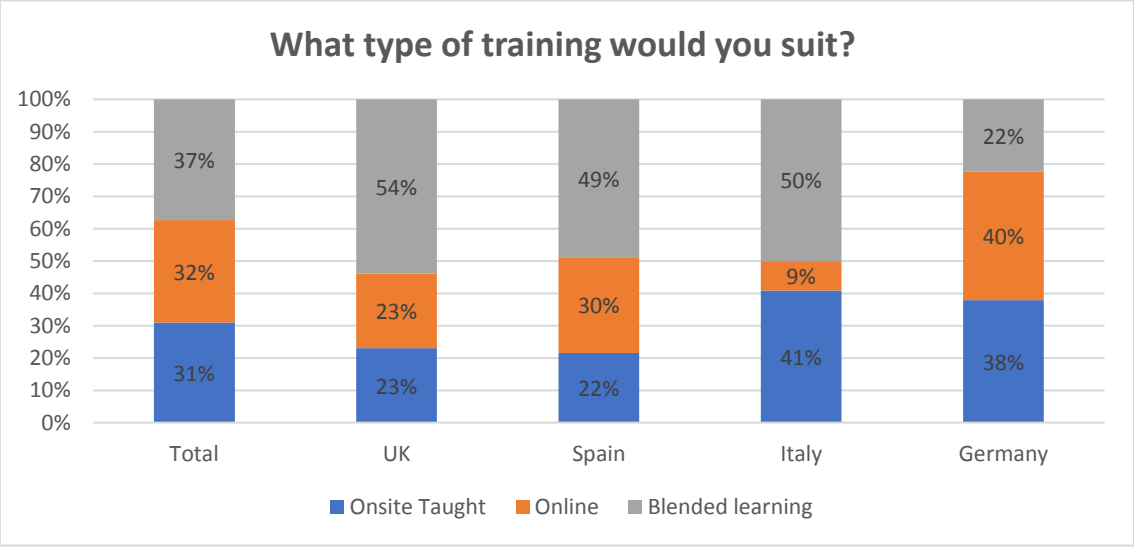


Graphic 11: Priorities in KET training within the furniture industry.

Preferences in type of training among VET/HE communities.



Graphic 12: Preferences in type of training among VET/HE communities.

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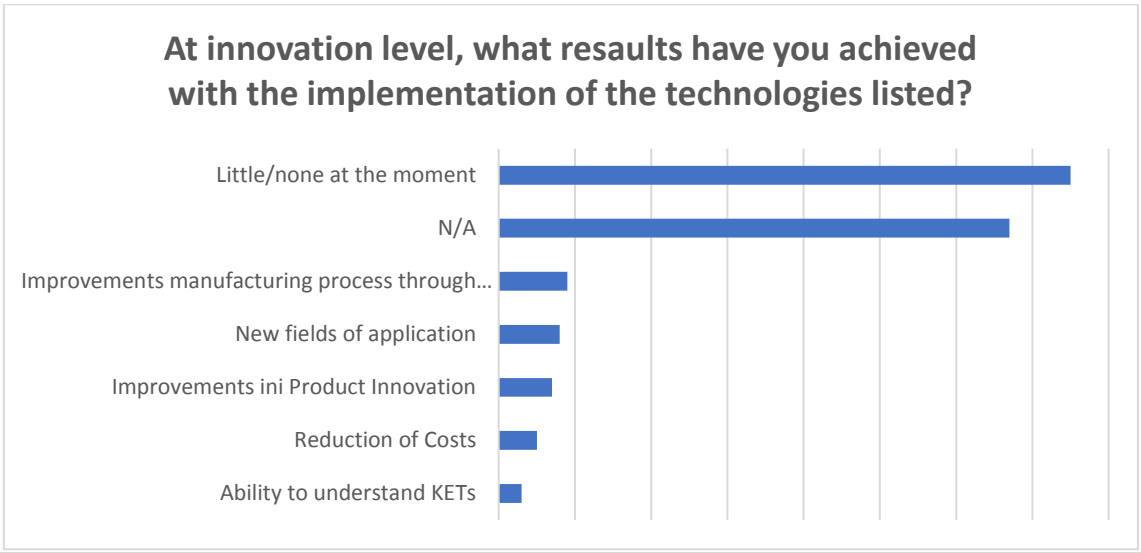
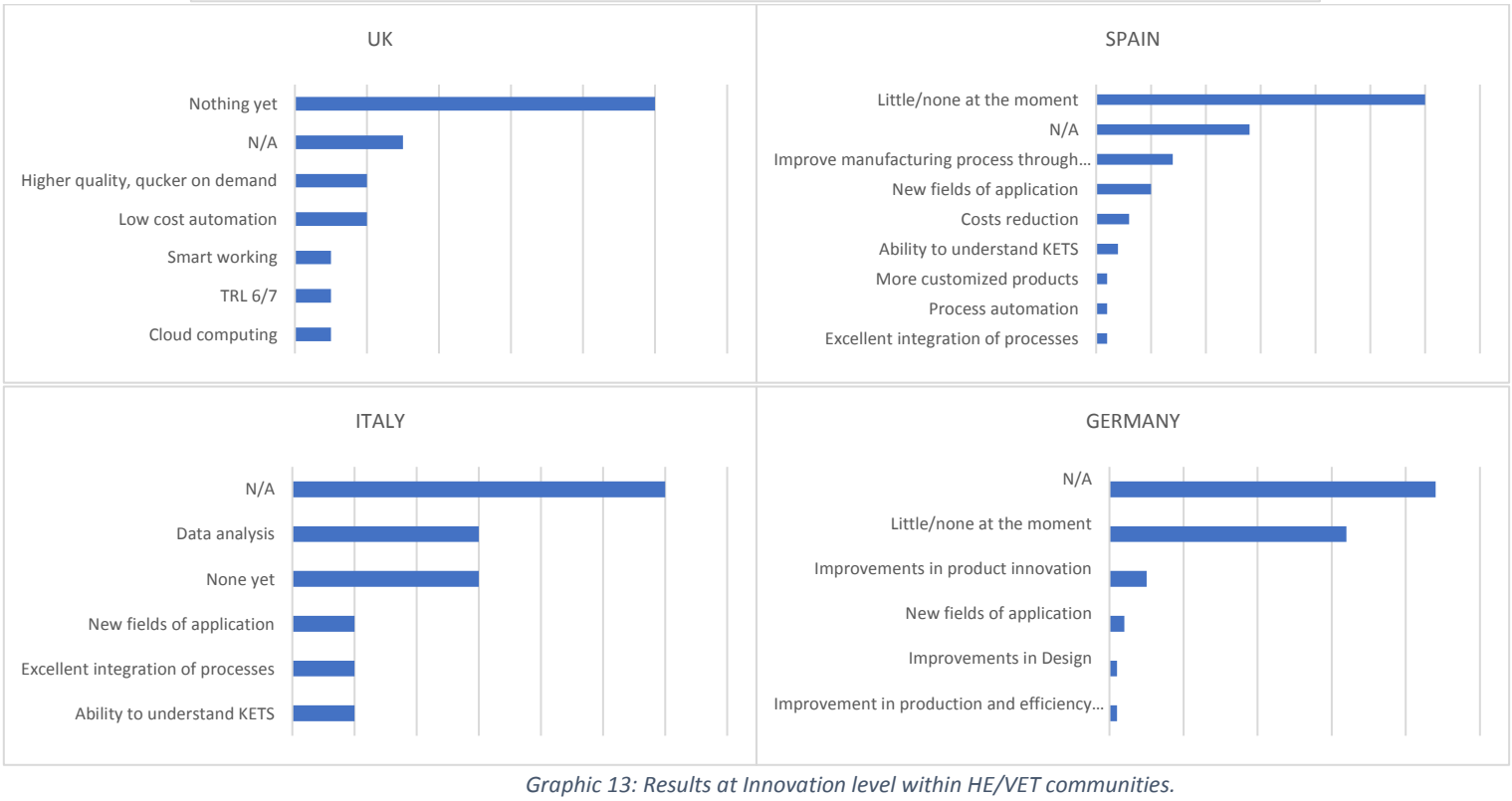
Results at innovation level





Graphic 13: Results at Innovation level within HE/VET communities.

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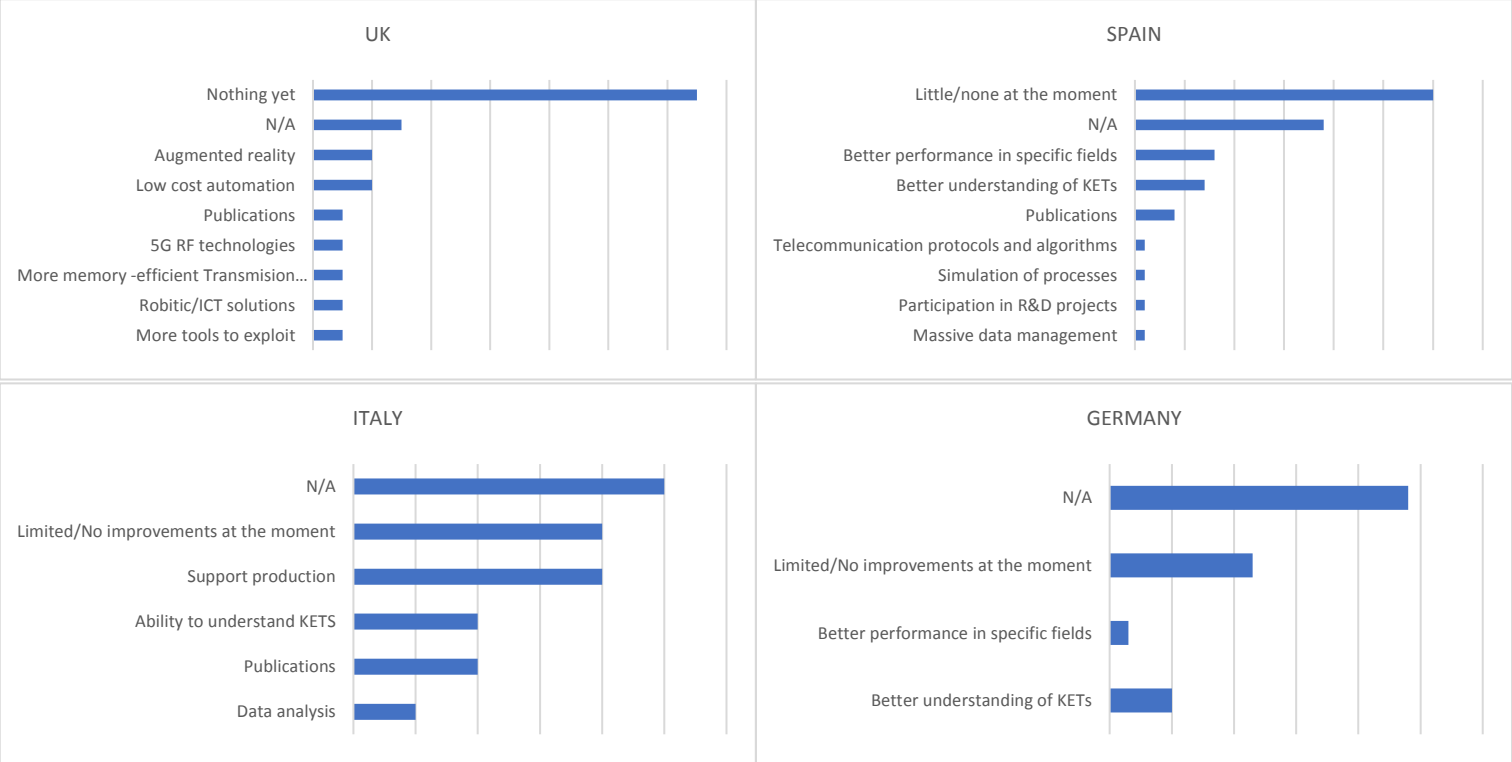
Results at research level



Graphic 14: Results at Innovation level within HE/VET communities.

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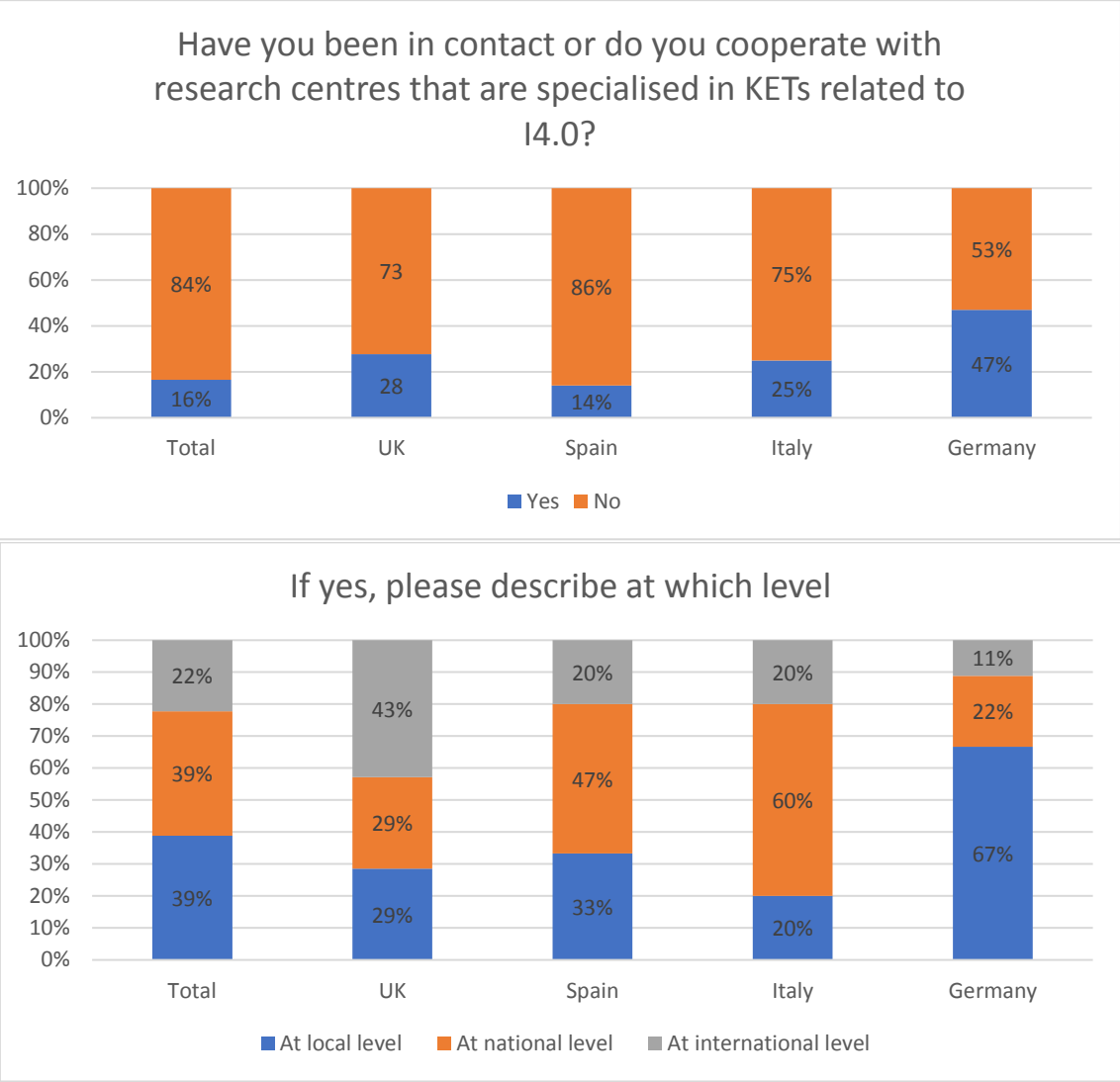
Collaborations of HE/VET communities with R&D centres in I4.0 KETS



Graphic 15: Colalborations of HE/VET communities with R&D centres in I4.0 KETS.

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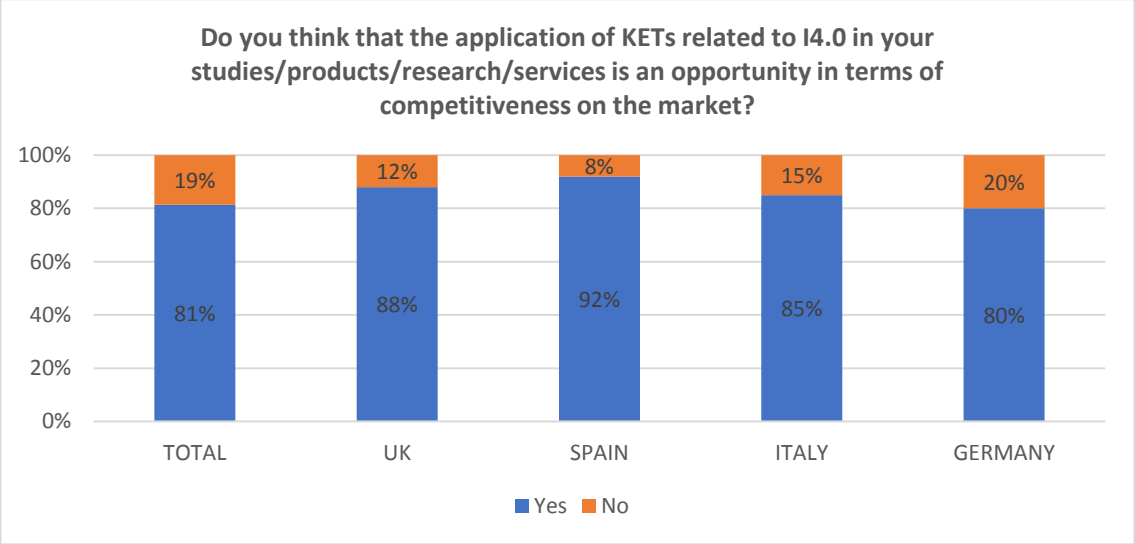
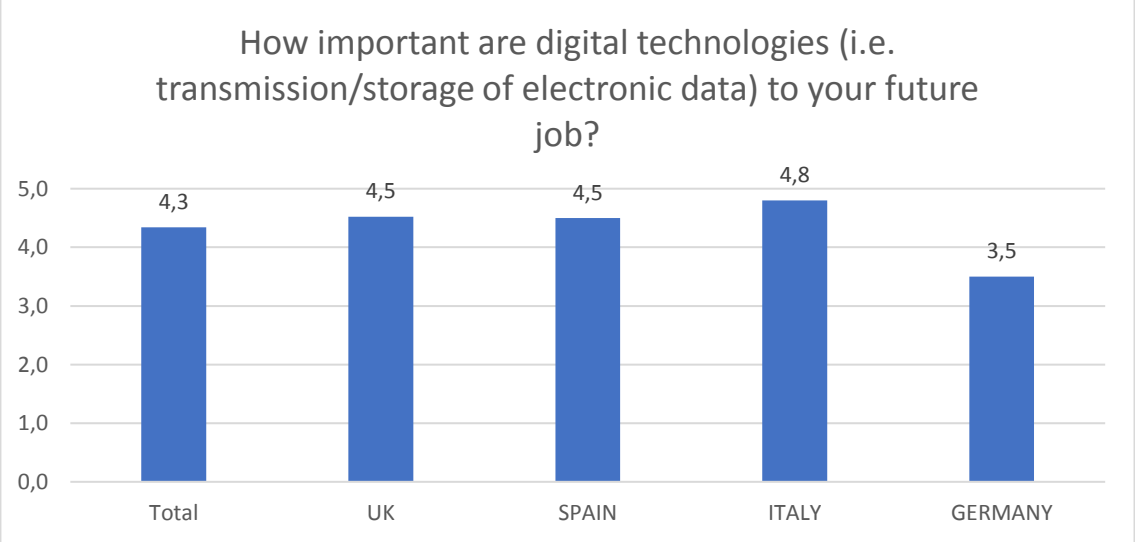
I4.0 KETS in VET/HE programmes



Graphic 16: I4.0 KETS in VET/HE programmes

The importance of digital technologies towards labour for HE/VET community.



Graphic 17 :The importance of digital technologies towards labour for HE/VET community.

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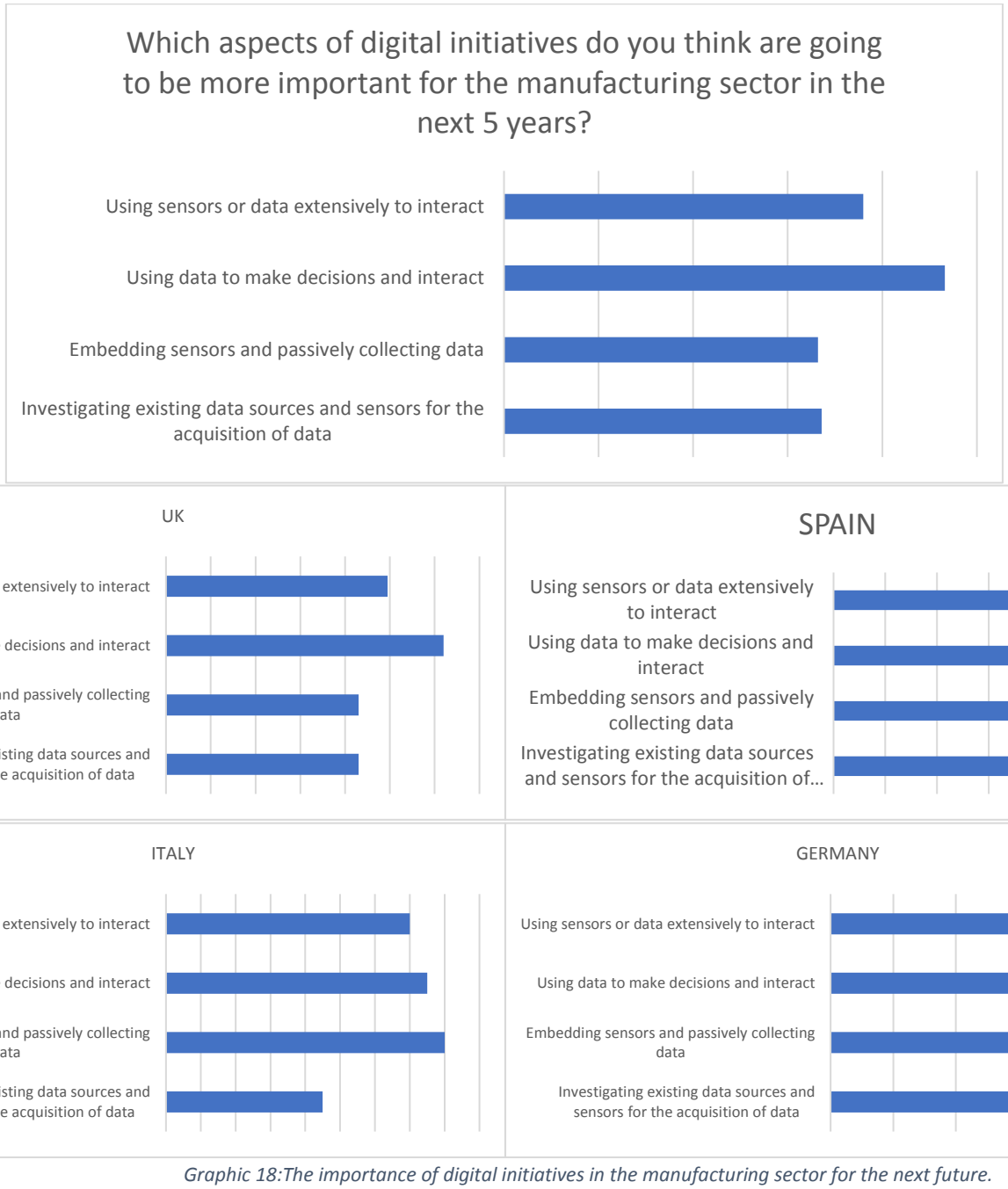
The importance of digital initiatives in the manufacturing sector for the next future.



Graphic 18:The importance of digital initiatives in the manufacturing sector for the next future.

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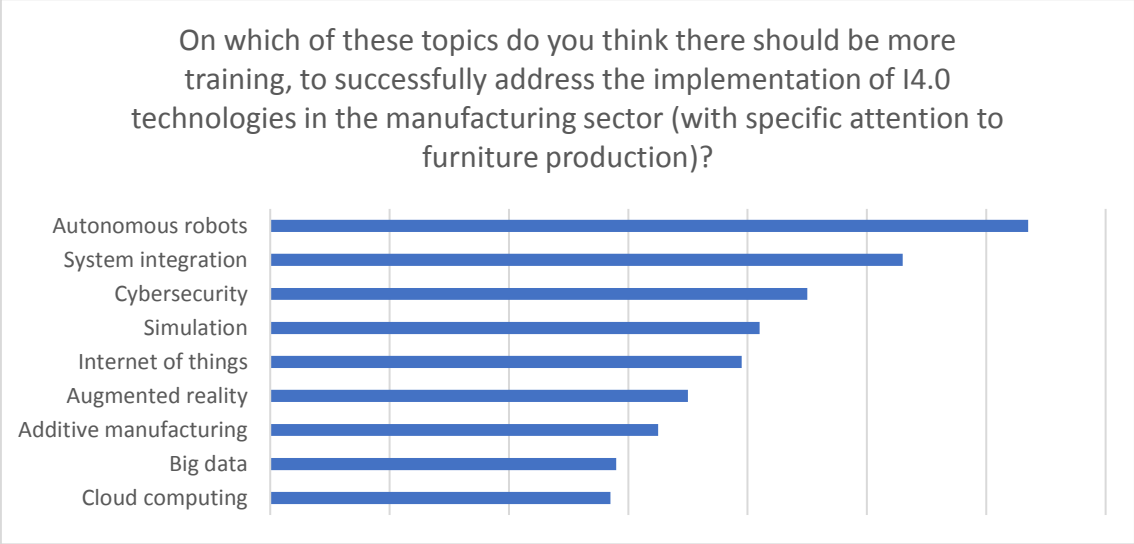
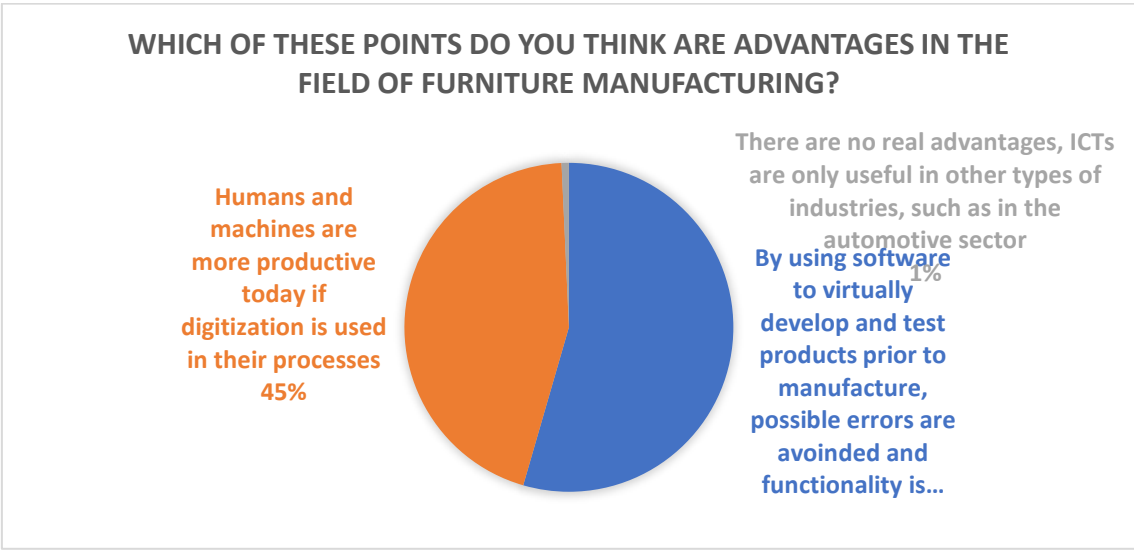
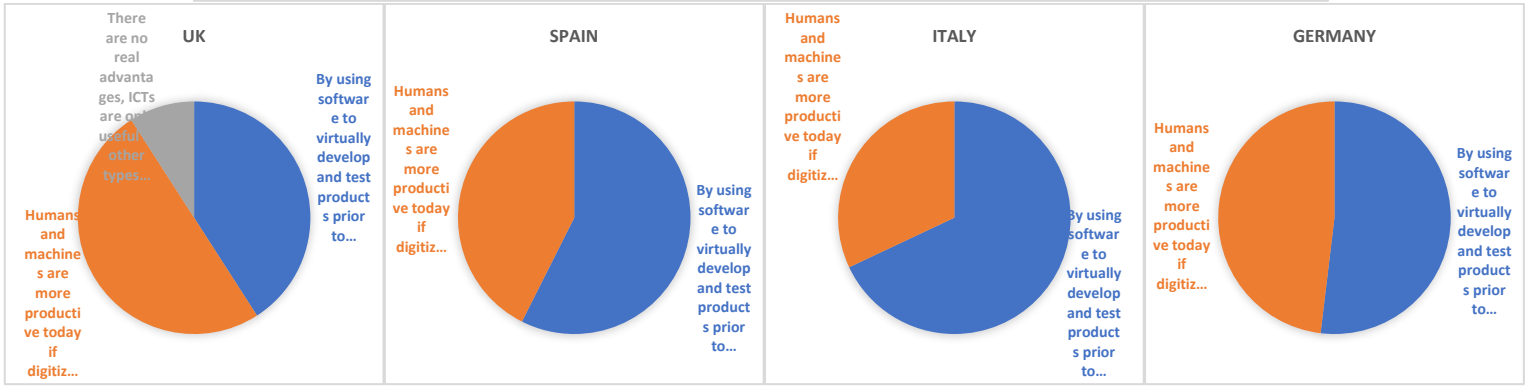
Training towards the implementation of I4.0 technologies in manufacturing sectors.



Graphic 19: Training towards the implementation of I4.0 technologies in manufacturing sectors.

Advantages of I4.0 in the field of Furniture Manufacturing.





Graphic 20: Advantages of I4.0 in the field of Furniture Manufacturing.

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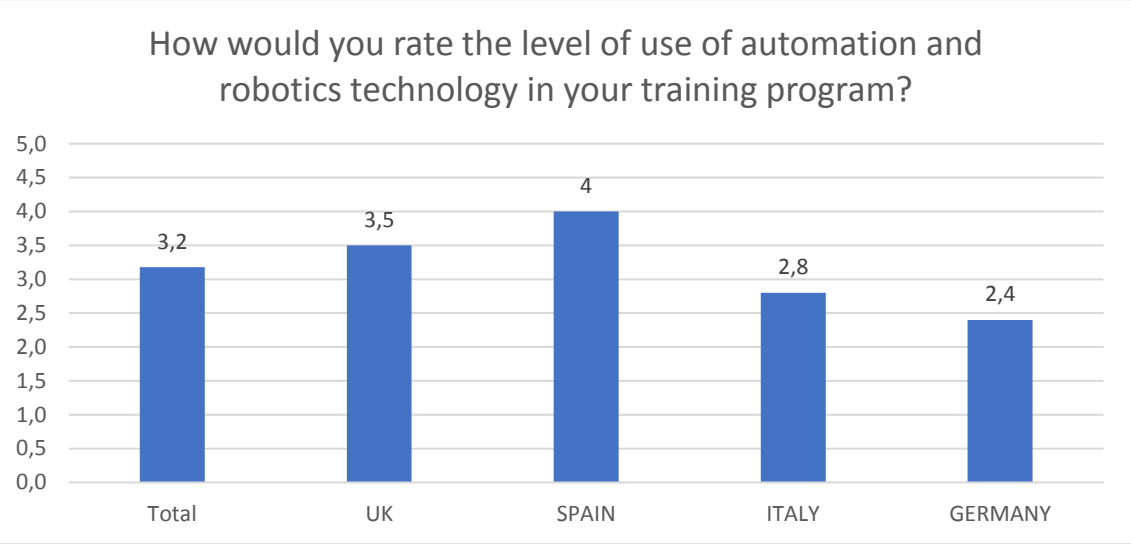
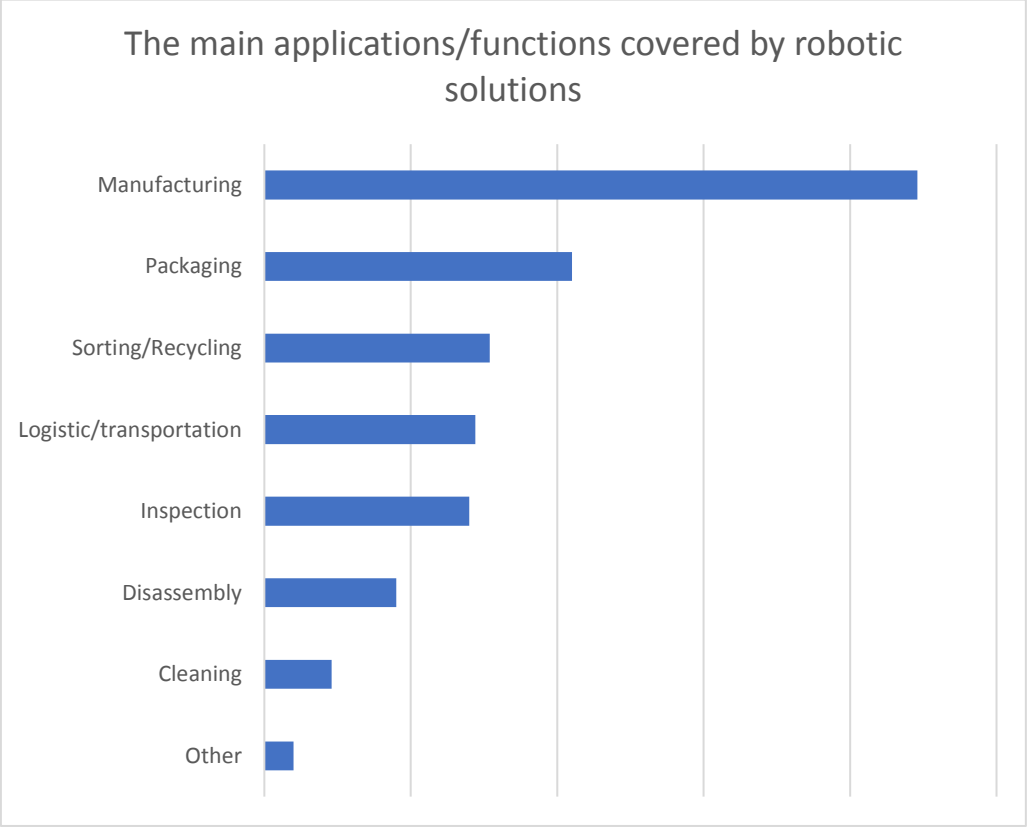
Level of use of Robotics Technology in HE/VET programmes



Graphic 21: Level of use of Robotics Technology in HE/VET programmes.

The main applications/functions covered by robotic solutions



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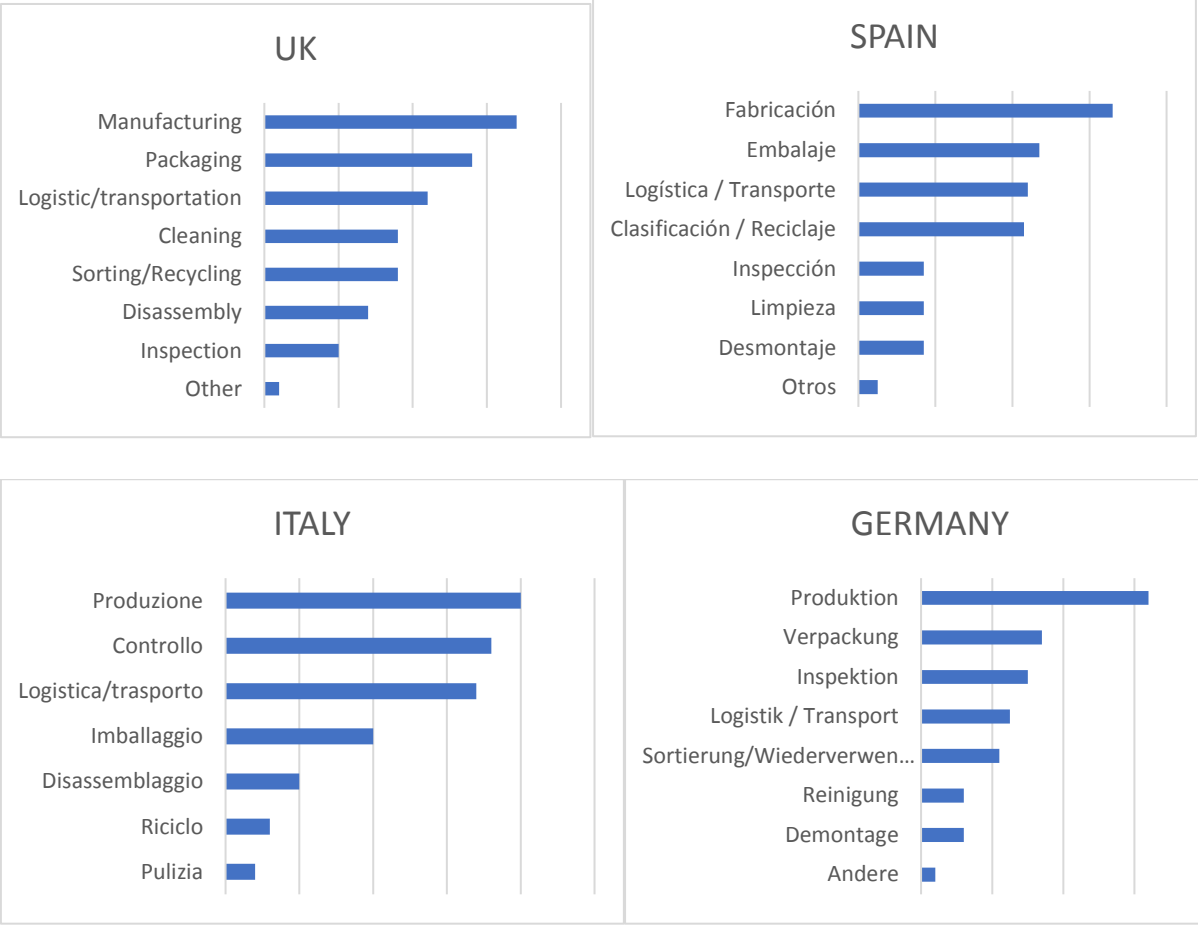
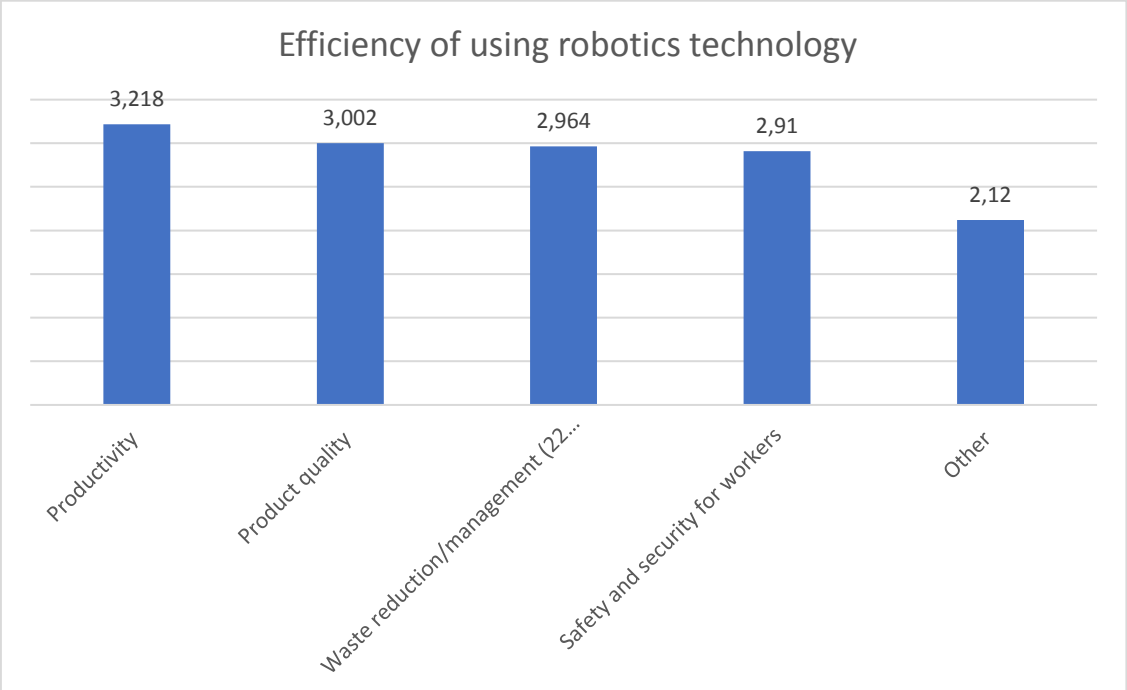


Graphic 20: Applications/functions covered by robotic solutions.

Efficiency of using robotics technology



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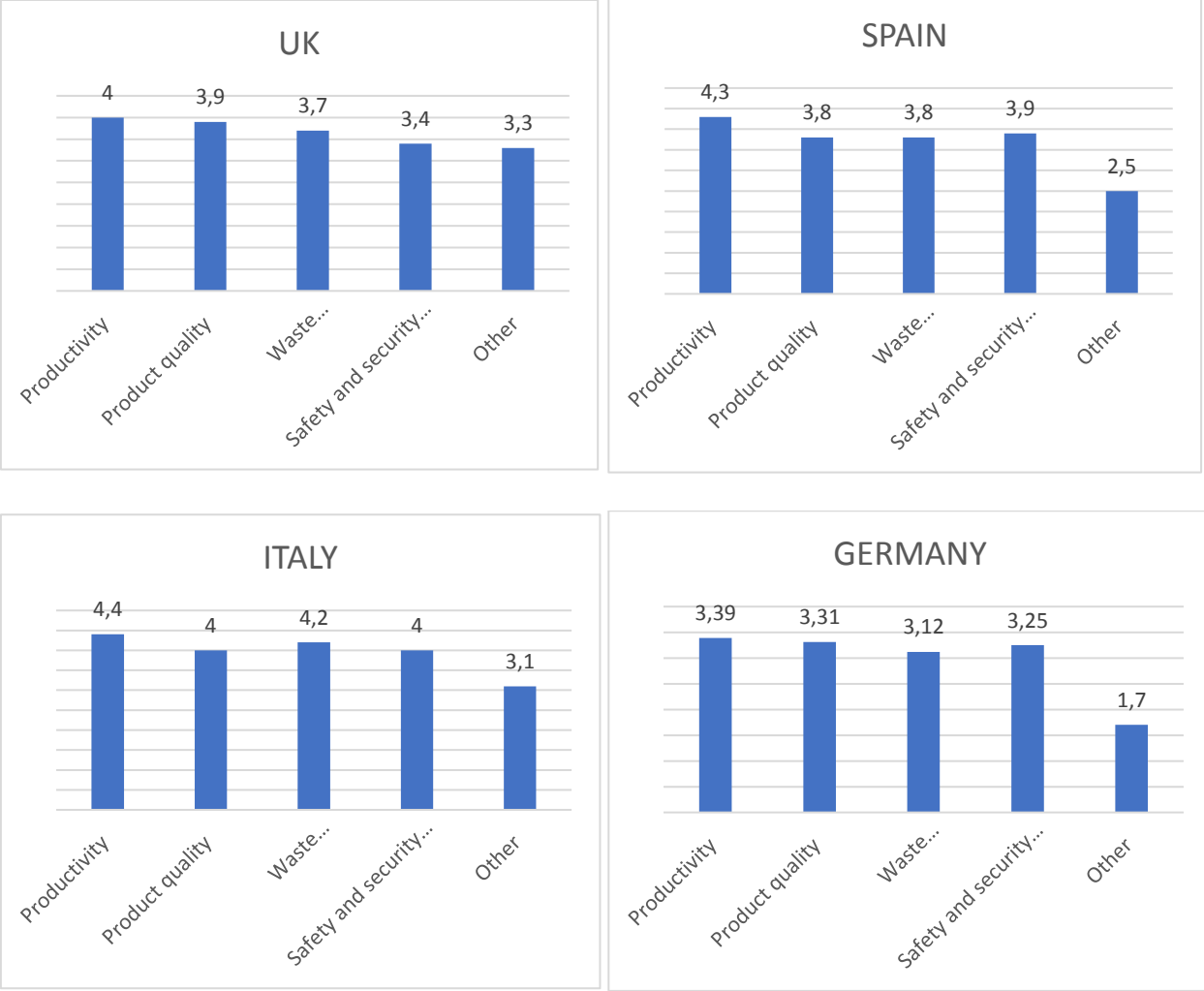

Graphic 21: Efficiency of using robotics technology

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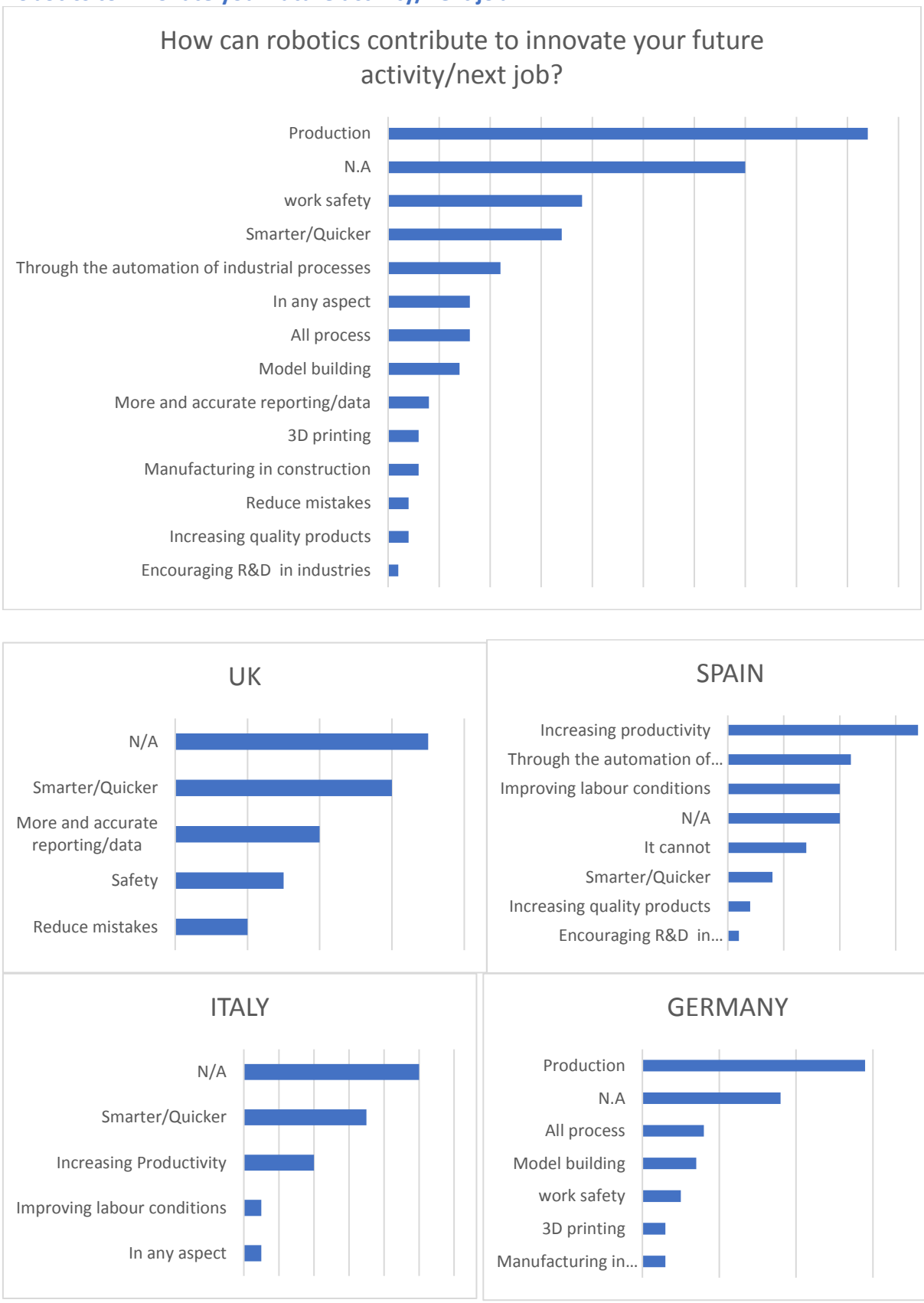
Robotics to innovate your future activity/next job



Graphic 22: Robotics in the future activity/next job

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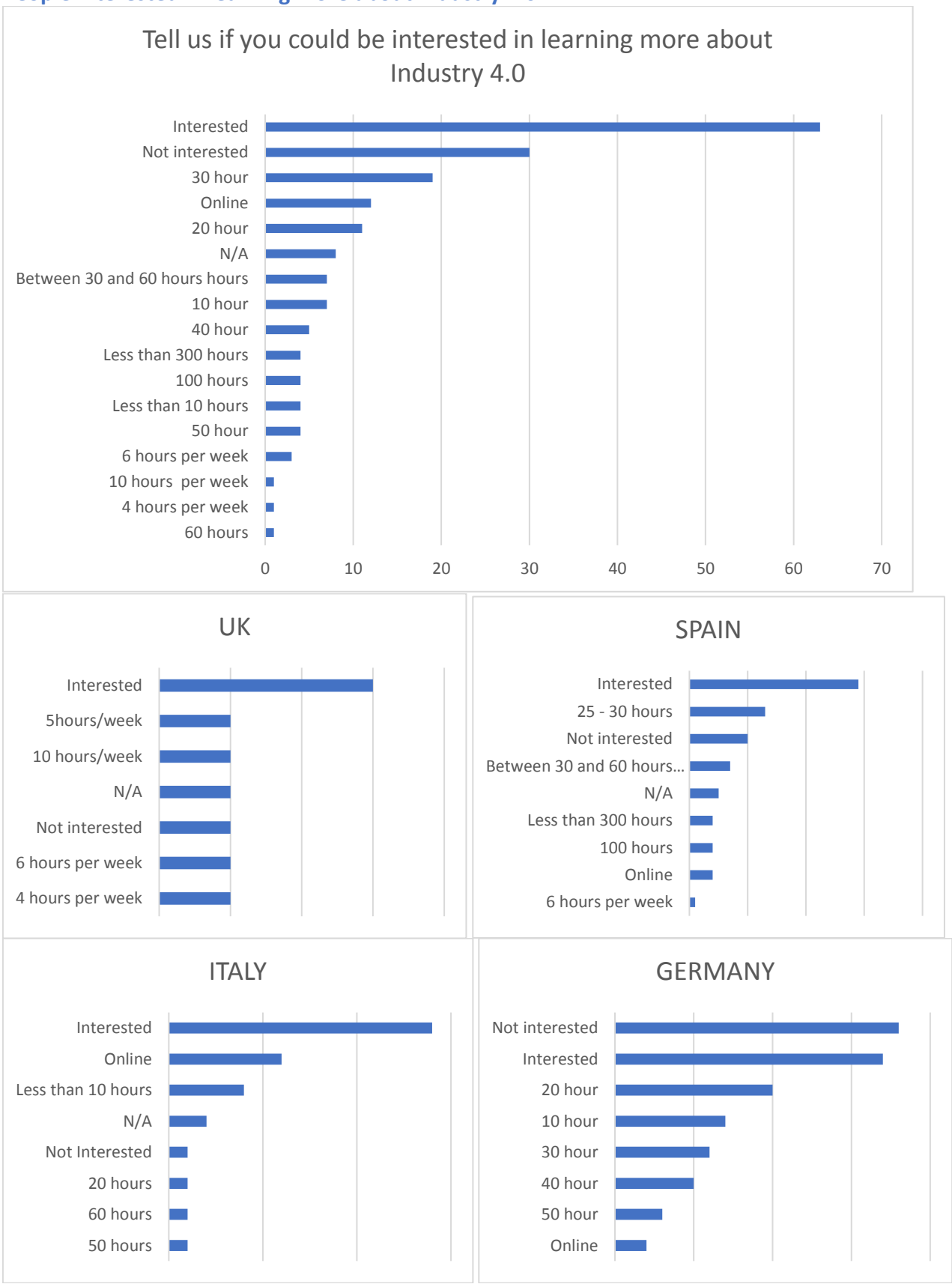
People interested in learning more about Industry 4.0



Graphic 23: Interest in learning more about Industry 4.0

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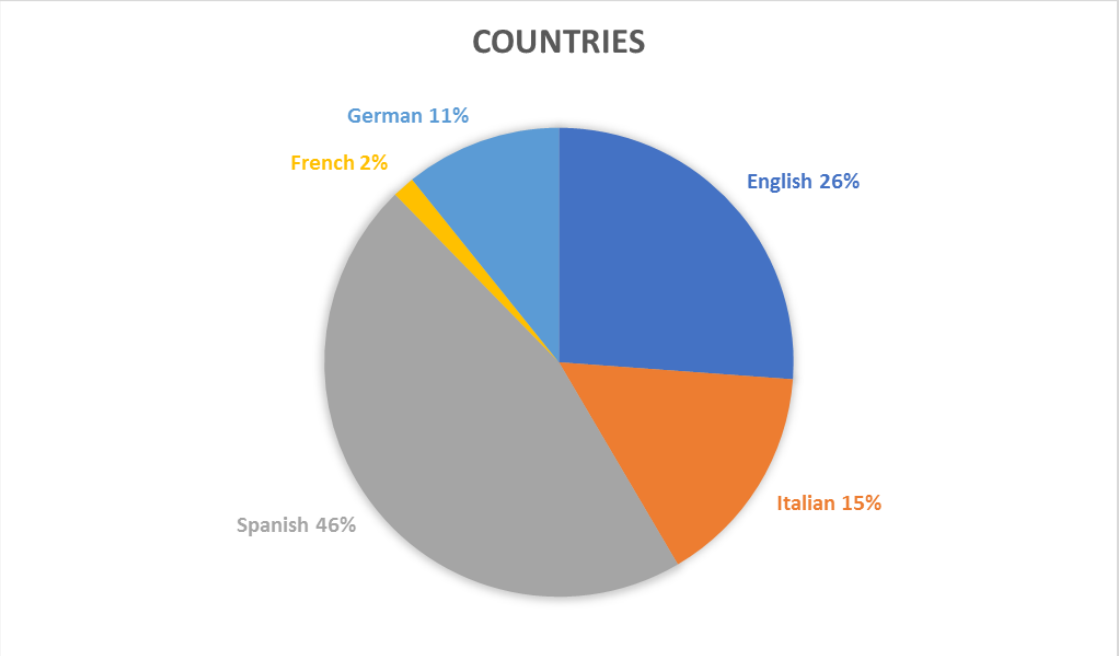
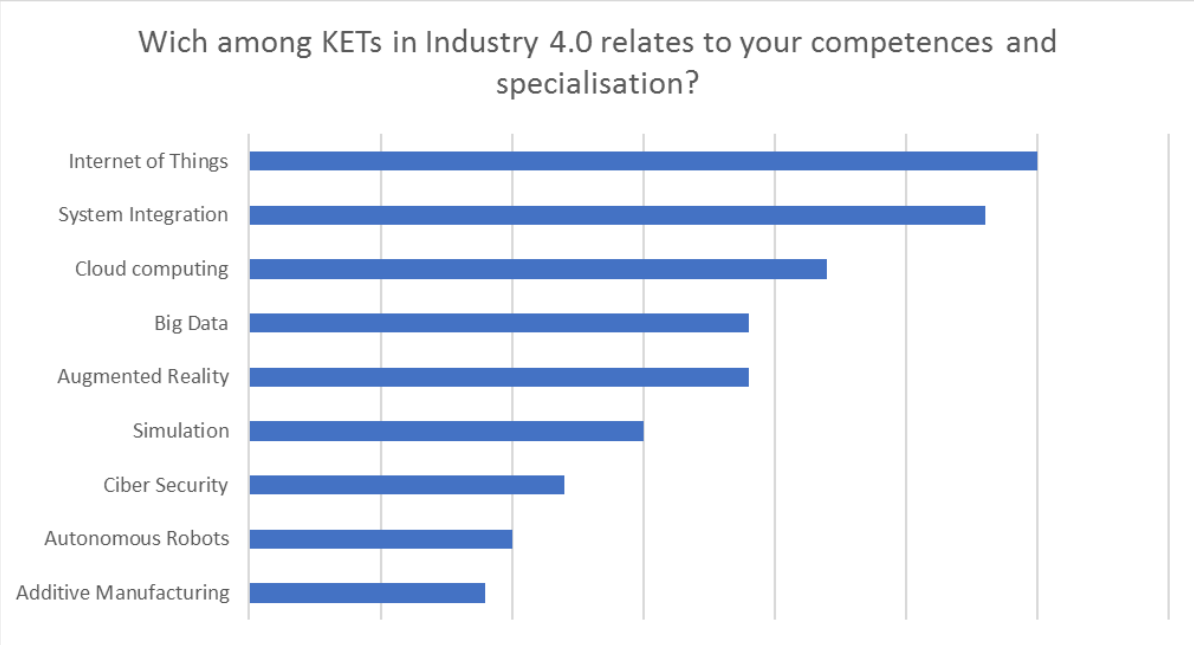
General Information

Origin of the respondents



Graphic 1: Origin of the respondents.

KET related to the competences



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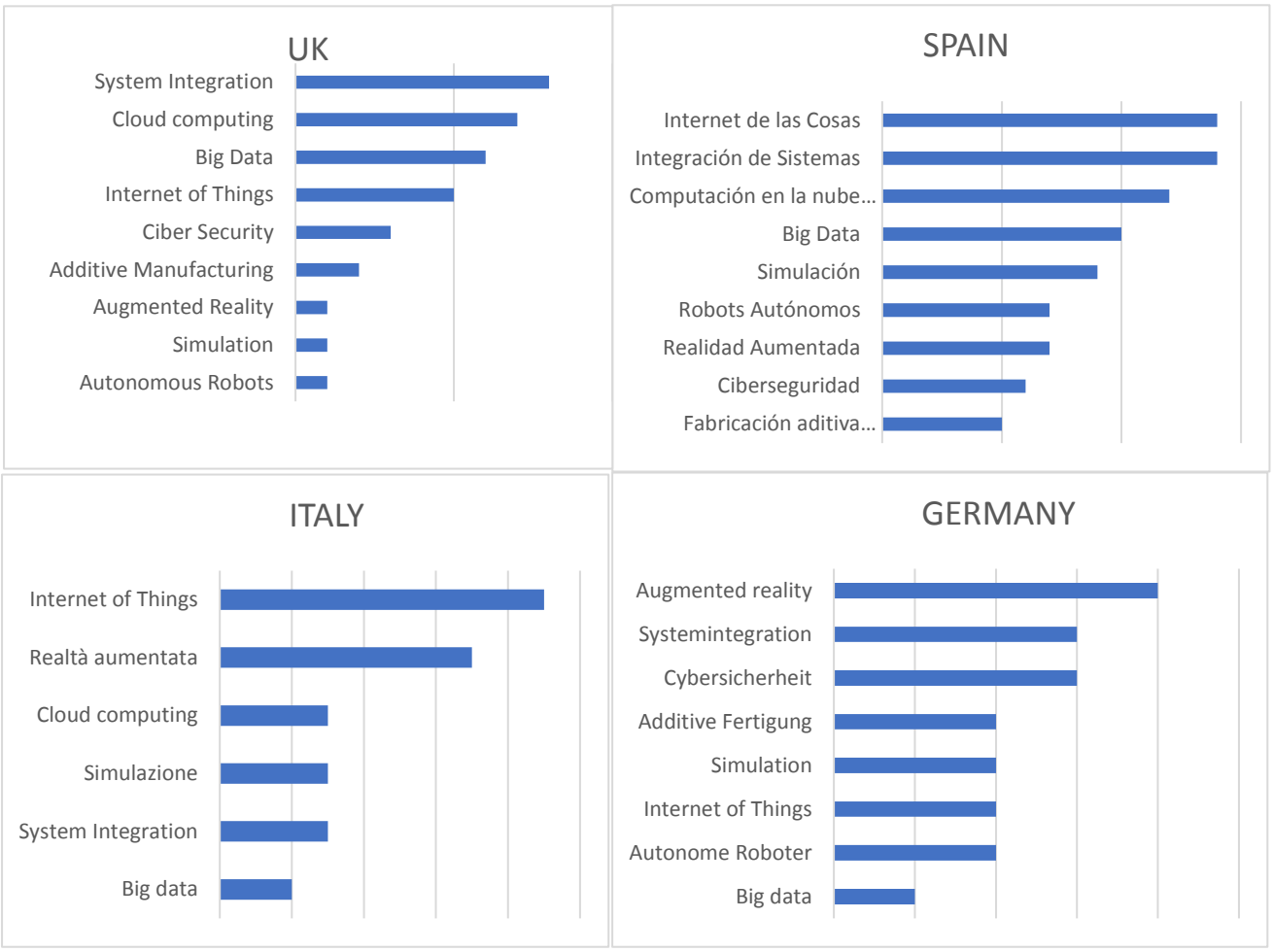

Graphic 2: KET related to competences and specialisation.

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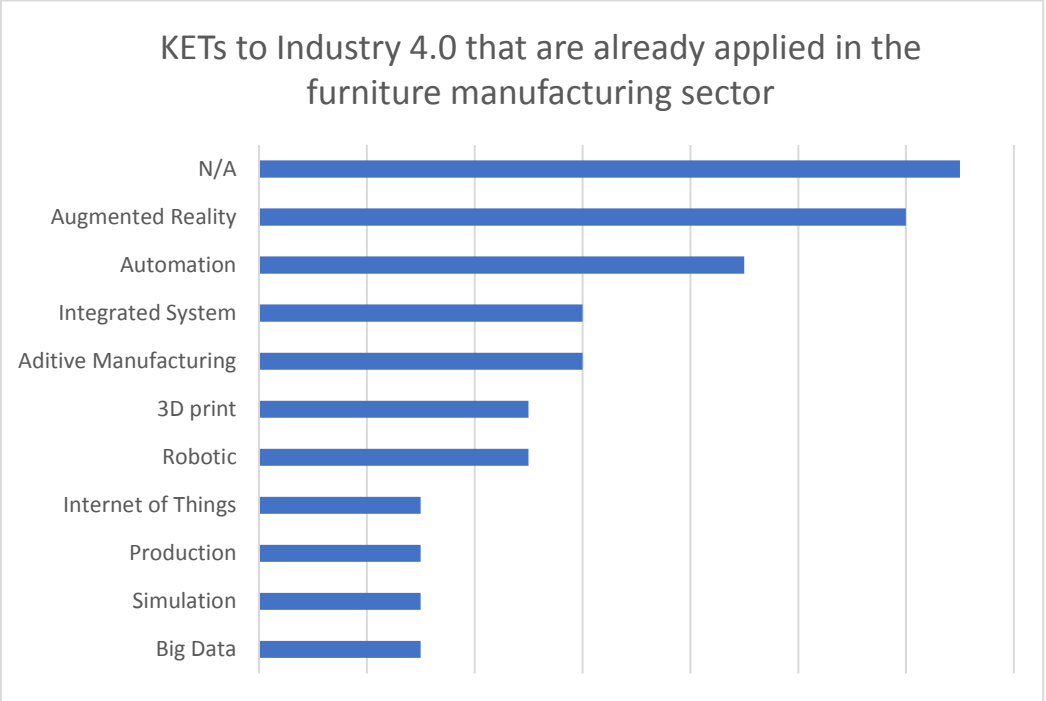
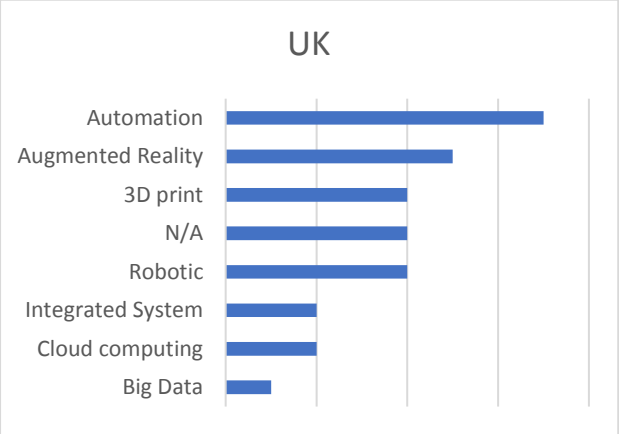
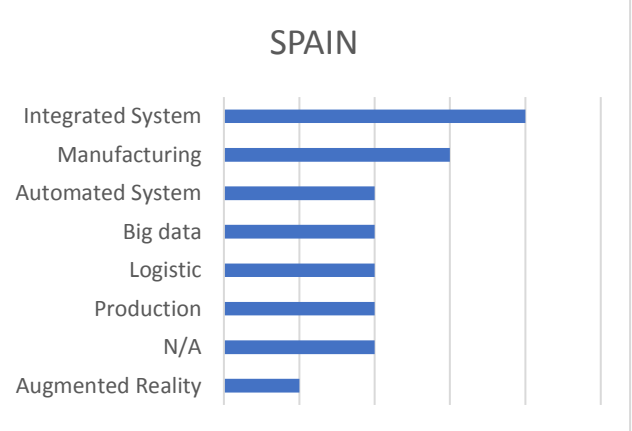
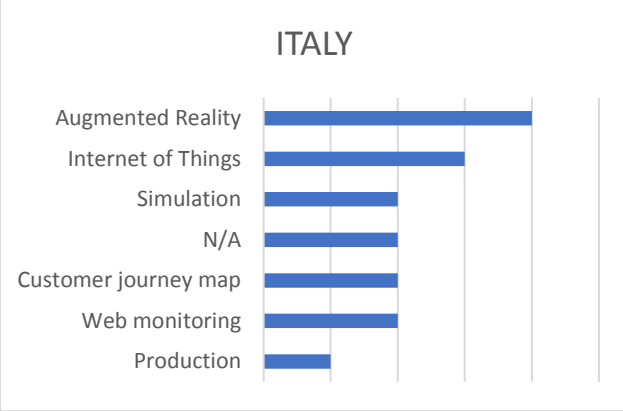
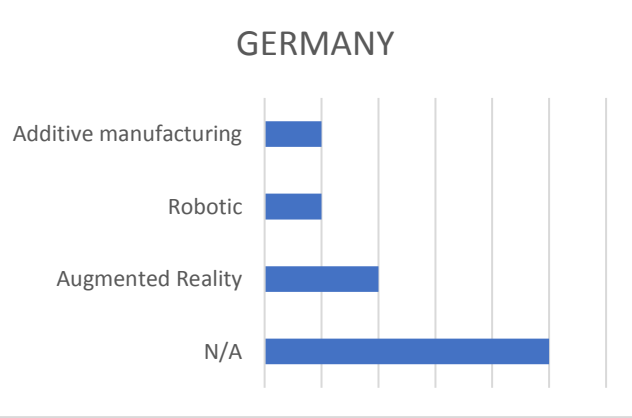
KETs to Industry 4.0 that are already applied in the furniture manufacturing sector











Graphic 3: KET already applied in the furniture manufacturing sector.

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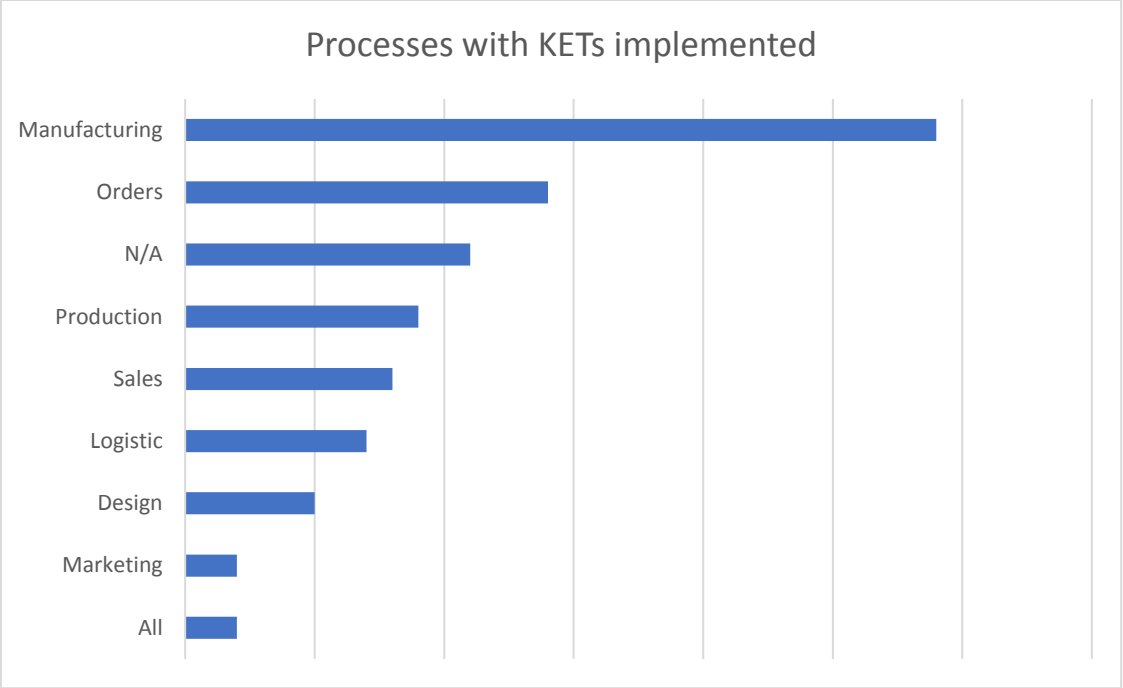
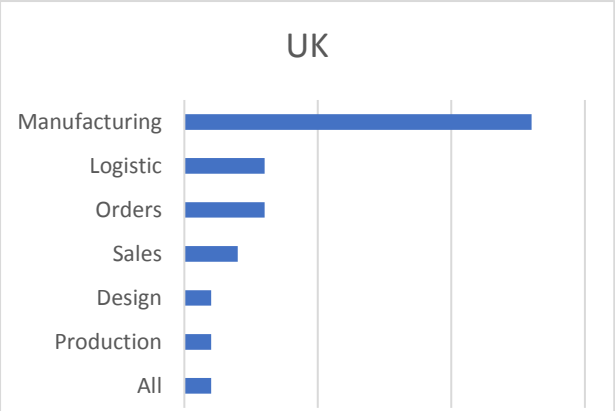
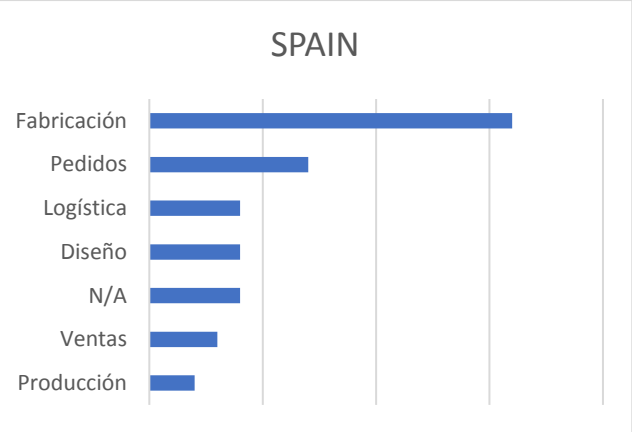
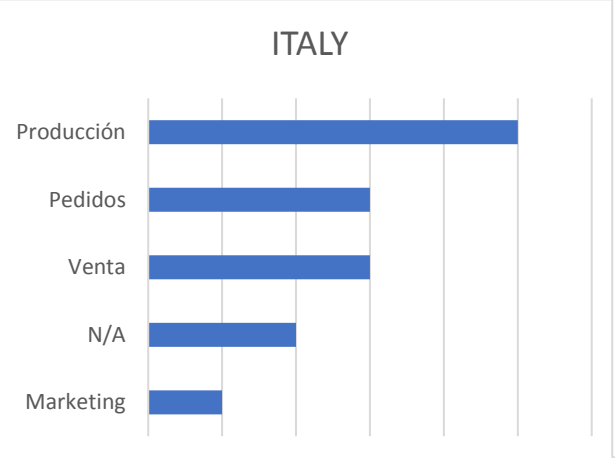
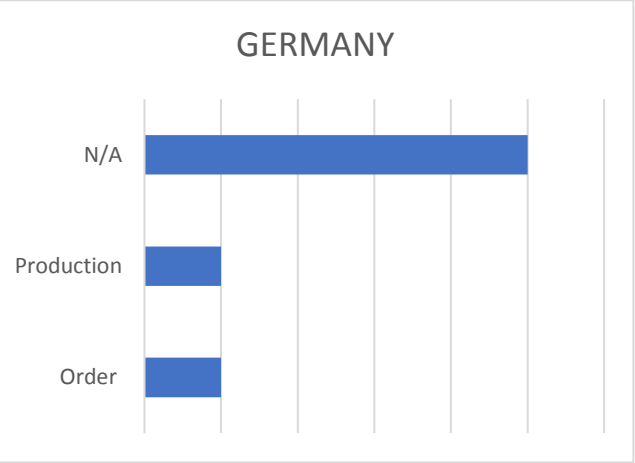
Processes with KETs implemented











Graphic 4: Processes with KET implemented.

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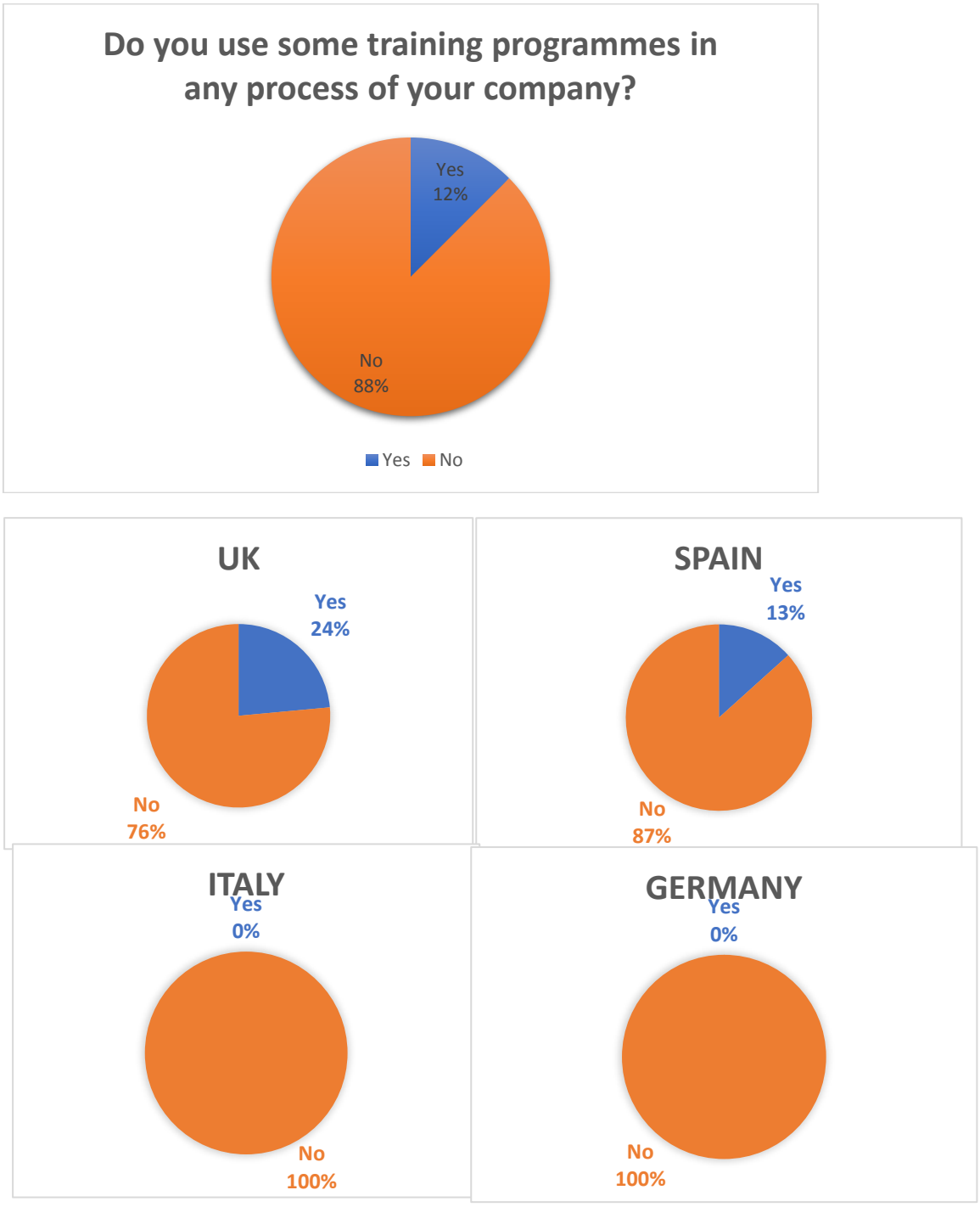
Professional training programmes for companies/manufacturers in relation to KETs



Graphic 5: Use of computer programmes in relation to KET

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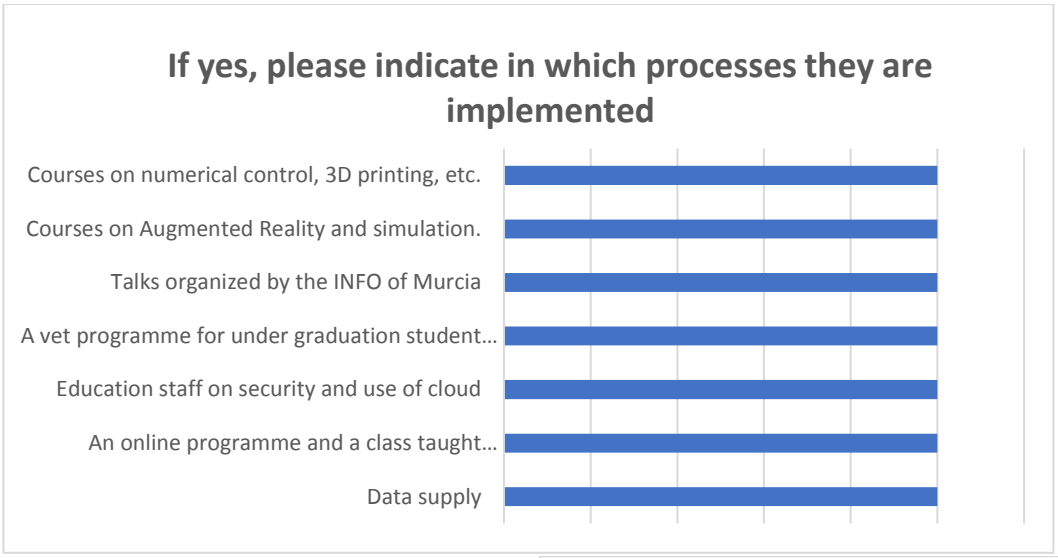

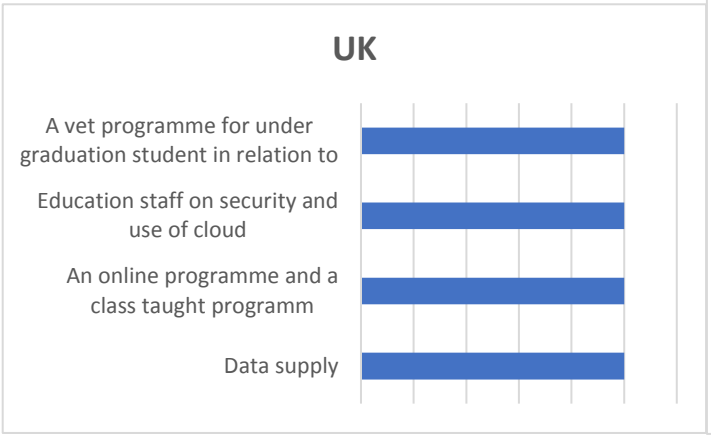

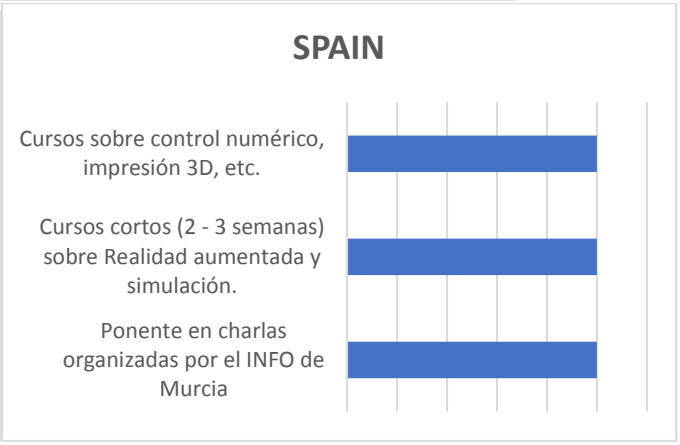

Graphic 6: Processes implemented KET.

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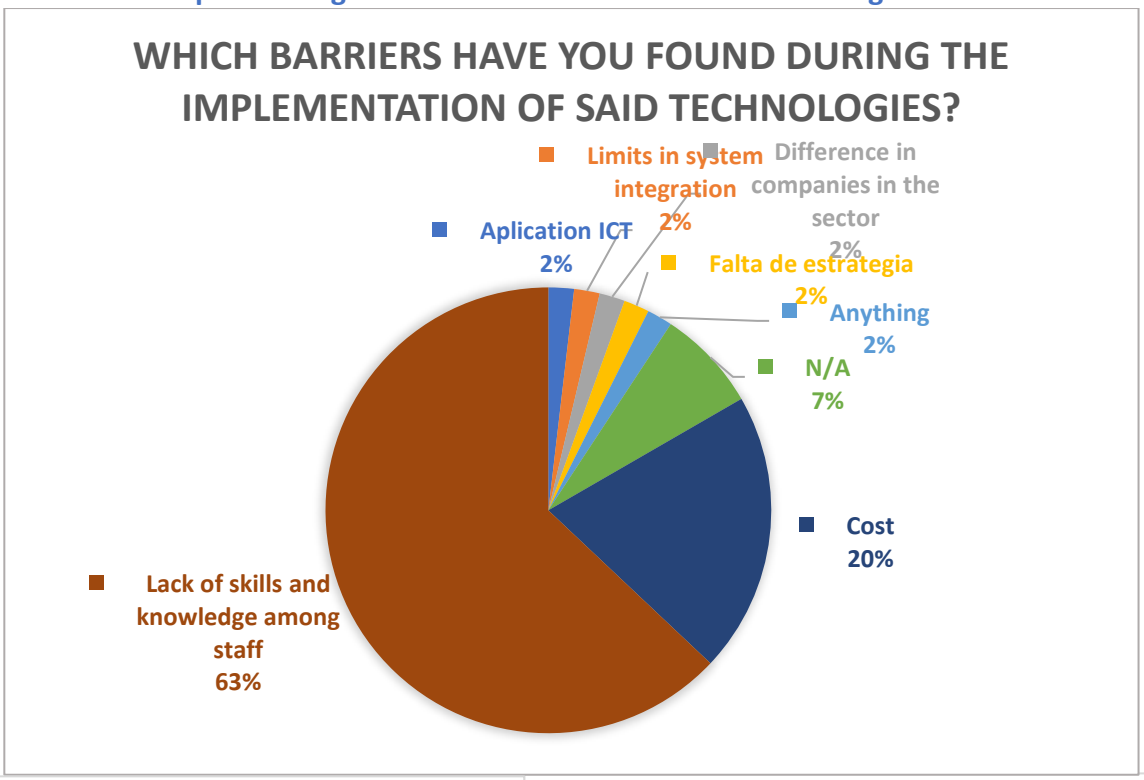
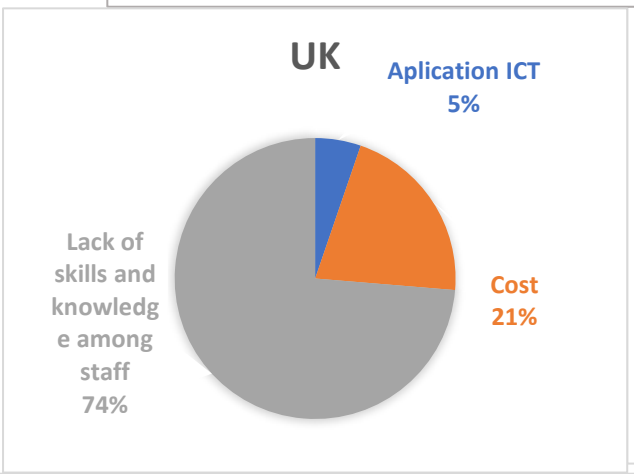
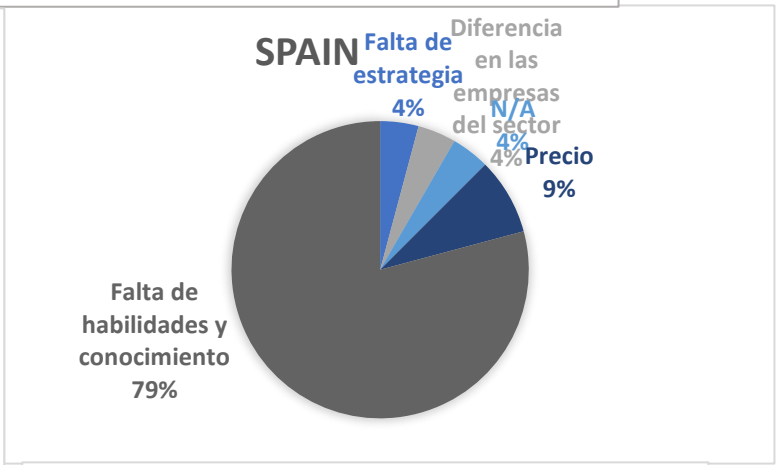
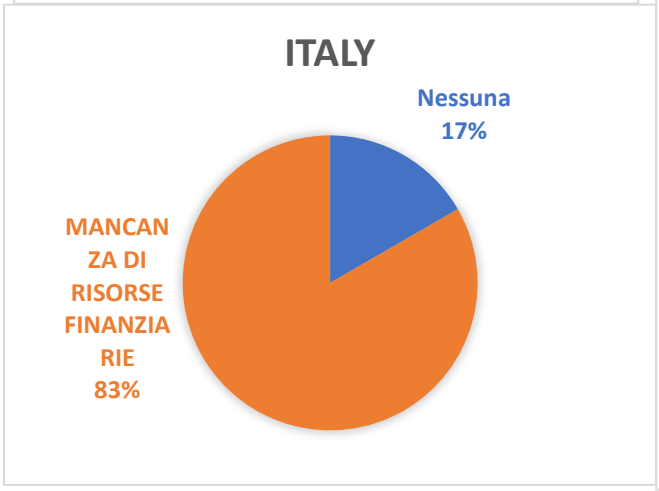
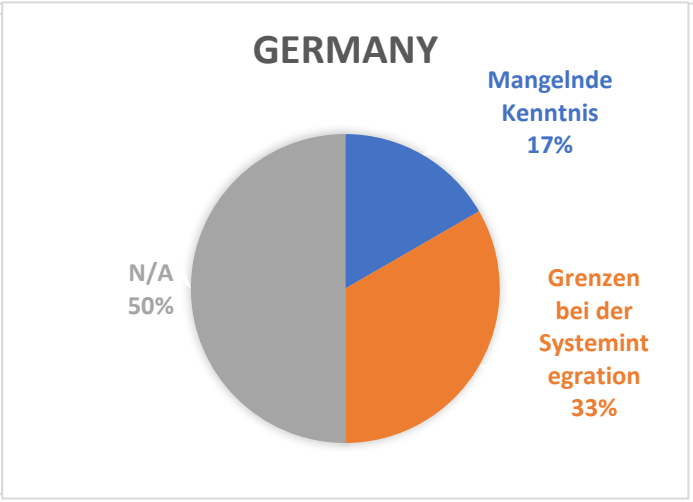
Barriers at implementing KETs in the Furniture and Woodworking Industries











Graphic 7: Barriers at implementing KETs in Furniture and Woodworking Industries.

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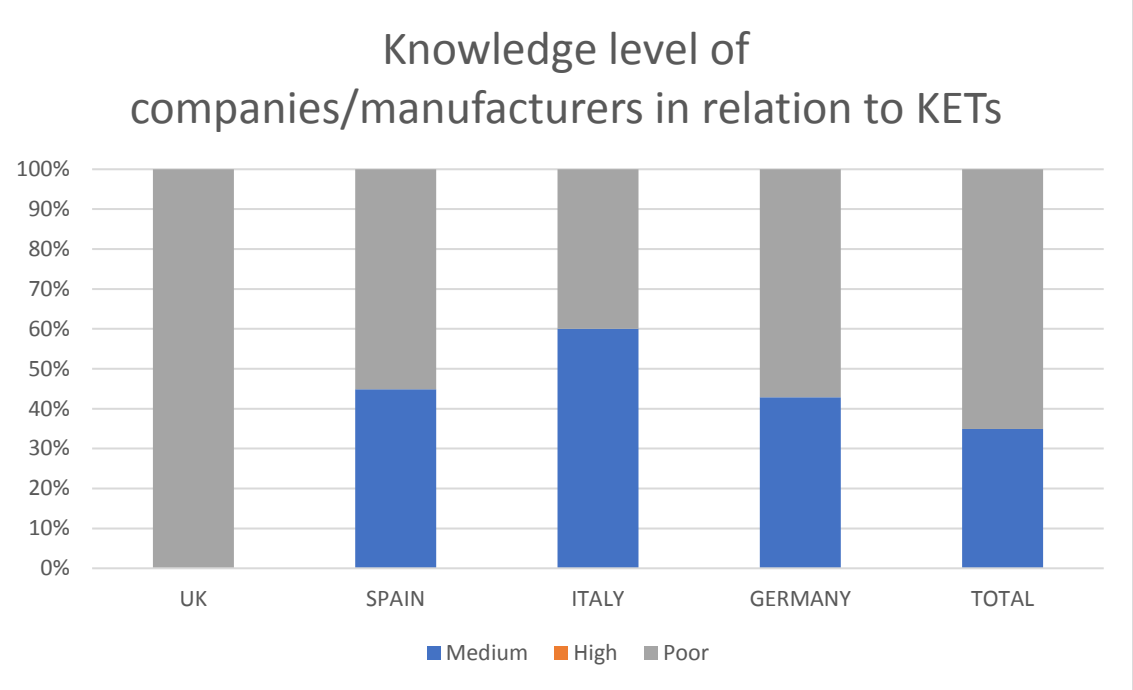
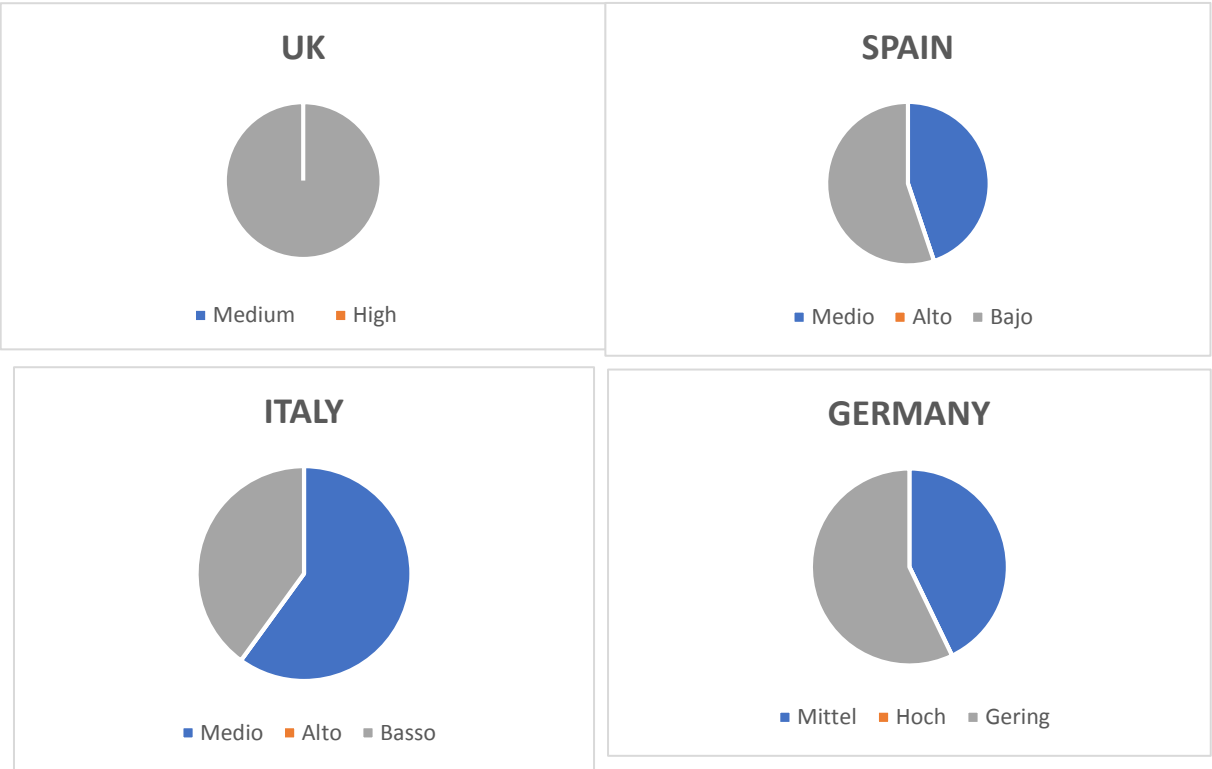
How do you rate the knowledge level of companies/manufacturers in relation to KETs?





Graphic 8: Knowledge level of companies/manufacturers in relation to KETs

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Area of application of KETs they think furniture manufacturers should be more interested and should get more benefit for their activity

Graphic 9: Interesting areas of application of KETs for the furniture Industry.

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IN4WOOD

Industry 4.0 for Wood and Furniture Manufacturers

Report on the Commercial Available products related to KETs of I4.0 for the furniture and woodworking industries.

Partners

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Table of Track Changes

Version	Date	Changes
1	31st August 2017	Definitive version of the document
2		
3		

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Project Number 575853-EPP-1-2016-ES-EPPKA2-SSA

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Table of Contents

This project has been funded by the action Sector Skills Alliances in Vocational Education and Training from the Erasmus+ Programme.
Project Number 575853-EPP-1-2016-ES-EPPKA2-SSA

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0. Intro

The following section aims to identify commercial products and solutions related to the KET (Key Enabling Technologies) that can be applied to the furniture and wood sector within a context related to Industry 4.0.

As specified previously within the main document, the KET are the set of technologies defined by the European Commission because of their excellent potential to improve economically and technologically the situation in Europe. The six-item list includes: Nanotechnology; micro- and nano-electronics (including semiconductors), photonics; advanced materials; industrial biotechnology; and advanced manufacturing systems. [i] [ii]

The current progress related to Industry 4.0 goes far beyond the expectations of even recent times in many specialized fields. By providing some insight into present possibilities, we can identify improvement points that can be reached. This is not as easy as can be expected: To give information on cutting-edge technologies that can be applied to the furniture industry, one single person needs expert knowledge about the real needs of the furniture industry and about the specifics of the latest technology, to find the best intersection of these two sets. The team in charge of this task has researched to improve their competence in both skillsets, and still considers that the result is to be taken as a first approach to the subject, maybe to be validated later by recognized experts in each area.

One concept related to these technologies is the Internet of Things (IoT). Although the term has been widely used since 2013, its mere definition has change through the years. [iii] For purposes of this document, we will consider the definition given by the Recommendation ITU-T Y.2060 (06/2012):

> *A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.* [iv]

In practice, IoT is an infrastructure that enables advanced services throughout the intercconnection of things (“things” understood here as physical or virtual objects that can be identified and integrated into comm networks) bsed on existing and interoperable information and communication technologies, at any momento and from any location, allowing for a greater integration of technologies such as machine-to-machine communication (M2M), data mining, decision-making security and cloud computing. [v]

In many cases the text speaks about technologies that have been tested and implemented in other domains like healthcare or other industries. This gives the furniture domain an important advantage when implementing these technologies, as the later have been debugged by these previous environments and are mature. The furniture domain needs only to incorporate these items to their processes in a much safer condition than its predecessors.

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A number of European manufacturers in the field are already, as of mid-2017, using KET and other very advanced technologies to contribute to their activities. In Great Britain, we can find Devonshire Oak and Pine,[vi] Ercol[vii] and West Bridge Furniture[viii] to mention a few.

1. Nanotechnology

Nanotechnology deals with manipulation matter on a supramolecular or smaller scale (traditionally with at least one dimension under 100 nanometres), mainly to build macroscopic products. In particular in industry, nanotechnology deals with such small detail that it is to be considered on the design phase of a product. The definition of the design to work with will be "the process of adaptation of the object environment to the physical and psychological needs of the people", which is related with the industrial process: Industrial design is defined as "the process of adapting consumer products which can be manufactured industrially (adapted) to the physical and psychological needs of users and groups of users."[ix]

Nanotechnology then plays one important role –along with material engineering– to provide an added functionality and potential, expanding the possibilities of an industrial product and also reducing ecological impact (which will become one constant in the KET products) and maintenance expenses and effort.[x]

Up until recently, nanotechnological design was all but unfeasible because of several reasons. Its development and optimization obviously required expertise, including detailed research on the intended results and mastery of advanced concepts in physics and mathematics, partly because the properties of materials -from optical properties to fusion temperatures, e.g. are different on a nanoscopic level.[xi]

It does however have a great number of interesting applications including: Polymer reinforcements, nanoparticle coating (resulting in surprising and special finishing), surface finishing with many properties (anti-fungi, anti-bacterial, anti-spots, anti-pollution, anti-scratches, anti-condensation, anti-reflection, photocatalytic, self-cleaning, self-repairing, water and oil repellent and with iridescent colour); reinforcement for materials; more efficient filter systems; solar panels; better food preservation systems; and longer-lasting items such as tennis balls and soda cans – to mention just a few.[xii] There are also self-healing coatings that autonomously repair and prevent corrosion of the underlying substrate are created through dispersion of microencapsulated healing agents in a polymer film. Following a damage event, these healing agents are released into the damaged region, passivating the substrate. This approach to self-healing coatings is quite general, and is effective for both model and industrially important coating systems.[xiii]

Materials that use nanotechnology to clean efficiently include the "Lotus Effect®"[xiv], based on nanoparticles, dirt and water repellent, and currently in use in several no-wet, self-cleaning surfaces like roofs and glass. Albeit it does have limitations in ceramics and clothing textiles, it has proved its efficacy protecting materials against spots and fungi, which can be of great use in outdoor furniture. It is currently an interesting technology to be implemented in textile domains, including furniture

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covering and upholstery, although it has not been implemented yet.[xv]

Another item is TiO_2- nanotitanium dioxide with photocatalytic self-cleaning, hydrophilic, transparent properties. It does require ultraviolet light and water to remove waste products, being less than adequate for indoor activities. Discovered in 1967, it is currently used in glass, PVC, sound-proofing panels, roof, concrete slabs, coating, etc.[xvi]

Both TiO_2 and Lotus Effect have been used for decades, having been submitted to a great number of risk assessments and, up to the date, there was no known harmful impact in either the environment or human health related to their use.[xvii]

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Project Number 575853-EPP-1-2016-ES-EPPKA2-SSA

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2. Micro and nanoelectronics

Microprocess engineering is very useful for machinery manufacturing, sometimes in conjunction with nanotechnology to provide industrial applications and to increase commercial value. Already microelectronics has some hold in European industry, which will ease its introduction in furniture domain because of the geographical proximity of the providers.

Consider Germany, which uses an umbrella to cover electronics, microelectronics and nanoelectronics. Germany annually invests 21.4 billion euro on this technology, which is the second largest industry segment in manpower for the country (with 843.000 domestic employees plus other 704.000 overseas), and ensure that one in every four people in industry-related research and development is in the sector.[xviii]

Figure 1: Elmasonic X-tra line pro.

The Singen-based German company ELMA - Elma Schmidbauer GmbH - produces and sells microtechnology applied to electronics and mechanics, particularly focusing in cleaning purposes.[xix] Some of their products of interest for furniture industry include:

The **Elmasonic X-tra line pro**, a modular design system with multi-frequency technology & manual power control, that also features robotic systems (manual or automated) with different programs, including functions to degas, pulse and sweep; and increasingly intuitive interfaces to be used by non-specialized staff, adding to the ever-growing popularity of the systems. There are also several optional peripherals to be incorporated in the final implementation.[xx]

The STC robot lines, single-transport systems based on standardized concepts with specialized processes, chambers in 5 different volumes and robust and proven components for industrial applications. Data logging systems monitors the production cycles for validated and consistent quality results. Accessories include dryers, oil separators, and water processing units and filter pumps; and the ever-present laminar flow technology to keep out air particles.[xxi]

Elma's Multi-transport system provides fully-automated standard lines, with life & push installation, constant validation, multi-frequency technology, process chambers in different volumes and accessories such as a vacuum dryer and a wet loading tank.[xxii]

Other Elma products with furniture application include tailor-made cleaning lines to address specific needs, including support from experts, maintenance, and repair and customized cleaning chemicals,[xxiii] cleaning agents to maintain the industrial devices themselves and prevent oxidation and hardware issues,[xxiv] and multi-frequency system for industrial fine cleaning.[xxv]

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2.1 Semiconductors.

Semiconductors are a specific case included in micro and nanoelectronics. Semiconductors are industrially used mostly for circuitry, being essential in the many electronic products such as computers, automation, communications infrastructure, etc. There are four main product categories for semiconductors:[xxvi]

- Memory chips, to store information in computer devices; but this category has cheapen to a point that only a few multinational companies (like Toshiba, Samsung and NEC) really compete in the area. It is not recommended for SME's.
- Microprocessors, including CPUs with the business logics. Intel is a dominant company here; and Advanced Micro Devices also has a slice of the pie chart. Other companies specialize in their own niches; and some cases may be still unexploited.
- Commodity Integrated Circuits, also known as Standard Chips. These are mass-manufactured for routine processing purposes. Large Asian manufacturers eat up most of this business, with a relatively low benefit.
- Complex SOC (SOC = System On a Chip): This refers to the creation of an integrated circuit chip with a system's capability on it. The demand in this case is growing, making this the most interesting business area for new parties.

The largest semiconductor companies are as of now (using 2016 data) multinationals like Intel, Samsung, Qualcomm or Toshiba, per Gartner.[xxvii] Entering the business is difficult, partly because the initial expenditure is too high; but also because of the intense rivalry between the main competitors. Traditionally, the whole production process of one semiconductor, from the design to the manufacture, was covered and controlled by one single industry. This model is starting to change, with specialized companies taking part in sections of the process. Besides, the Intellectual Property production is also offering new alternatives to stale systems.[xxviii]

The semiconductor industry famously tends to miniaturize the circuitry so that space use is optimized. Finer lines mean more transistors can be packed onto the same chip. The more transistors on a chip, the faster it can do its work. New technologies and fierce competition can reduce the production costs of a chip design in 50% in a matter of a few months, and change all the technology.[xxix] Memorable Moore's Law is kept in mind (here in its original version):

> "The complexity for minimum component costs has increased at a rate of roughly a factor of two per year *[Currently adapted to 18 months]*. Certainly over the short term this rate can be expected to continue, if not to increase. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least 10 years." (Gordon Moore, Intel's co-founder)[xxx]

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3. Photonics

Photonics is the physical science and technology of using, applying and manipulation light, visible or not.[xxxi] This can be used in a number of ways, including generating, detecting, emitting, transmitting, modulating, processing, switching and amplifying the light. Many technical applications happen only because of the use of visible and near-IR (infrared) light.

This has obvious uses in telecommunications and information technology, but also in laser welding, drilling, cutting, levelling or range-finding for industrial manufacturing.[xxxii]

Specifically VLC (Visible Light Communications, not related to VLC media player) and Infrared Communication (IRC) are wireless technologies with multiple uses, including Data transfer, power transfer, sensing, geo-location, and even actuation. They are currently being studied for IoT in R&D&I for public and private projects to generate connectivity comparable to radio frequency, green, renewable, wireless, in an IoT environment.[xxxiii] Photonics contributes in hybrid materials, lightweight construction, mass customization, rapid manufacturing, print technology, etc. Laser technology in particular has recognized advantages in industry, not only improving the product's quality but also because it is more ecological than other energy sources, automatic, resilient, customizable and, of course, accurate.[xxxiv]

One very important use of photonics is to modularize the products to specific needs, reaching a level of customization that was unreachable. An example of product on this sense is the Leica DMi8.[xxxv]

There are several very active communities that see the advantage in industrial photonics, such as **Photonics21**, a 2005-founded association of industrial representatives and research & development stakeholders in Europe, whose Work Group 2 is dedicated to Industrial Manufacturing and Quality,[xxxvi] and the South African Light-based Technologies Innovation Forum event.[xxxvii]

Like what happened in nanoelectronics, Germany is a European reference on this KTE: German turnover in photonics for 2013 was of 44 billion euro, with a 38% dedicated to production-oriented segments.[xxxviii] Consider Lasernes from Humantec Industriesysteme GmbH of Wemding (Germany). It is a semiautomatic system very useful to use laser in industry that can be applied to furniture, and it is a 1998 technology in its first version.[xxxix]

The company SDILasers, later acquired by PAR system, has a number of photonics products with the following main industrial applications: Non-Destructive Testing (NDT); Light Detection and Ranging (LIDAR); Differential Absorption LIDAR (DIAL); Extreme Ultraviolet (EUV) generation; Laser marking; Pulse amplification; High energy physics; Pump sources for spectroscopy; and Wavelength shifting using Raman cells[xl] with their products being divided in: Expert Operator Crane Controls, Friction Stir Welding, Non-Destructive Testing and High Powered Pulsed CO2 Lasers.[xli] They also provide material handling technologies such as specialty cranes and robotic integration, and technologies for aerospace, marine, life science, hazardous environments,[xlii] which are very customizable and can be incorporated in the furniture and wood domain to provide added value.

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Consider the American company **Zeus Inc.** and try to emulate their niche within European borders.[xliii] Industries making the most of photonics include medical, aerospace, automotive, energy, fluid management and fibre optics, partly because they demand specific isolations against abrasion, chemicals and extreme temperatures. Notice the advantage of their products in cases like fluid handling, where the demand for fluoropolymer tubing in fluid applications continues to increase as requirements become more specific; and extruded tubing; coated optical fibre; biomaterials; etc.[xliv]

A joint European-American effort gave interesting results in a 2011 issue of Nature:[xlv] A polymer-based material that can heal itself when exposed to ultraviolet light for less than a minute has been developed for use in automotive paints, floor and furniture varnish, and others. The team included the Adolphe Merkle Institute of the University of Fribourg (Switzerland) along with Case Western Reserve University, and the Aberdeen Proving Ground.[xlvi]

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4. Advanced Materials

An advanced material with fascinating properties, graphene is famously a film one single atom thick.[xlvii] [xlviii]It is a film of carbon atoms in a perfect atomic[xlix] high-quality crystal lattice, with no vacancies or dislocations in the structure.[l]

It was discovered in 2004 by Kostya Novoselov and Andre Geim,[li] by extracting it from common graphite (the one that can be found in office pencils) at a time where many scientists had discarded the idea of a stable one-atom-thick material.[lii]

Graphene is not only extremely hard, but it is also conductive of electricity (better than copper),[liii] [liv]heat (the best known), almost transparent but so dense that not even the smallest atom of a gas (Helium) can cross through the spaces between its carbon atoms. Its properties are fascinating in science, as it allows for studies of quantum physics in a 2-dimension environment, and contribute to the many applications it can have.[lv]

Its uses are obvious particularly in electronics to generate faster transistors[lvi] [lvii] and smaller circuit boards, but it can also be an alternative to plastic to generate stronger composite materials.[lviii] It can also replace Germanium in many applications.[lix] It also provides longer-lasting batteries with reduced loading times, currently used in automotive but with applications for industry; lighter and safer armours including helmets and vests; and uses in computer science, telecommunication, energy, fuel, water processing, food,[lx] and of course robotics.[lxi] Transparent screens for TVs, computers and touch devices, and even solar panels, are also possible.[lxii] Crystals that can change colour are also a possibility; and graphene is one of the more impervious materials known, anticorrosive to fight oxidation. It has been said graphene composites will be intelligent enough to generate or dissipate heat.[lxiii]

Graphene mixed with plastics is very good conducting electricity, resisting heath and mechanic issues, and thus allows for the creation of superstrong thin resilient materials that can be used in vehicles and satellite.[lxiv] Its applications in textile will generate anti-bacteria clothing that can monitor health, resist scratches, provide heat to a person if needed, and contribute greatly to, for instance, mountain environments. Graphene is being considered for 3D-printing adding it to different thermoplastics and polymers.[lxv]

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5. Industrial Biotechnology

Industrial Biotechnology can be defined as the application of biotechnology to industrial process (as opposed to, for instance, health care or agricultural biotechnology). Biotechnology transforms the manufacture process, provides new products and has additional benefits in consumption and ecosustainability.[lxvi] White biotechnology is known because it consumes fewer resources than traditional processes for comparable results. From food to cosmetics, biotechnology process provides benefits to consumer, manufacturer and environment.[lxvii]

In practice, biotechnology is used frequently along with microbial production of specialized proteins (enzymes) evolved in nature to become super-performing biocatalysts to speed complex biochemical reactions.[lxviii] An example is the designing of an organism to produce a useful chemical. Another example is the using of enzymes as industrial catalysts to either produce valuable chemicals or destroy hazardous and/or polluting chemicals.

Biotechnology does not require very long review times to be implemented, at least not as long as compared with other fields like medicine, which is easy two to five times longer - although there is always a gap before the use of a given biotechnology progress is widespread.[lxix]

Once more, Germany is a known referent in Europe. Germany has a successful biotechnology industry with over 39.000 employees, over 725 companies, incomes of 3.28 billion euro and a ROI that consistently triples the costs from 2012 to 2015.[lxx] Germany has also defined BioRegions - regional initiatives for the advance of biotechnology, numbering over 30 thought its territory, that have become specialized R&D hubs.[lxxi]

Consider the petroleum-produced polyurethane foam that was used in furniture. Currently it has been replaced by biotechnology items of comparable quality and properties like polyols, like Cargill's BiOH and Dow's Renuva (which will be discussed later) that are derived from soy and other renewable feedstocks and then chemically mixed with other ingredients to create flexible foam. This had reduced the energy demand in a 23%, and the non-renewable energy consumption in a 60%, with no hindrance for the final consumer.[lxxii]

Dow's Renuva is a product of Dow Polyurethanes, a business group of The Dow Chemical Company that uses RENUVA Renewable Resource Technology, natural oil-based bio-based polyol with excellent performance, no unwanted odour, minimal environmental impact and at least equal performance. The technology breaks down natural oil and functionalizes it, then uses a distinct process to polymerize the molecules into designed polyols with control of functionality and molecular weight for greater quality and consistency, improved water resistance ,excellent chemical resistance, ease of application, good adhesion on a variety of substrates, high flexibility, lower viscosity reducing need for solvents. It is useful in several domains, but in this case it is specific for wood and furniture.[lxxiii] The RENUVA technology is durable, resilient and robust, having applications in furniture and particularly in bedding.[lxxiv] In Europe, Latin America and North America, Renuva is used by companies like Ecoflex (BR), Eurospuma (PT) and Isbir (TR).[lxxv]

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Initiated in the 2007 Polyurethanes Technical Conference, Dow reported a number of mattress industry successes with Renuva technology. The polyurethane foams used broadly in the mattress and upholstered furniture industry traditionally have been created using chemical compounds called polyols derived from petroleum products. The polyurethane industry has begun turning to polyols produced from natural oils derived from soybeans and other crops, motivated by growing interest in ecology. In early 1990s, Dow started working with natural-oil based polyps, initially soybeans, but only in 2007 they can provide the market with sizeable stocks. Renuva uses a patented, proprietary process that un-builds and re-builds the oil components.[lxxvi]

Cargill's BiOH® polyols and polymers are soy-based, industrial ingredients for polyurethane products such as flexible foam. Polyurethane foam traditionally is produced from fossil fuel-based chemicals (petroleum) but BiOH replaces part of this. BiOH technology allows customers to create foam products with typical levels of renewable content from 5 to 20%: For every 1 million pounds of BiOH polyols used, over 2,050 barrels of crude oil are saved, and performance can be even superior. It is used in upholstered furniture, mattresses, pillows, carpet cushion and automotive seats, and in binder systems, such as carpet backing, load bearing foams, memory foam with more than 50% renewable content, and binder systems, such as carpet backing with 60% latex replacement. In furniture, BiOH® polyols can help furniture foam manufacturers reduce their environmental footprint. Foams created with BiOH® polyols for bedding can help mattress manufacturers meet consumer demands for performance and pricing.[lxxvii] There are many products but in particular BIOH 5300 is designed for beds and other furniture.[lxxviii] There are several foam manufacturers providing performance-based products that adapt to customer's specific needs and BiOH provides solutions to each specific demand, both in product quality, in environmentally-responsible impact and even in cost.

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6. Advanced Manufacturing Systems

Manufacturing systems in furniture technology are advanced as such but room for improvement is always present in industry. Germany in particular has proved interest in this area as one of the representatives of the European Union by attending last year's Composites and Advanced Materials Expo in Anaheim. Germany Trade & Invest Director Investor Consulting Omar Oweiss contributed to explain both advantages and business opportunities within European borders.[lxxix]

There are some specialized companies that offer their RFID services (See **Section 6.1** for details on RFID) to the wood and furniture manufactures. Some examples of these are **Northern Apex,**[lxxx] **GAO RFID Inc.**[lxxxi] and **Abaco.**[lxxxii]

A number of Spanish furniture companies have already adopted several of these advanced manufacturing systems:[lxxxiii]

- RFID is used for production control, packing and dispatching by Gomarco Descanso, S.L. and ECUS Sleep, S.L.U. for their mattress business; by Tapizados Acomodel Yecla, S.L. for their sofa activities; and by Confort Dina, S.L. and Fama Sofás, S.L. for upholstery.
- The new systems for the clients to input their orders directly is already adopted by Confort Dina, S.L.; Fama Sofás, S.L.; and Tapizados Acomodel Yecla, S.L. These same three companies (Dina, Acomodel and Fama) also use 3D configuration for the products, allowing the client to provide specifics for their orders.
- Fama Sofás, S.L. uses 3D Printing systems for product prototyping and virtual reality for product presentations.
- Lastly, Formas Descanso, S.L. resorts to robotics for the welding in the creation of articulated beds.[lxxxiv]

6.1 RFID

RFID (Radio Frequency Identification) provides vision and clarity into manufacturing, sorting, warehousing and shipping of products. Wood product manufacturers struggle with tracking components and orders through their production facilities, and throughout the warehousing and shipping process. The aim of RFID technology is to streamline throughput while keeping faults, rejects and complaints to a minimum. A RFID Factory activity zone provides an immersive perspective on RFID-based applications and solutions across the entire furniture-industry production and supply chain, from parts suppliers and logistics operators to manufacturers, and from finished-furniture warehouses to furniture stores and right through to the end customer.

There are four basic components to an RFID system: **RFID Tags** are small and simple electronic devices that consist of a chip and an antenna. They serve the same purpose as a barcode label, providing a unique identifier for the object where they are attached to. In wood and furniture production and tracking, passive tags are the most used; they are powered by the radio waves from a **RFID antenna**. This is part of the **RFID reader**, the device that provides the intelligence in

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the system. It feeds the tags, collect the info from tags and send the info to the middleware systems (**RFID software**) to manage and drive the data to the existing ERP/MRP/SAP. RFID tags have rewrite functionality. For example, a wood piece that is classified as "white wood" could have one SKU (Stock-Keeping Unit), but when it is stained, the same wood piece could have a different SKU. Then RFID allows the new SKU to be written to the tag, without stopping or delaying production.

Figure 2: RFID solutions for woodn and furniture industry. [lxxxv]

While barcode technology improves production in many cases, a barcode reader has to be able to have a clear "view" of the barcode in order to read the unique identifier. RFID does not require "line-of-sight" and can be read up to 10 meters distance,[lxxxvi] making it a good choice for the sanding, staining, upholstery, and finishing processes in cabinet, furniture, case goods, window and door manufacturing plants. By placing RFID readers and antennas at strategic places along the production process, components are tracked, providing better visibility into the manufacturing process, from receiving to shipping.

RFID also resolve many of the wood manufacturer's outbound order fulfillment issues as well. Many of the company's manufacturing plants not only have problems tracking their components in production, but there are issues keeping their orders together for shipping, and sequencing them properly onto the delivery trucks. These types of errors can lead to lose deliveries as well as costly chargebacks. RFID readers can be installed to "read" RFID tags as they enter the warehouse/shipping areas and on the dock doors. This enable workers to identify the products and orders to which they belong, and allow orders to be grouped together for shipping, and sequenced properly for the delivery trucks. If a worker attempt to load the incorrect part on a truck or the correct part in the wrong sequence, a notification is sent via a warning light, so that corrections can be made.[lxxxvii]

Many furniture companies are using RFID for having a complete view of information via Web, allowing customers and partners to view the history and location of a particular piece of furniture. Increasingly, they are also looking into integrating their RFID systems with smart phones and tablets, in order to enable truck drivers and retailers to track and trace the goods that they ship or receive.[lxxxviii]

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It is clear that RFID enables automatic identification of product for grouping/packaging and shipping purposes. It is a proven technology that has saved countless wood component manufacturing companies time and money by enabling faster, more accurate production of their components.

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7. Related relevant aspects

7.1 Cloud Computing

Cloud Computing refers to delivery IT services over a network, typically the Internet network. It is an emerging and relatively newly-commercialized delivery model that allows consumers to access IT services using any device, such as desktops laptops, smart phones, and tablets. The only requirement is to have Internet access. The IT services, such as software applications, data, and storage services, are delivered to the consumers without the need, for the end user, of understanding the infrastructure and components required to provide a service. The term Cloud Computing represents both the delivered service over the network and the software and hardware at the datacenters that provide those services. The hardware and software at datacenters is commonly called the Cloud.[lxxxix]

The main features of cloud computing are:

1. The availability of computing resources on demand.
2. The omission of upfront commitments by the users as the service is provided and managed by the cloud provider.
3. The flexibility to use computing resources as much as needed.

Cloud Computing is not a single piece of technology, like a microchip or a mobile phone. Rather, it is a system, primarily comprised of three services: infrastructure as a service (IaaS), software as a service (SaaS) and platform as a service (PaaS).

- **Software as a Service (SaaS)**: SaaS involves the licensure of a software application to customers. Licenses are typically provided through a pay-as-you-go model or on-demand.
- **Infrastructure as a Service (IaaS)**: Infrastructure as a service involves a method for delivering everything from operating systems to servers and storage through IP-based connectivity as part of an on-demand service. Clients can avoid the need to purchase software or servers, and instead procure these resources in an outsourced, on-demand service.
- **Platform as a Service (PaaS)**: Of the three layers of cloud-based computing, PaaS is considered the most complex. PaaS shares some similarities with SaaS, the primary difference being that instead of delivering software online, it is actually a platform for creating software that is delivered via the internet.

Cloud Computing offers a potential cost-saving to companies. Before the cloud became a viable alternative, companies were required to purchase, construct and maintain costly information management technology and infrastructure. Now, instead of investing millions in huge server

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centers and intricate, global IT departments that require constant upgrades, a company can use "lite" versions of workstations with lightning fast Internet connections, and the workers will interact with the cloud online to create presentations, spreadsheets and interact with company software.

Businesses can employ Cloud Computing in different ways. Some users maintain all apps and data on the cloud, while others use a hybrid model, keeping certain apps and data on private servers and others on the cloud.

Nowadays, some of the main providers of Cloud Computing are:

- **Google Cloud**
- **Amazon Web Services**
- **Microsoft Azure**
- **IBM Bluemix**
- **Aliyun**

Amazon Web Services (AWS) includes a pay-as-you-go, outsourced model. Once the users are on the platform, they can sign up for apps and additional services. Google Cloud, which targets consumer banking and retail, is one of the latest entrances. Microsoft Azure, which recently launched U.K. data centers, allows clients to keep some data at their own sites.[xc] IBM Bluemix is a cloud platform to help developers build and run modern apps and services. It provides instant access to the compute and services they need to launch quickly, iterate continuously and scale with success[xci]. Aliyun is a Chinese Cloud Computing service from the Alibaba Group. Alibaba Cloud provides a comprehensive suite of global Cloud Computing services to help power and grow your business. It ranks as the top fourth largest public cloud services provider globally and is the leading cloud provider in the China market.[xcii]

In the white paper *A Crisis at Hafford Furniture: Cloud Computing Case Study* (2011, Levine and White)[xciii] we can view a practical example about how Cloud Computing technology solution can help a company in the wood and furniture sector, devastated by a natural disaster. After a hurricane, the company recovered because of a solid disaster recovery plan. The Vice President of Information Technology suggested using Cloud Computing to cut internal information technology costs. IT infrastructure servers, hardware, programs, processing would be done by a vendor "the cloud", although responsibility for information technology would be retained by the company.

Business like Canary Closets & Cabinetry has adopted other Cloud Computing services as Allmoxy, a cloud based computer software systems, which manages its entire business operation. This application is a web-based woodworking enterprise resource planning (ERP) system that manages e-commerce, business accounting, bids and order entry, exporting files from customer input, and converting them to files that drive production machinery.[xciv]

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Others business like Bernhardt Furniture Company adopt an hybrid cloud environment, with several micro-services running on the IBM Bluemix platform and an analytics engine hosted on local IBM servers.[xcv]

7.2 Cybersecurity

Computer security, also known as cybersecurity or IT security, is the protection of computer systems from the theft or damage to their hardware, software or information, as well as from disruption or misdirection of the services they provide.

Cybersecurity includes controlling physical access to the hardware, as well as protecting against harm that may come via network access, data and code injection.

In the industry, employee behavior can have a big impact on information security. Cultural concepts can help different segments of the organization work effectively or work against effectiveness towards information security within an organization. Employees often do not see themselves as part of the organization Information Security "effort" and often take actions that ignore organizational Information Security best interests. To manage the information security culture, four steps should be taken:

1. **Pre-Evaluation:** to identify the awareness of information security within employees and to analyze the current security policy.
2. **Strategic Planning:** to come up with a better awareness program, clear targets need to be set and clustering people is helpful to achieve it.
3. **Operative Planning:** a good security culture can be established based on internal communication, management-buy-in, and security awareness and a training program.
4. **Implementation:** four stages should be used to implement the information security culture. They are commitment of the management, communication with organizational members, courses for all organizational members, and commitment of the employees.[xcvi]

In the age of Industry 4.0, cybersecurity strategies should be **secure**, **vigilant** and **resilient**, as well as fully integrated into organizational and information technology strategy from the start. In **Figure 3** we can see the cyber risks faced by a smart factory environment, categorizing them into the main cybersecurity strategies.

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Production life cycle stage	Secure, vigilant, resilient categorization	Cyber imperative	Objective
Smart factory	Vigilant	Health and safety	Ensure safety for both employees and the environment
	Vigilant, resilient	Production and process resilience/efficiency	Ensure continuous production and recovery of critical systems
	Vigilant, resilient	Instrumentation and proactive problem resolution	Protect the brand and reputation of the organization
	Secure, resilient	Systems operability, reliability, and integrity	Support the use of multiple vendors and software versions
	Vigilant, resilient	Efficiency and cost avoidance	Reduce operating costs and increase flexibility with remote site diagnostics and engineering
	Secure	Regulatory and due diligence	Ensure process reliability

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Figure 3: Smart factory imperatives and risks.[xcvii]

The implementation of Industry 4.0 technologies involves that manufacturers take into account the impact of digitalizing processes, machinery and objects. This can be commonly known as uniting the Information Technology (IT) and Operational Technology (OT). **Figure 4** shows an example of those strategic imperatives and operational values and their corresponding cybersecurity actions to consider when companies run industrial or manufacturing processes that involve IT and OT.

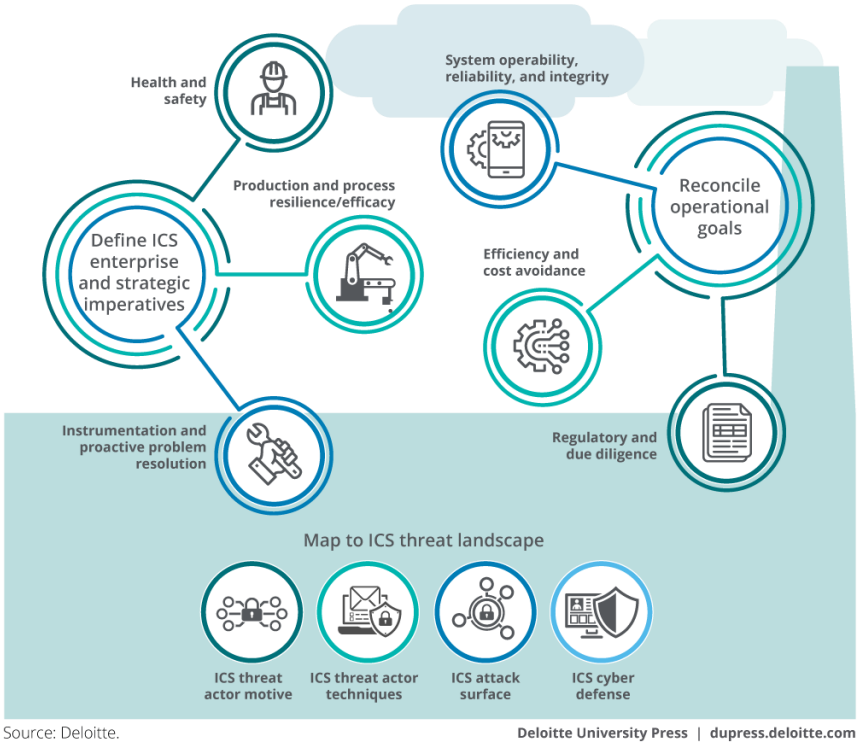

Figure 4: Smart factory business drivers and threat landscape.[xcviii]

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Firstly, manufacturers are commonly driven by three strategic imperatives:

- **Health and safety**: Physical safety for both employees and the environment is mandatory in any place. Intelligent safety equipment could be upgraded in future environments as technology evolves.
- **Production and process resilience and efficiency**: It is often critical to ensure continuous production at all times. In practice, any production downtime reflects loss of money, but recovery of critical processes can result in greater losses, given the time to rebuild and restart.
- **Instrumentation and proactive problem resolution**: Corporate brand and reputation increasingly play a role in the global business market. In practice, malfunctions or production issues in plant sites can be critical to reputation, and changes in the environment should be acted upon to protect the organization brand and reputation.

Secondly, organizations need to react to different operational values in their daily business:

- **Systems operability, reliability, and integrity**: To reduce the cost of ownership and ease component replacement, sites could invest in interoperable systems that support the use of multiple vendors and software versions.
- **Efficiency and cost avoidance**: Sites are continuously under pressure to reduce operating costs. In the future, businesses could invest more in commercial off-the-shelf (COTS) equipment and flexibility with remote site diagnostics and engineering.
- **Regulatory and due diligence**: Regulators require different requirements on safety and cybersecurity in Industrial Control Systems (ICS) environments. In the future, businesses could invest even more in changes within the environment to ensure process reliability.

There is no simple fix or single product or patch that a company can apply to address the cyber risks and threats presented by Industry 4.0. Connected technologies already support critical business processes today, and these processes will likely grow more connected, integrated, and vulnerable in the future. Organizations may need to rethink their business continuity, disaster recovery, and response plans to accommodate the increasingly complex and ubiquitous cyber environment.[xcix]

Industry 4.0 also creates new risks and requires companies to integrate security and privacy safeguards into their businesses and throughout their ecosystem, extending to the companies and consumers buying their products. **Figure 5** shows some of the risks that Industry 4.0 could create in a smart factory.

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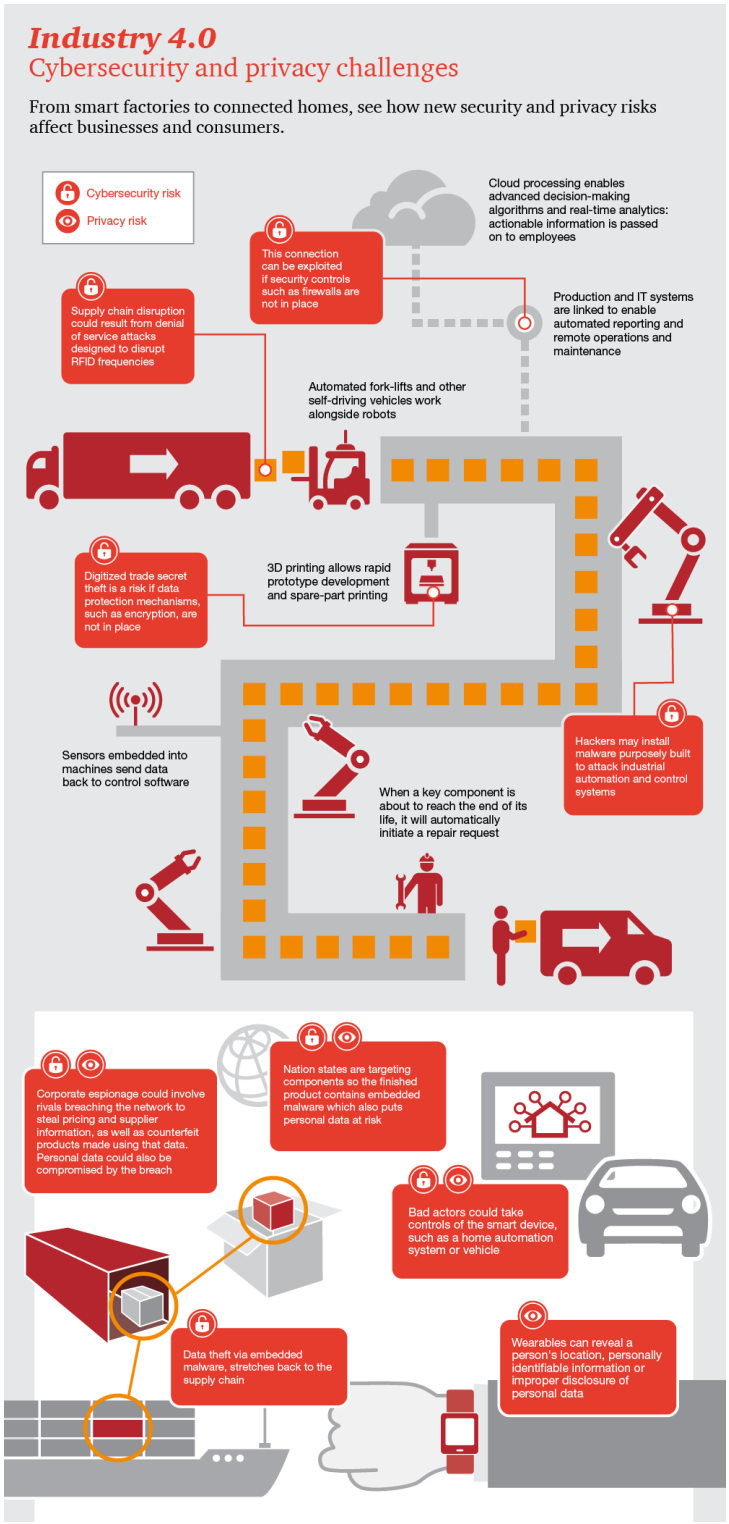

Figure 5: Cybersecurity and privacy challenges.[c]

The risks require a secure, vigilant, and resilient approach to understand the dangers and address the threats:

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- **Be secure**. Take a measured, risk-based approach to what is secured and how to secure it. Is the intellectual property safe? Is the supply chain or Industrial Control Systems environment vulnerable?
- **Be vigilant**. Continually monitor systems, networks, devices, personnel, and the environment for possible threats. Real-time threat intelligence and AI are often required to understand harmful actions and quickly identify threats across the multitude of new connected devices that are being introduced.
- **Be resilient**. An incident could happen. How would your organization respond? How long would it take to recover? How quickly could you remediate the effects of an incident?

As an example of cybersecurity in the industry, one of the biggest company of furniture in the world, IKEA, explain us in the article *How IKEA Does PCI-DSS* published at eSecurity Planet[ci] the security practices they use in their business.

The cybersecurity is an abstract term, so there is not a fixed way to give security in the business. However, there are some International Reference Projects for IT security in Industry 4.0 like IUNO. The research project IUNO unites 21 partners from industry and academia in Germany, who together develop solutions for a secure Industry 4.0 giving a solution for each of the four issues they consider that are present nowadays. These issues are: Secure Processes, Secure Data, Secure Services and Secure Networks.[cii]

IUNO is used by TAPIO. TAPIO combines digital products for the entire wood industry with thousands of production machines as well as a wide range of materials and tools in an IoT platform. The security plan for this platform is given by IUNO.[ciii]

7.2.1 Ransomware

On the subject of ransomware, we will first use a well-known instance of this technology to explain several of its aspects: The May 2017th WannaCry disaster. WannaCry was a malicious software that tried to reach a victim's computer, takes control of it, then encrypt all the information in it -e.g. files that may include past e-mails, spreadsheets and data or software needed to operate a machine tool. The software then informs the user that the data can be recovered with a password (different for each infected computer) that the ransomware programmers will provide, in exchange for an amount of money in cryptocurrency (the "ransom"). The victim commonly is given a small time window to pay, after which either the data is irrecoverable or the ransom is increased. The computer is mostly useless until the ransomware process can be reverted (either with the password or via other means), or until the system is restored to factory values (thus losing all the data stored on it). That is the general process of a ransomware in most cases.[civ] The ransomware programmers cannot steal the user's data for themselves; they can only prevent the user from accessing the data or destroy the data.[cv]

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In general, victims are unlikely to sabotage their own computers in purpose. The ransomware must be distributed stealthily, in many cases pretending to be a different thing like the Trojan horse.[cvi] It is very common for ransomware to be distributed via *phishing*: A great number of e-mails are sent to different victims, each with an attached file (the ransomware itself) or a hyperlink to download a file, along with a text prompting the user to download and run the file under the pretense of it being a different thing like an invoice. Once the user clicks on the file, and assuming that the user has enough privileges on the computer –or that the program can obtain these–, the infection starts. Now, WannaCry indeed reaches computers in this way,[cvii] [cviii] but then it also "spreads laterally" to the local network, something infrequent –but not unheard of– in ransomware.[cix] In particular, WannaCry exploits a vulnerability in Microsoft Windows' Server Message Block (SMB), a network technology to get shared access to printers, files, etc.[cx] Once WannaCry had infected a computer, it tried to spread through the local network and through the Internet.[cxi]

Microsoft had already identified this issue in SMB and distributed a patch that shielded the system against this issue for all the supported versions of Windows (Windows 7, 8.1 and 10 and Windows Server 2008, 2012 and 2016) a few months before. Unsupported Windows XP had been without any corrective patch since 2014, but it had only a residual niche of users.[cxii] But a number of organizations had not updated their systems with the patch, making themselves vulnerable.[cxiii] [cxiv] Why would someone do this? In many cases, these were systems with ad-hoc, customized software that is sometimes incompatible with updates. The organizations then have a protocol for updates and patches: These are to be tested and validated beforehand, to confirm that they can be added to the system because, if not, then critical parts of the system (such as an assembly line) may be suddenly stopped or worse – bear in mind the potential dangers of uncontrolled robots and machine presses.[cxv]

WannaCry was specific for many versions of Windows,[cxvi] allowing it to cover many areas because it had a net market share of 90.37% as of April that year.[cxvii] Per the forensic analysis by Europol and cybersecurity provider Kaspersky Labs, WannaCry affected around 200,000 computers in 150 countries, mostly in India, Russia, Taiwan and Ukraine;[cxviii] Russian authorities admitted they had suffered one thousand infections.[cxix] Some relevant industries were several hospitals and at least 40 healthcare organizations related to the UK's National Health Service (NHS),[cxx] Dacia Automobile,[cxxi] Deutsche Bahn,[cxxii] Honda,[cxxiii] Nissan,[cxxiv] Renault in France, Telecom in Portugal, FedEx in the United States and Spanish power providers Iberdrola and Gas Natural,[cxxv] affecting all of their operation and stopping or hindering their activity.

One important company in Spain that was affected is telecommunication provider Telefónica, S.A.[cxxvi] This was particularly important because, as a provider of services, Telefónica had the potential to seed WannaCry among its many customers. Telefónica's information security manager Dr. José María Alonso, also a renowned cybersecurity expert, covered the company's actions in his blog. He explained that one of the measures allowed protecting the customers by cutting any potential distribution through the internal LAN, even if that affected the company's internal activity. Alonso and others also clarified and rebutted a number of baseless rumors, gossips and hoaxes that been extended due to disinformation or even ill intent.[cxxvii]

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Soon after the outbreak, however, the situation was again under control, thanks to many measures taken by the main players: In one day, Microsoft provided an emergency update for Windows 7, 8, Server 2003 and even discontinued XP.[cxxviii] An individual English security researcher discovered and exploited a vulnerability in WannaCry, which slowed down the spread until the programmers of WannaCry updated their ransomware.[cxxix] Eventually, a software to discover the password without paying was developed and publicly, freely distributed in the GitHub repository.[cxxx] This is also relatively frequent in ransomware: In many cases, decryption tools are eventually developed, allowing users to revert the effects of many ransomware.[cxxxi]

On the subject of the ransom, WannaCry requested the fixed amount of $300 (U.S. dollars) in bitcoin in the following three days, or $600 in six days. Due to the nature of the bitcoin account, anyone could see the balance but not know the owners of the account. As of June 2017, 327 payments for a total $130,637.77 had been made,[cxxxii] and apparently they lost it all when trying to launder it.[cxxxiii] In any ransomware case, security experts discourage paying the amount, because there is no guarantee that the ransomware programmers will provide the decrypting password.[cxxxiv]

WannaCry was not the only ransomware case to affect critical systems and infrastructures. Petya, also making use of a SMB vulnerability and also targeting Windows-based systems, was widely widespread on June 2017 (although the ransomware is known to exist since 2015)[cxxxv] and it affected hardware including drones, printers, etc.[cxxxvi] A similar software called ExPetr or NotPetya was initially believed to be ransomware, but it eventually proved itself a data destroyer.[cxxxvii]

One system affected by Petya is the Chernobyl facility (Ukraine), seat of the worse nuclear disaster. It is no longer used as a power provider, but its staff has devices to monitor the amount of radiation in the area. This technology was disabled due to the attack.[cxxxviii] Bear in mind the importance of these attacks affecting a critical installation such as a power plant. Spanish cybersecurity expert Rubén Santamarta reported carefully about the possibility of a software simulating, or hiding, radioactive leaks in a plant like this one.[cxxxix]

Indeed, a great deal of the ransomware problem is how ransomware can affect industrial facilities in a way that can, in turn, affect the environment and even human lies. At the same time, the issue has reached the public eye and, precisely due to the propaganda, trained professionals are dealing with the problem and providing useful solutions to minimize or completely cancel the damage.

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7.3 Exemplifying Industry 4.0 in furniture

After the study conducted through Internet searches, we can say that Industry 4.0 is increasingly integrated in the furniture and wood sector at all levels, and that the application of these new technologies is increasing in the sector. A great example of this is the last trade fair that took place in May in Hanover "LIGNA" where many new intelligent and interconnected automation solutions have been presented for the future of the wood and furniture industry.

We can highlight companies whose main task is the transformation of the traditional factory into an interconnected factory, through various commercial solutions adapted and customized to the demands and needs of customers, such as the company HOMAG.

HOMAG (https://www.homag.com/en/) is a world leader in the manufacture of machinery and installations for the wood processing and handicraft sector. Their main commercial solution related to Industry 4.0 is automation; they prepare the machinery for optimum production in both size one and mass production batches, covering all phases of the chain, from design to packaging and storage. Providing fully interconnected chain production lines for the specific production of furniture with a high level of industrialization. For this, they also have a specific software Wood CAD / DAM, extensible with woodFACTORY for the organization of production and optimization of processes, and woodNET for the connection to the Internet.[cxl]

Figure 6: Networked production.

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Companies like those described below, are constantly developing new products related to the new technologies of the industry 4.0:

PEPPERL FUCHS

Pepperl+Fuchs is a pioneer and an innovator in electrical explosion protection and sensor technology, its products including:

Sensorik4.0® – the Future Generation of Sensors.
Pepperl+Fuchs understands Sensorik4.0 is a pioneer for the fourth industrial revolution: it delivers the necessary data. A good example for Sensorik4.0 is the R100 photoelectric sensor—this smart sensor is used in its own manufacture at Pepperl+Fuchs in Berlin. Due to its IO-Link interface, the R100 allows communication down to the sensor level, thus enabling a fully connected plant.

Figure 7: R100 Optical sensor.

The R100 optical sensor consists of 65 components that can be combined in two thousand variants; R100 is available in ten thousand different software versions. It has numerous applications in all conceivable sectors. It is a smart product manufactured in a smart factory.[cxli]

Visit this video of Sensorik 4.0 for more information:

https://www.youtube.com/watch?v=3Ic1bfCkrXU

MICROTEC

As a global partner in the global timber industry, Microtec constantly creates new approaches and solutions to increase value in wood processing. They are experts in solutions of wood scanning. They have many innovative products on the market.

PRODUCTS:
CT Log Computed Tomography scans and digitally reconstructs the internal features of the log allowing the assessment of the optimum cutting solution in real time.[cxlii]

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Figure 8: CT Log Computed Tomography.

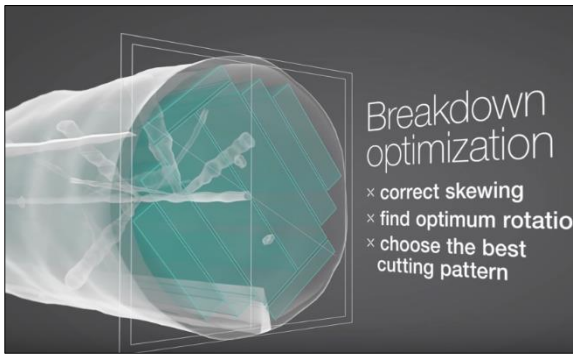

Figure 9: Breakdown Optimization.

See a video of how the machine works at: https://www.youtube.com/watch?v=xK4CdNT3DK4

ADVANTAGES:

- 100% optimum cutting solution based on highest value of final products
- Increased value in every sawn log compared to any other breakdown solution
- Maximization of lumber recovery quality that significantly increases revenues & resale value

Software Winlog Sorting Optimization: automatically sorts logs according to its geometry, quality, species or other customer specific criteria.

FEATURES:

- Provides all necessary information for the log sorting line.
- Gathers all log information and creates reports by date, supplier, log qualities, etc.
- Automates and streamlines production processes and log procurement.
- Creates database of log information
- Exchanges information through open protocols and interfaces.[cxliii]

Figure 10: Software Sorting Optimization.

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BIGREP

They design and build large-scale industrial 3D printers and additive manufacturing solutions that fit individual production needs. BigRep is redefining the entire value-chain: from the raw material to the delivery of the final product.

With a capacity of one cubic meter, the BigRep ONE provides the largest FFF build volume for professional and industrial use.[cxliv]

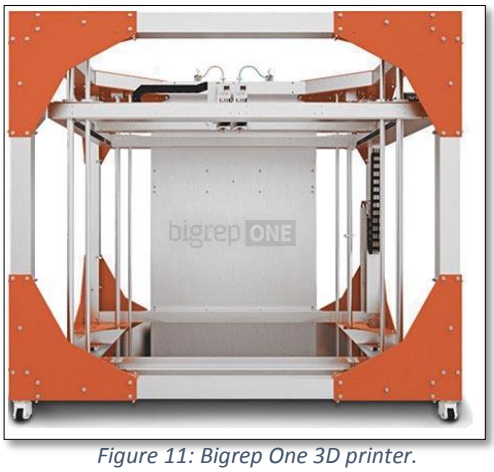

Figure 11: Bigrep One 3D printer.

VIEWAR

ViewAR offers the leading template system to create Augmented- and Virtual Reality applications. Solutions built with the ViewAR system are not "one size fits all", but customized to meet specific business objectives.[cxlv]

Examples of Viewar App:

Figure 12: ViewAR app.

Willisau 3D Configurator

The customized tool is not only used supporting sales-teams in new business acquisitions, but also creates an emotional user experience for every potential customer when getting in touch with the brand.[cxlvi]

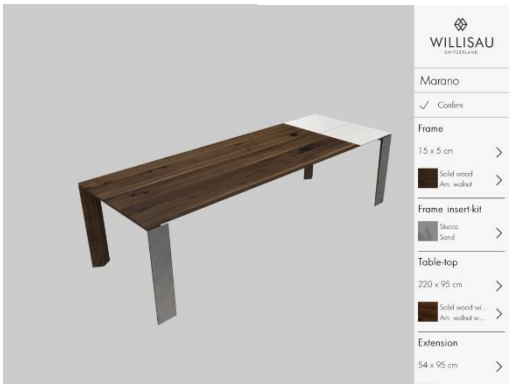

Figure 13: Willisau App.

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Fama ViewAR App

Fama needed a better way to engage their customers around the world with their wide array of product design options. The custom designed application by ViewAR made this possible, visualizing products and giving clients the possibility to individualize various products.[cxlvii]

See more in this video: https://www.youtube.com/watch?v=9XnyQmJ0K-o

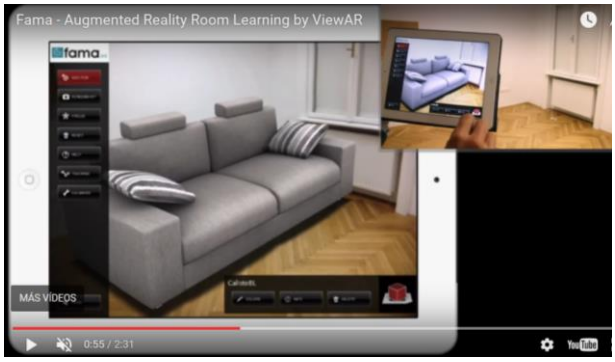

Figure 14: Fama App.

DAQRI

It is the world's leading AR Company that drives the future of work through innovative hardware and software products.

Daqri Smart Helmet. It is designed for the industry, enabling Augmented Reality features like the visualization of data, receiving instructions on-site, thermal vision, remote support and many more. The DAQRI Smart Helmet delivers real-time data, based on the environment, direct to the user, enabling them to visualize and understand their environment.


Figure 15: Dagri Smart Helmet.

- Data Visualization: distributed information and situational awareness outside of the control room.
- Thermal Vision: a safer environment for your team by giving them the ability to visualize and passively record temperature data in their real world environment.
- Guided Work Instructions: augmented Reality instructions on-site but with the safety of a helmet, letting your team understand process quickly, increasing productivity.[cxlviii]

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Daqri Smart Glasses.

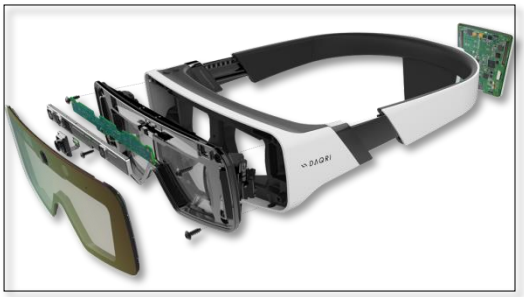

Figure 16: Daqri Smart Glasses.

Data visualization: utilize distributed information and situational awareness from the office to the field, improving efficiency while reducing the amount of movement required in a centralized location.

Guided work instructions: access and assign intuitive AR instructions on the job, displayed in your field of view, relating relevant project data, maximizing efficiency and accuracy in task completion.

Remote Expert: allow your experts to remotely assist workers, by enabling them to see their colleague's point of view and elevate their skill level. Both the expert and the onsite team member will be able to address issues quickly.[cxlix]

7.4 Exemplifying Robotics in Wood Industry

ABB

ABB (http://new.abb.com) provides industrial robots and robot software, equipment and complete application solutions – more than robots are installed in the industries. Moreover ABB offers robotic solutions to automate wooden furniture and construction materials industries worldwide. In this context ABB is working with IKEA and VELUX to create new fully automated production lines and reap a rapid return on investment.

ABB offers robotics solutions for:

- *Material Handling applications:* Every size, shape and weight of wooden components can be handled by robotic arms. ABB robots can provide exceptional positioning accuracy (0.05 – 0.08 mm) and ensure maximum safety during the handling tasks. Moreover, the use of up to four robots with just one control module brings significant space saving and allows for a clear, easily managed work space.

- *Packaging & Palletizing applications:* ABB offers robot-based packaging automation solutions, comprising specialized robots for picking, packing and palletizing, also for applications in wood related industries. The experience includes handling and packing of wood panels, handling flat-pack furniture, doors and door frames, windows and widow frames and other wooden construction materials.

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- *Painting & Coating applications:* ABB coating robot solutions for the wooden parts or furniture fabrication process can produce parts with constant, high finish quality; because achieving an even film build using manual spraying is difficult. Moreover, a big benefit is that the over-spray is reduced, thus reducing material consumption and waste.

- *Polishing, Sanding & Finishing applications:* ABB provides hardware and software solutions to improve the automated sanding, polishing and finishing of wooden parts because the robot is able to sense the environment and the workpiece. Finishing or assembly operations often require a sense of "feel," such as assembling a wooden window frame, polishing the edges of a wooden table top or routing designs in wooden panels. ABB has developed two technologies that improve robots' tolerance of the variability found in real-world assembly and finishing operations. One of these technologies gives robots a sense of "feel" by adding force control capabilities. The other uses machine vision systems to let robots "see" and adapt to variation in part dimensions and locations. Taken together, force control and vision not only raise the technical capabilities of robots but also improve the economics of using them in both wooden furniture and construction materials industries.

Case Study 1:Assembling the perfect flat pack: Svedplan, Sweden

Svedplan is a fast emerging producer of flat-pack furniture and has deployed a team of nine ABB robots to improve competitiveness and reduce risk to manual handlers. As a result production has increased by 45%.

Figure 17: ABB robots handling furniture panels for Svedplan.

- Industry: Furniture Wooden Products & Paper.
- Application: Material Handling and Packaging/Palletizing.
- Customer End Products: Furniture.
- Robotics Product: Industrial Robot.

Case Study 2: Efficient low cost production: Swedwood International

ABB has already supplied Swedwood International, a wholly-owned subsidiary of the leading home furnishings brand IKEA, with robotic solutions and a variety of power and automation products and systems for its 35 factories. From complete factory electrification solutions to distributed control systems and factory automation platforms, Swedwood is equipped with the technology to produce flat-pack furniture efficiently at a low cost.

Figure 18: ABB robot work in Sweedwood

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Ep[illegible] Srl Painting Robot Division (http://www.epistoliorobot.com/en/)

Epistolio is able to engineer robots and customized solutions to paint chairs, window frames, doors, assembled furniture, profiled panels and edges of panels on stack, coffins and any kind of wood components.

WINSIX ROBOT

NSIX ROBOT.

Epistolio Robots are used for painting applications with vision systems or offline programming to guarantee a particular precision in the painting process or a larger working area.
EPI-WINVISION: it is a 2D (optionally 3D) system used for the automatic painting of windows and doors. EPI-WINVISION is able to scan the image of the windows while they are moving on the conveyor and to send the data directly to the robot, who will immediately elaborate them and create the painting program, using some parameters set by the operator.

EPI-3DVISION: it is an hardware and software package for the analysis and partitioning of 3D surfaces through cameras or laser scanners.

Figure 20: MRK ROBOTS.

EPI-SIMULATION: This software allows to program the robot using only a personal computer. The robot is programmed like a CNC machine, starting from a CAD/CAM base which is used to import the 3D drawing of the piece to be painted and generate the path of the tools. After that, EPI-SIMULATION allows the user to simulate the created program in a 3D environment and to convert it into the language of the robot.

The robot arms are built with very light but strong materials and are pneumatically balanced in order to achieve high levels of maneuverability during the programming stage. The self-learning programming system is simple and quick, thanks to the use of an ergonomic joystick which includes few programmable buttons, allowing a single operator to manage the entire programming stage directly from the painting area.

Epistolo Robot applications include:

- Painting robots and lines for wood industry (see video: https://www.youtube.com/watch?v=gqmxv-OS5ys)

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- Chairs Painting (translated: Pintura das Cadeiras (PT), Sandalye Boyama (TR), Pintura Sillas (ES)) (see video: https://www.youtube.com/watch?v=fpZGhc_3iFA)
- Painting Furniture (translated: Verniciatura Mobili (IT), Pintura de Moveis (PT), Mobilya Boyama (TR)) (https://www.youtube.com/watch?v=j5JTGwlcFJwKUKA)

KUKA

KUKA (https://www.kuka.com/)

Figure 21: A KUKA robot palletizes wooden panels.

Case study: KUKA KR QUANTEC in operation at woodworking company Voit. KUKA robot palletizes wooden panels with speed and precision.

Industry: Voit is responsible for the interior fittings of the showrooms as well as the fittings and furnishings of the office, lounge and customer areas.

Applications: Handling and Palletizing.

Results: 2,400 individual parts per shift are stacked at day, compared with 40 percent less in the past.

The palletizing of various wooden boards in the vicinity of a double-sided edge banding machine is performed at the workshop by a KUKA KR 180 R3200 PA jointed-arm robot of the KUKA KR QUANTEC series with a payload capacity of 180 kg and a range of 3,200 mm.

FANUC

(http://www.fanucamerica.com)

Automated Solutions for Woodworking Industries

FANUC America and their authorized system integration partners are experienced in providing automated systems for sanding, polishing and finishing, as well as machine loading and part transfer.

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Robotic Applications for the Woodworking Industry are:

- Assembly
- Dispensing & Sealing Robots
- Machine Tending Robots
- Material Removal
- Part Transfer Robots
- Painting Robots

Figure 22: Fanuc Painting Robot.

YASKAWA

(https://www.yaskawa.eu.com)

YASKAWA

Case study: Lifting of transport goods
Industry:

- Goldfuß engineering, Balingen, Germany
- AERO Lift Vakuumtechnik GmbH, Geislingen, Germany.

Figure 23 Lifting of transport goods

Applications: Packaging / Palletising

System components:

- 1x MH6-10D
- 1 VUSS 400x200mm
- 1 ejector 60 m³/h

Challenge: Lifting of different transport goods processed in the wood industry without the need to use a separate gripper for each item.

Solution: Use of a large-area vacuum gripper with patented valve system

Results:All transport goods can be picked up with a single suction cup, irrespective of their shape and contours

Application in IKEA factory: 18 Motoman robots make it possible for IKEA to produce an assembled, flat-packed “Billy” bookcase kit every 6 seconds for a total of 40,000 units per week. The robotic solution also helps saving 20% in production costs. (see video: https://youtu.be/TVfvzXtwo5k).

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Automatech robotic

Automatech Robotik (http://www.automatechrobotik.com/index-en.html), with its unmatched expertise in the woodworking industry, develops a wide range of robotic cells[cl] for cutting, processing, sanding, painting, palletizing, and CNC machines feeding.

Case studies:

- Cercueil Concept: http://www.woodworkingrobot.com/#video
- Muskoka: http://www.woodworkingrobot.com/#video
- Ro-Bois-Tic: http://www.woodworkingrobot.com/#video
- Teknion: http://www.woodworkingrobot.com/#video

GRIPPER

Vacuum Gripper
Vacuum is used to clamp and handle workpieces made of wood. Usually the application is characterized by a dusty environment, fast cycle times and a high degree of automation.

SCHMALZ

(https://www.schmalz.com/en/)

Vacuum Layer Gripping Systems SPZ with or without mechanical gripping support

Max. layer weight: 250 kg

Gripper dimensions [mm]: 1.250-2.100x850-1.800x275-1000

Gripper weight [kg]: 90-390.

Application: Palletizing and de-palletizing of layers by the combination of vacuum technology and mechanical gripping support

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SBX-C with or without Ejector

It is a robust gripper with integrated or external vacuum generation, for powerful handling of lumber, planed or glued timber, sheet materials, construction timber, pallets and crate elements.

- Handling of naturally growing materials with knots or cracks or with warped, rough surfaces
- Ideal for the rough application conditions in saw mills or in woodworking and furniture construction
- Also suitable for un-stacking and transporting work pieces in layers when in the double gripper configuration.
- Ideal for operation with industrial robots and gantries due to its low weight and compact dimensions.

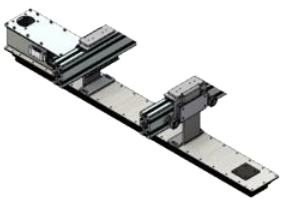
Application:

- Handling layers of planed wooden boards (see video: https://www.schmalz.com/en/applications/application-reports/details/vacuum-area-gripping-system-sbx-for-handling-layers-of-planed-wooden-boards/)
- Unloading a wood saw (see video https://www.schmalz.com/en/applications/application-reports/details/vacuum-area-gripping-system-sbx-for-unloading-a-wood-saw/)
- Handling Sawn Timber and Frames by Layer (see video https://www.schmalz.com/en/applications/application-reports/details/vacuum-gripping-system-sbx-for-handling-sawn-timber-and-frames-by-layer/)
- Loading an edge banding machine (see video: https://www.schmalz.com/en/applications/application-reports/details/vacuum-area-gripping-system-sbx-for-loading-an-edge-banding-machine/)
- Handling Pallets (see video: https://www.schmalz.com/en/applications/application-reports/details/vacuum-area-gripping-system-sbx-for-handling-pallets/)

SCHMALZ

JOULIN vacuum handling (http://www.joulin.com/)

LUMBER GRIPPER



It is a foam vacuum gripper and it is used worldwide in the wood industry . It can be used with uneven surfaces and the gripping power remains constant with single parts or entire layers. Its advantage is that is not sensitive to the dust (see video: https://www.youtube.com/watch?v=UN14v0OWLgY).

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MOBILE PLATFORM

KUKA

(https://www.kuka.com/)

KUKA

KUKA Mobile Platform 1500

It is an omnidirectional, mobile platform that navigates autonomously. Thanks to the KUKA Sunrise controller, it provides modular, versatile and above all mobile production concepts for the industry. The KMP 1500 independently and autonomously handles the transport of the products and it has a payload capacity of 1500 kg.

METRALABS

(http://www.metralabs.com)

Metralabs - Scitos X3 is a mobile base developed specifically for transportation, mobile manipulation and narrow environments. its load capacity is up to 100 kg. and it can be used for intralogistics, commissioning and transportation tasks.

6 River System

(http://6river.com**)**

6 RIVER SYSTEMS

Chuck

It is a mobile robotic platform that can navigate in any warehouse with no new infrastructure. Its maximum payload is 72.5 kg (see video: https://www.youtube.com/watch?v=MorgeqVkedw).

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EiraTech robotics

(http://www.eiratech.com/**)**

EiraTech™ robotics

Eirabot

It is developed to navigate  autonomously for warehouse solutions (see video: https://www.youtube.com/watch?v=l0cECgaDivg).

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[xix] https://www.elma-ultrasonic.com/en/industry/microtechnology/
[xx] https://www.elma-ultrasonic.com/en/products/ultrasonic-cleaning-lines/x-tra-line-pro/#tabs|p169:downloads
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Publication Analysis and overview of national qualifications framework developments in European countries. Annual report 2016

ITALY
European inventory on NQF 2016

Introduction and context

The Italian education system has undergone several improvements in recent years, with greater proficiency in basic skills and almost universal participation in early childhood education. However, although the early school leaving rate has decreased, it remains above the EU average. The rate of tertiary education attainment is the lowest in the EU – 18.8% in 2014, compared to the EU average of 33.6% – while the employment rate of recent graduates is relatively low at 45.0% in 2014, compared to the EU average of 76.1% (European Commission, 2015).

Since 2003, reforms have been implemented across education and training (upper secondary general education, vocational education and training (VET) and higher education) anticipating the principles of a learning-outcomes-based NQF. Technical work has been carried out in recent years towards a national qualifications framework (NQF). Given the complex model of governance in the country and the fragmentation of the education and training system ([1]), one of the challenges has been to achieve effective inter-regional coordination with a view to encouraging recognition of the regional qualification systems and inter-regional mobility, especially with reference to the labour market ([2]).

The European qualifications framework (EQF) is seen as a point of reference for indicating the level of learning outcomes related to nationally recognised education and training pathways. In spite of not yet having an NQF, work has been done to reference public national formal qualifications directly to the eight EQF levels. The first Italian referencing report was adopted in December 2012 and presented to the EQF advisory group in May 2013 (Italian technical working group, 2012). The report focuses on describing levels and subsystems of formal education and training, along with the formal qualifications awarded throughout,

([1]) In Italy there are 21 regions and two autonomous provinces. With the modification of the V Title of the Constitution in December 2001, the regions increased their competence in education, maintained the competence in vocational training field and in the definition of the professional profile and qualifications, with a greater need for coordination between regions.

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and those awarded by regions in the framework of the State-regions agreement, and on their referencing to the EQF.

The Italian qualifications framework for higher education (*Quadro dei Titoli Italiano dell'Istruzione Superiore* – QTI) ([3]) was published in 2010 by the Ministry of Education, University and Research. Self-certification to the qualifications framework for the European higher education area (QF-EHEA) was completed in 2012 ([4]) and decisions made for higher education qualifications were taken up in referencing to EQF.

Referencing is work in progress towards putting in place an NQF, in dialogue with all national stakeholders. The EQF national coordination point has been mandated to prepare a proposal for a comprehensive national qualifications framework, which has been submitted for approval. A decree for the establishment of an NQF is currently underway.

Policy objectives

Italy faces a challenge of integrating different levels of lifelong learning systems into a coherent national qualification system. It is a complex context, governed by multiple legislation on competences of regional and national authorities in designing and awarding qualifications.

A comprehensive NQF would help with transparency and comparison between different qualification types awarded by different authorities. A coherent NQF, based on explicit levels of learning outcomes, would also ease validation of non-formal and informal learning. It would also support adult participation in lifelong learning, an area challenged by both low participation and a large proportion of people with low literacy and numeracy skills ([5]).

Development of a system in the NQF direction would respond to several needs:

(a) make integration of the different systems within the national context easier;

(b) respond to a request of the EQF recommendation designed to ease dialogue between education systems and the labour market;

([3]) The Italian qualifications framework for higher education is available at: http://www.quadrodeititoli.it/index.aspx?IDL=2

([4]) National report regarding the Bologna Process implementation 2012-15 – Italy, 2015. http://media.ehea.info/file/Italy/84/4/National_Report_Italy_2015_567844.pdf

([5]) Adult participation in lifelong learning has increased to 8% in 2014, but remains lower than the EU average (10.7% in 2014). European Commission (2015). *Education and training monitor 2015: Italy.*

(c) make individual geographic and professional mobility easier, both at national and European levels;
(d) help individuals, throughout their lives, to capitalise on their non-formal and informal experiences. The system should promote social inclusion for people without regular qualifications and competences needed in the labour market; a national system based on a learning outcomes approach and involving different stakeholders is a precondition for validating non-formal and informal learning.

All institutional, national and regional authorities are aiming towards a NQF and a clearer commitment to the EQF. An important milestone is Law 92/2012 on labour market reform ([6]), with provisions related to lifelong learning. This aims to set up a national system of certification of competences and services for validation of non-formal and informal learning.

In 2015 ([7]), stakeholders reached agreement on an operational common framework for national recognition of regional qualifications and related skills. For the purposes of matching and recognising regional qualifications across the whole national territory ([8]), this common framework is seen to represent:
(a) a professional reference in terms of occupational standards;
(b) a reference for the recognition of the regional qualifications and competences at national and European level;
(c) a performance reference for the assessment to be carried out within the services of identification, validation and certification of competences (European Commission et al., forthcoming).

Levels and use of learning outcomes

The Italian education and training system has introduced the learning outcomes approach at national and regional levels, with each subsystem having its own characteristics. The debate on using learning outcomes in the country started about a decade ago and it is still going on, along with the gradual reform of the

([6]) Law 92/2012 on labour market reform: http://www.dplmodena.it/leggi/92-2012%20legge%20RML.pdf

([7]) Inter-ministerial decree of 30 June 2015 (Ministry of Labour and Ministry of Education) defining the operational common framework for national recognition of regional qualifications and related skills.

([8]) Qualifications databases of 21 regions can be found at: http://nrpitalia.isfol.it/sito_standard/sito_demo/atlante_repertori.php

entire education and training system. One of the main fora for this debate was the public consultation that preceded the adoption of the first EQF referencing report.

The eight EQF levels and level descriptors have been used directly in the Italian referencing process to link all national qualifications from formal education and training to the EQF. The starting point of the referencing process was analysis of both learning processes and learning outcomes in relation to the EQF levels, including a critical analysis of the EQF level descriptors: knowledge, skills and competence. The 'knowledge' and 'skills' descriptors of the EQF were deemed clear enough to permit correlation with Italian qualifications, while the 'competence' descriptor was divided into three dimensions: work/study context; type of tasks, problems and problem-solving approaches; and autonomy and responsibility.

However, despite the move towards a learning outcomes approach, a gap still exists between theory and practice, especially in general school education and higher education. Learning outcomes implementation is mainly part of pilot projects.

In general school education, there has been a shift towards a more student-centred approach and, due to the introduction of ICT tools, teaching is more focused on competences: a combination of competences and knowledge replaces the idea of purely content-based learning (Cedefop, 2016). At upper secondary level, there are three main pathways: general (*licei*), technical and vocational education. Each pathway lasts five years, leading to a diploma, and learning outcomes are linked to the EQF.

In vocational training, where the regions have main responsibility, there is a focus on competences, which are described in terms of learning outcomes. There are two different possibilities for vocational training: a three-year or a four-year pathway. Both lead to a diploma and a qualification acknowledged at national level. The four-year course can open up higher education options, provided the student takes an additional year and sits a State exam. The apprenticeship system has also been reformed in recent years, and the new legislative framework ([9]) includes important references to the EQF and the use of learning outcomes. It contains the definition of competences as the smallest units for certification defining a professional profile, collected into codified lists based on the relevant EQF level and on clear explanation of learning outcomes (Italian technical working group, 2012).

([9]) Legislative Decree No 167/2011 (entered into force on 25 April 2012) and the State-regions agreement on the national apprenticeship certification system (19 April 2012).

The higher (non-academic) technical education and training pathway (*Istruzione e formazione tecnica superiore*) (IFTS) used a national standard system based on competences from 2000; since 2008 the standards have been updated to make them more coherent with the learning outcomes approach. With this 2008 amendment, IFTS was reorganised and higher technical education (*istruzione tecnica superior* (ITS)) was established ([10]). IFTS courses last one year, ITS courses two. Both types of curricula are made up of units consistent with the learning outcomes approach. They are linked to EQF levels.

In academic education (universities), policy-makers strengthened the need to align diplomas and certificates to commitments of the Bologna process. In the existing framework for higher education (QTI), Dublin descriptors ([11]) are used nationally for the cycles of higher education agreed within the Bologna process. More specific descriptors are being defined for each programme by universities but, clear evidence on application of the learning outcomes approach is still missing (Cedefop, 2016). Higher education is still under reform, aiming to move the system closer to the European standards designed by the Bologna process.

Stakeholder involvement and institutional arrangements

The Ministry of Education, University and Research and the Ministry of Labour and Social Policies are leading developments in EQF-related processes, in agreement with the regions, autonomous provinces and social partners, as laid down in several agreements. The Ministry of Education, University and Research is the competent authority for qualifications awarded in the education system, while the Ministry of Labour and Social Policies is responsible for qualifications awarded by the regions.

At technical level, the National Institute for the Development of Vocational Training (ISFOL) sets up national methodologies and coordinates sectoral and professional expert groups involving social partners. ISFOL has been designated as the EQF national coordination point (NCP), and hosts the national Europass centre and the national reference point for quality assurance in VET (part of the EQAVET network). The country is represented in the EQF advisory group by a representative of ISFOL, and a representative jointly designated by the two leading ministries (labour and education).

([10]) Higher technical education and training courses organised by higher technical institutes with qualifications awarded by the Ministry of Education.

([11]) The Dublin descriptors used are: knowledge and understanding; applying knowledge and understanding; making judgements; communication skills; learning skills.

Since the referencing process started in 2008, a technical group has involved stakeholders in the work: Ministry of Labour and Social Policies, Ministry of Education, University and Research, Department for European policies of the Presidency of the Council of Ministers (involved in referencing professional licences in regulated professions), regions and autonomous provinces (in charge of initial and continuous vocational training) and the social partners. In addition, ISFOL and the Information Centre on Academic Mobility and Equivalence (CIMEA), a body of the Ministry of Education, were involved.

The first Italian referencing report was adopted in the State-regions conference, following public consultation in 2012. A total of 150 stakeholder organisations took part in the consultation, along with universities, regions and enterprises.

The national repertory of qualifications, established by Decree 13/2013 ([12]), will comprise six different sections ([13]), with three already available. The repertory is managed by a national technical committee led by the Ministry of Labour and Ministry of Education and composed of all the qualification authorities. The committee is also responsible for developing the validation system.

The EQF NCP was tasked with managing EQF implementation, preparing the technical referencing report, and communication with stakeholders. It has also been mandated to develop the proposal for a comprehensive national qualifications framework based on the national repertory of qualifications ([14]).

Recognising and validating non-formal and informal learning and learning pathways ([15])

A national legal framework on validation has been progressively developed in Italy since 2012. Law 92/2012, reforming the labour market, prepared the creation of a national system of competence certification and validation of non-

([12]) Legislative Decree No 13/2013 *Definition of general rules and basic level of performance for the identification and validation of non-formal and informal learning and minimum service standards of the national system of competences certification.* http://www.gazzettaufficiale.it/eli/id/2013/02/15/13G00043/sg;jsessionid=QtVQDnVhW+1EjOvvz7I8GA__.ntc-as1-guri2b

([13]) The national repertory of qualifications *(Repertorio nazionale dei titoli di istruzione e formazione e delle qualificazioni professionali*): http://nrpitalia.isfol.it/sito_standard/sito_demo/atlante_repertori.php#repertori_SR

([14]) Cedefop (2015). *Survey on the sustainability and visibility of NQFs* [unpublished].

([15]) This section draws mainly on input from European Commission et al. (forthcoming).

formal and informal learning as key elements of lifelong learning. The law establishes rules and regulatory requirements (standards) concerning the characteristics of validation/certification services and the parties involved, with the aim of ensuring transparency, usability and broad accessibility. The implementation of Law 92/2012 led to the adoption of different provisions including Legislative Decree No 13/2013 on National competences certification and validation of non-formal and informal learning. The decree defines some important principles and features for the validation system in its Article 3:

(a) the focus is on the competences acquired by an individual;
(b) a whole qualification or parts of it can be validated;
(c) the system is designed to serve the individual, assuring simplicity, confidentiality and reliability;
(d) documents and certificates issued in the validation process are public;
(e) the reliability of the national competence certification system is based on a shared and progressive system of indicators, tools and quality standards applied at national level.

The system designed by Decree 13/2013 is national and comprehensive as it covers all qualifications from general education, higher education and VET. It also includes professional qualifications and regulated ones. The institutional authority in charge of implementing the system is a national technical committee led by the Ministry of Labour and by the Ministry of Education and comprising all qualification authorities (entitling bodies). The committee took office on 28 January 2014.

Agreement on an operational common framework for national recognition of regional qualifications and related skills was reached in 2015, followed by an inter-ministerial decree signed by the Ministry of Labour and Ministry of Education. This framework establishes a mechanism of mutual recognition for regional qualifications, and standard procedures for the process, attestation and system for validation services. It is expected that, by 2016, validation services will be available across the regions according to the same methodological and system standard; the outcomes of validation processes will be related to the official qualifications framework and recognised at national level. The national technical committee decided in 2015 to agree on a draft of national guidelines for validation of non-formal and informal learning and certification of competences.

There is already some application of these rules for specific target groups: a national programme has run over the course of 2015/16 to validate the competences of approximately 5 000 volunteers in the civil service within the *Youth guarantee programme*. The main challenge for the future will be to extend the new validation services to other target groups, to ensure reliability and

sustainability. Other priorities are related to training or requalifying practitioners (counsellors and assessors), and strengthening the capacity of the education system to develop validation tools and create greater involvement of companies and the third sector.

NQF implementation

Developing an Italian national qualifications framework is still a work in progress and has been carried out alongside wider reforms of the education and training system. In the first stage, the country has referenced its formal qualifications recognised at national level directly to the eight levels of the EQF. The qualifications described in the referencing are already included and positioned in the national education and training system. These qualifications are used by almost 85% of people involved in education and training activities in Italy. One important issue not covered by the referencing report refers to the qualifications awarded by regional authorities, their importance, the methodologies used for developing them and their recognition beyond the regions. This issue remained to be dealt with in the second stage of referencing planned for 2017.

An important milestone towards the development of an NQF occurred as part of wider labour market reform. Law 92/2012 and the ensuing Decree 13/2013 support the work on a comprehensive validation system and further developments towards a NQF.

Decree 13/2013 also establishes a national repertory of education, training and professional qualifications ([16]) as the single framework for certifying competences, which could form the basis for designing a comprehensive NQF. The register is a comprehensive collection of existing national, regional and sectoral repertories, under the responsibility of the competent authorities or 'entitling bodies'. It contains qualifications from the following subsystems: higher education (universities); secondary education; vocational education and training; national framework of regional qualifications; apprenticeship system; regulated professions. For each title, it is necessary to identify standard features: competent certification bodies, definition of qualifications including the relevant competences, correlation with the national statistical code of economic activities and of professional units, and correlation with the EQF. According to comments

([16]) The national repertory of qualifications (*Repertorio nazionale dei titoli di istruzione e formazione e delle qualificazioni professionali*): http://nrpitalia.isfol.it/sito_standard/sito_demo/atlante_repertori.php#repertori_SR

and suggestions on the first referencing report, Italy is analysing regional vocational qualifications to be included in the national repertory.

In January 2015 the State and the regions agreed on setting up the national framework of regional qualifications, in order to reference qualifications issued by the regions, and on using the national repertory of qualifications as a basis for this work. The operational common framework for national recognition of regional qualifications and related skills was subsequently established through a decree in June 2015. The national framework of regional qualifications is structured according to the classification of 24 economic-professional sectors and is intended to serve as a reference for the regional qualifications repertories, including:

(a) referencing to the national statistical codes and to the sequence of descriptors of the classification of economic-professional sectors;
(b) identification and description of qualifications and their related competences in line with the criteria of the EQF;
(c) referencing of qualifications according to the EQF, carried out through the formal inclusion of these qualifications in the EQF national referencing process (European Commission et al., forthcoming).

Work towards an overarching NQF has progressed over the past couple of years. The EQF NCP has set up a working group composed of representatives of qualification authorities and social partners. In 2016, a technical proposal for a comprehensive framework was elaborated, along with guidelines for its management. The proposal was submitted to the institutional stakeholders and a decree for establishment of the NQF is currently underway. The Italian NQF will be a comprehensive framework including qualifications from general education, higher education, regional qualifications and, in the future, also professional and private qualifications.

The EQF NCP has also organised communication actions aiming to inform Italian citizens and different groups of stakeholders on the qualifications referenced to the EQF and on the significance of the EQF levels recorded on qualifications. This has been done through events, articles, leaflets and brochures, as well as workshops and promotion on the web.

Referencing to the EQF

The referencing of Italian qualifications to the EQF started in 2008; the first report was adopted in 2012 and presented to the EQF advisory group in May 2013.

National qualification descriptors have been analysed in terms of learning outcomes and mapped directly to EQF level descriptors.

The first referencing report represented an important milestone for subsequent developments. The second stage of referencing has built upon new legislative measures brought about by labour market reform and materialised in the form of the new national repertory of education, training and professional qualifications, which is seen as a step towards a comprehensive NQF.

The EQF level is currently indicated directly on several types of certificate and diploma ([17]);starting with the school year 2015/16 it is compulsory to indicate the EQF level on Europass certificate supplements and diploma supplements. The country is preparing a national qualifications database (called DBQc) and all qualifications included in this will indicate the EQF level.

The referencing of qualifications to the EQF is continuing in dialogue with stakeholders.

Important lessons and future plans

Italy has been implementing reforms consistent with EQF principles and the learning outcomes approach in various subsystems of education and training. In recent years, legislative initiatives as part of the labour market reform have led to important steps forward: setting important priorities in defining national qualifications standards based on learning outcomes; developing a national public certification system and a national register of qualifications as a step towards the NQF; and setting out principles for developing a system of validation of non-formal and informal learning.

Now the main challenge is to put in place a comprehensive NQF including all qualifications awarded at national and regional level and to establish procedures for including private qualifications in the NQF. The main difficulty in this is the high degree of fragmentation of the education and training system and the difficulty of harmonising qualifications issued at regional level. Steps towards this aim have been the creation of an operational common framework for national recognition of regional qualifications and related skills, and the establishment of

([17]) The EQF level is indicated in the following types of certificate and diploma: professional operator certificate (EQF level 3); professional technician diploma (EQF level 4); upper secondary education diploma (EQF level 4); higher technical specialisation certificate (EQF level 4). For higher technical education diploma (EQF level 5) and university degrees the EQF level is indicated in Europass diploma supplement.

the national repertory of education, training and professional qualifications. Adoption of the decree for a comprehensive NQF establishment is expected in the near future.

A related area of work in recent years has been the development of a national system for validating non-formal and informal learning. Here the main challenge is to implement the newly adopted validation services beyond the initial target groups and to ensure the sustainability of validation practices.

The adoption of a learning outcomes approach has gradually started, but the gap between formal regulations and practical implementation of learning outcomes remains a challenge. For example, curricula in VET and higher education are still influenced by the subject-based approach, although necessary regulations are in place. According to a recent Cedefop study on the application of learning outcomes (Cedefop, 2016), more tools and incentives should be provided to teachers and a cultural change from an input to an output orientation is necessary.

Although working with national qualifications in a possible framework should strengthen the orientation towards a lifelong learning approach, it remains a challenge that lifelong learning aspects are not well enough communicated. There is little information so far on system flexibility and on future plans for promoting lifelong learning and supporting access, progression and participation, especially for adults.

Further source of information
The Italian Ministry of Education, University and Research: http://www.istruzione.it/
The Italian Ministry of Labour and Social Policies: http://www.lavoro.gov.it/Pagine/default.aspx
ISFOL (National coordination point for EQF): http://www.isfol.it

Italian national qualifications framework

EQF levels	Qualifications
8	Research doctorate (*Dottorato di ricerca*) Academic diploma for research training (*Diploma accademico di formazione alla ricerca*) Specialisation diploma (*Diploma di specializzazione*) Second level university master (*Master universitario di secondo livello*) Academic specialisation diploma (II) (*Diploma accademico di specializzazione* (II)) Higher specialisation diploma or master (II) (*Diploma di perfezionamento o Master* (II)
7	Master degree (*Laurea magistrale*) Second level academic diploma (*Diploma accademico di secondo livello*) First level university master (*Master universitario di primo livello*) Academic specialisation diploma (I) (*Diploma accademico di specializzazione* (I)) Higher specialisation diploma or master (I) (*Diploma di perfezionamento o Master* (I))
6	Bachelor degree (*Laurea*) First level academic diploma (*Diploma accademico di primo livello*)
5	Higher technical education diploma (*Diploma di tecnico superiore*)
4	Professional technician diploma (*Diploma professionale di tecnico*) Upper secondary education diploma (*Licei diploma liceale)* Upper secondary education diploma – technical schools (*Diploma di istruzione tecnica*) Upper secondary education diploma – vocational schools (*Diploma di istruzione professionale*) Higher technical specialisation certificate (*Certificato di specializzazione tecnica superiore*)
3	Professional operator certificate (*Attestato di qualifica di operatore professionale*)
2	Compulsory education certificate (*Certificato delle competenze di base acquisite in esito all'assolvimento dell'obbligo di istruzione*)
1	Lower secondary school leaving diploma (*Diploma di licenza conclusiva del primo ciclo di istruzione)*

Source: Adapted from the Italian technical working group (2012).

List of abbreviations

EQF	European qualifications framework
IFTS	*Istruzione e formazione tecnica superiore* [higher (non-academic) technical education and training pathway]
ISFOL	National Institute for the Development of Vocational Training
ITS	*Istruzione Tecnica Superiore* [higher technical education]
NCP	national coordination point
NQF	national qualifications framework
QF-EHEA	qualifications framework for the European higher education area
QTI	*Quadro dei Titoli Italiano dell'Istruzione Superiore* [Italian qualifications framework for higher education]
VET	vocational education and training

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[URLs accessed 25.11.2016]

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Italian technical working group (2012). *First Italian referencing report to the European qualifications framework (EQF), adopted on 20 December 2012*. http://ec.europa.eu/ploteus/en/documentation#documentation_73

European Commission (2015). *Education and training monitor 2015: Italy* http://ec.europa.eu/education/tools/docs/2015/monitor2015-italy_en.pdf

European Commission; Cedefop; ICF International (forthcoming). *European inventory on validation of non-formal and informal learning 2016: country report Italy*.

THE UNITED KINGDOM European inventory on NQF 2014

A total of five different qualifications frameworks currently operate in the UK. England and Northern Ireland have the framework for higher education qualifications (FHEQ) established in 2001, the regulated qualifications framework, established in 2015. The Scottish qualifications framework (SCQF) has operated since 2001; in Wales, the credit and qualifications framework of Wales (CQFW) has been in place since 2003. This multitude of frameworks is partly explained by the gradual devolution of powers to the UK nations, in particular giving more autonomy to Scotland and Wales. The many frameworks also reflect the needs and interests of subsystems of education and training, explaining the existence of a separate FHEQ and RQF in England and Northern Ireland. .

In contrast, Scotland and Wales have chosen to develop comprehensive frameworks covering all levels and types of qualifications. While these developments show that frameworks develop and change continuously, they also show that the visibility and overall impact of frameworks depends on the political context in which they operate

From the perspective of the new and emerging frameworks introduced throughout Europe 'post-European qualifications framework (EQF)', the Scottish and Welsh frameworks are important learning cases. Both are comprehensive and have set themselves ambitious targets for lifelong learning. The evaluation of the Welsh framework, published in July 2014, points to the importance of integrating the RQF into mainstream education and training policies. While the CQFW is considered a useful tool, it tends to operate on the margins of the education and training system, not as a central entry and focal point. The Scottish framework, on the other hand, is considered a key tool for all stakeholders and is increasingly emerging as the most visible and consistent of the UK frameworks.
The relative complexity of the UK situation has led to the publishing of a brochure (Quality Assurance Agency for Higher Education et al., 2014) explaining to users how the frameworks interact, as well as how they link to the Irish framework.

England and Northern Ireland

Introduction

There is a single comprehensive RQF covering all levels and types of qualification in England and Northern Ireland. The Office of Qualifications and Examinations Regulation (Ofqual) is responsible for the daily running of the framework (taking over from the now disbanded Qualifications and Curriculum authority (QCA). The FHEQ is not a regulatory framework but introduces some common objectives (benchmarks) to be pursued voluntarily and provides a language of communication supporting transparency and the positioning of qualifications to each other.

Main policy objectives of the RQF and the FHEQ

While the policy objectives of the RQF and the FHEQ may be seen to complement each other, they also differ in important respects.

RQF

The framework helps people understand all the qualifications Ofqual regulate, general and vocational in England, and vocational in Northern Ireland, and how they relate to each other. Its intention is to improve consistency around how awarding organisations describe the size and challenge, or demand, of the qualifications they offer.
https://ofqual.blog.gov.uk/2015/10/01/explaining-the-rqf/

FHEQ

A separate FHEQ has been established for England, Northern Ireland and Wales. This framework has five levels and is based on the concept that qualification is awarded for demonstrated achievement. These levels are comparable to levels 4 to 8 of the QCF, although a different approach (descriptors) is used to describe them. The five levels of the FHEQ are differentiated by a series of generic qualifications descriptors that summarise the knowledge, understanding and the types of abilities that holders are expected to have. The FHEQ is certified against the qualifications framework in the European higher education area (Bologna), but not against the EQF. The attitude of FEHQ in relation to the EQF is significantly different from that signalled by the QCF. A 'scoping group' was set up in 2008 to explore the relationship between FHEQ and the EQF, concluding that, while they support the lifelong learning goals of the EQF, the group was not aware of any additional benefits which might accrue to the higher education sector at present by referencing the FHEQ to it. The group recommends that the position can be reviewed, taking into account development of the EQF and the Bologna process and monitoring of levels of interest expressed by professional, statutory and regulatory bodies.

Stakeholder involvement

Responsibilities for regulating the RQF are distributed between the Office of Qualifications and Examinations (Ofqual) in England and the Council for Curriculum, Examinations and Assessment in Northern Ireland. The responsibility for the FHEQ lies with the Quality Assurance Agency for Higher Education (QAA). Publication Analysis and overview of NQF developments in European countries. Annual report 2014

Level descriptors and learning outcomes

Can be found here: https://www.gov.uk/government/publications/qualification-and-component-levels

There are 9 qualification levels.

Entry level

Each entry level qualification is available at three sub-levels - 1, 2 and 3. Entry level 3 is the most difficult.

Entry level qualifications are:

- entry level award
- entry level certificate (ELC)
- entry level diploma
- entry level English for speakers of other languages (ESOL)
- entry level essential skills
- entry level functional skills
- Skills for Life

Level 1

Level 1 qualifications are:

- first certificate
- GCSE - grades 3, 2, 1 or grades D, E, F, G
- level 1 award
- level 1 certificate
- level 1 diploma
- level 1 ESOL
- level 1 essential skills
- level 1 functional skills
- level 1 national vocational qualification (NVQ)
- music grades 1, 2 and 3

Level 2

Level 2 qualifications are:

- CSE - grade 1
- GCSE - grades 9, 8, 7, 6, 5, 4 or grades A*, A, B, C
- intermediate apprenticeship
- level 2 award
- level 2 certificate
- level 2 diploma
- level 2 ESOL
- level 2 essential skills
- level 2 functional skills
- level 2 national certificate
- level 2 national diploma
- level 2 NVQ
- music grades 4 and 5
- O level - grade A, B or C

Level 3

Level 3 qualifications are:

- A level
- access to higher education diploma
- advanced apprenticeship
- applied general
- AS level
- international Baccalaureate diploma
- level 3 award
- level 3 certificate
- level 3 diploma
- level 3 ESOL
- level 3 national certificate
- level 3 national diploma
- level 3 NVQ
- music grades 6, 7 and 8
- tech level

Level 4

Level 4 qualifications are:

- certificate of higher education (CertHE)
- higher apprenticeship
- higher national certificate (HNC)
- level 4 award
- level 4 certificate
- level 4 diploma
- level 4 NVQ

Level 5

Level 5 qualifications are:

- diploma of higher education (DipHE)
- foundation degree
- higher national diploma (HND)
- level 5 award
- level 5 certificate
- level 5 diploma
- level 5 NVQ

Level 6

Level 6 qualifications are:

- degree apprenticeship
- degree with honours - for example bachelor of the arts (BA) hons, bachelor of science (BSc) hons
- graduate certificate
- graduate diploma
- level 6 award
- level 6 certificate

- level 6 diploma
- level 6 NVQ
- ordinary degree without honours

Level 7

Level 7 qualifications are:

- integrated master's degree, for example master of engineering (MEng)
- level 7 award
- level 7 certificate
- level 7 diploma
- level 7 NVQ
- master's degree, for example master of arts (MA), master of science (MSc)
- postgraduate certificate
- postgraduate certificate in education (PGCE)
- postgraduate diploma

Level 8

Level 8 qualifications are:

- doctorate, for example doctor of philosophy (PhD or DPhil)
- level 8 award
- level 8 certificate
- level 8 diploma

Validating non-formal and informal learning (3)

(3) This section draws mainly on the European Commission et al., 2014.

There is no comprehensive validation strategy or policy covering all sectors of education in England or Northern Ireland. Recognition of prior learning (RPL) is understood to refer to recognition of prior non-formal and informal learning. In relation to the QCF, RPL can lead to the award of units or full qualifications. In higher education, it is used for both admissions and exemptions, but most university regulatory frameworks limit RPL credit to between half and two thirds of an award.

RPL is available through the QCF that awards formal qualifications. Individuals can apply for exemption from credits based on their work-based learning. Non-formal certificated learning (employer in-house training, adult and community learning or other types of certified training) can also serve to provide credit exemption. Unlike the QCF, the NQF does not include any reference to RPL. Further, the QCF enables a much wider application of RPL than the NQF, because its units of assessment allow for wider recognition of a set of achievements, as individuals do not have to demonstrate completion of a full qualification to be awarded credit.

In higher education, the fundamental premise of the FHEQ is that qualifications should be awarded based on achievement of outcomes and attainment, rather than years of study. The responsibility for RPL (formerly referred to as accreditation of prior (experiential) learning) lies with the awarding organisation (as that is where ultimate responsibility for academic standards lies). Although there is no legislation that regulates RPL for higher education, there is a long tradition of RPL and encouraging mature students to participate. Since 2010, the QAA has introduced the quality code for higher education. This sets out the 'expectations' that all providers of UK higher education are required to meet (the code applies to England, Wales, Northern Ireland and Scotland). Each expectation is accompanied by a series of indicators that reflect 'sound practice', and through which providers can demonstrate they are complying. RPL is given significantly more emphasis in

the new quality code and is specifically included in a chapter entitled ‘assessment of students and the RPL’ (Chapter B6, which

refers only to experiential learning, not credit transfer) as well as in the chapter on admissions (Chapter B2).
Recording progress and achievement in non-accredited learning (RARPA) is another route by which individuals can have their prior learning validated. It relates mainly to adult and community learning and is compulsory in some specific projects, mainly related to second-chance education. Guidance on the application of RARPA has been prepared by the National Institute for Adult and Continuing Education which also provides events and training for practitioners in the application of RARPA.
There are also many qualifications not included in the QCF, NQF or FHEQ which can be achieved through validation, as it is up to the learning provider to decide what processes individuals are required to undertake to obtain the qualification in question.

Referencing to the EQF

The QCF was referenced to the EQF in February 2010 as a part of the overall UK referencing process. The relationship was established as shown in Table 1.
The FHEQ is not referenced to the EQF. While this option was discussed during the referencing process, agreement was not reached. As the five upper levels of the QCF are consistent with the FHEQ, an implicit and indirect link is established. Preparations are under way for presenting an updated referencing report to the EQF advisory group. Such a report would make it possible to revisit the linking of the FHEQ to the EQF.

Table 1 **Level correspondence established between the QCF and the EQF**

QCF	**EQF**
Level 8	Level 8
Level 7	Level 7
Level 6	Level 6
Level 5	Level 5
Level 4	
Level 3	Level 4
Level 2	Level 3
Level 1	Level 2
Entry level 3	Level 1
Entry level 2	
Entry level 1	

GERMANY
European inventory on NQF 2014

Introduction

Germany is implementing an eight-level national qualifications framework (NQF) for lifelong learning based on learning outcomes (German qualifications framework for lifelong learning (*Deutsche Qualifikationsrahmen für lebenslanges Lernen* (DQR)). It was formally launched in May 2013 by the joint resolution of the Standing Conference of the Ministers for Education and Cultural Affairs, the Federal Ministry of Education and Research, the conference of Ministers for Economics of the *Lände*r and the Federal Ministry of Economics and Technology ([1]). This resolution creates prerequisites for further steps of DQR implementation (establishment of federal government/*Länder* national coordination points and indicating EQF levels on new certificates and diplomas). A complete list of allocated qualifications to DQR levels and the DQR manual are included as annexes to the joint resolution ([2]). Currently, the DQR does not comprise all formal qualifications. It includes the main VET and higher education qualifications. Qualifications from general education (including the general school leaving certificate *Allgemeine Hochschulreife*) are not yet included in the framework and consequently not linked to the EQF. A decision on which levels will be included has been postponed and will be reviewed after a five-year period.

The DQR is a result of lengthy development work which started in 2006, when the Federal Ministry of Education and Research (Bundesministerium für Bildung und Frauen) (BMBF) and the Standing Conference of the Ministers for Education and Cultural Affairs of the *Länder* (*Kultursminister Konferenz*) (KMK) agreed to work together on it in response to the emerging European qualifications framework. Following extensive preparatory work, a proposal for a German NQF was published in February 2009. This proposal provided the basis

([1]) See *Gemeinsamer Beschluss der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, des Bundesministeriums für Bildung und Forschung, der Wirtschaftsministerkonferenz und des Bundesministeriums für Wirtschaft und Technologie zum Deutschen Qualifikationsrahmen für lebenslanges Lernen (DQR)*. http://www.bmbf.de/pubRD/Gemeinsamer_Beschluss_final_ohne_Unterschriften.pdf [accessed 22.7.2014].

([2]) For more information see http://www.dqr.de [accessed 22.7.2014].

for extensive testing to be followed by full-scale implementation. The piloting stage (May-October 2009) used qualifications from four selected sectors (information technology (IT), metal, health and trade) as a 'testing ground' to link qualifications to DQR levels. A broad range of stakeholders, including experts from school-based and work-based VET, continuing education and training, general education, higher education, trade unions and employers, collaborated in testing the proposal ([3]). Following evaluation of the testing phase, amendments to the original proposal were introduced, for example to level descriptors. A final agreement on a comprehensive DQR was adopted in March 2011 by the German qualifications framework working group (*Arbeitskreis* DQR) (DQR, 2011). At a high-level meeting on 31 January 2012, stakeholders extended the agreement to align important qualifications from vocational education and training (VET) and higher education to DQR levels.

Main policy objectives

Germany has actively supported the EQF initiative from the start and the extensive effort put into developing the DQR reflects this. The EQF, with its insistence on the learning outcomes perspective, is seen as an opportunity to classify German qualifications adequately and to use it as a tool to improve opportunities for German citizens in the European labour market (Hanf, 2011, p. 50 ([4])).

The learning outcome approach is seen as a catalyst for strengthening coherence of the whole education and training system, linking and integrating various subsystems and improving progression possibilities ([5]). The shift to learning outcomes is seen as a precondition for strengthening overall permeability (*Durchlässigkeit)* of German education and training. Learners should be allowed to move between levels and institutions according to their actual

([3]) http://www.dqr.de/content/2328.php [accessed 22.7.2014].

([4]) '... the clear outcomes and competence orientation of the EQF is first and foremost seen as an opportunity to classify German qualifications more adequately than existing international classifications, such as ISCED-97 or the 2005 EU directive for recognition of qualifications based on types of certificates and time spent in education and training.'

([5]) One important principle of DQR is that each qualification level should always be accessible via various education pathways.

knowledge, skills and competences, and be less restrained by formal, institutional barriers.

The DQR and the shift to learning outcomes are seen by all relevant stakeholders, notably the social partners, as an opportunity to focus on parity of esteem between general education and VET.

Another important issue is that providers of continuous training and those who provide training for groups at risk see opportunities to become part of the integrated system and offer better progression possibilities (Hanf, 2011, p 52) ([6]).

These considerations have been translated into a series of objectives, with the DQR expected to:

(a) increase transparency in German qualifications and aid recognition of German qualifications elsewhere in Europe;
(b) support mobility of learners and employees between Germany and other European countries and within Germany;
(c) improve visibility of equivalence and differences between qualifications and promote permeability;
(d) promote reliability, transfer opportunities and quality assurance;
(e) increase skills orientation of qualifications;
(f) reinforce learning outcomes orientation of qualification processes;
(g) improve opportunities for validation and recognition of non-formal and informal learning;
(h) encourage and improve access to and participation in lifelong learning.

Stakeholder involvement

Development and implementation of the DQR is characterised by a bottom-up and consensus-seeking approach (Klenk, 2013). A national steering group (*Bund-Länder-Koordinierungsgruppe*) was jointly established by the BMBF and the KMK at the beginning of 2007. This coordination group appointed a working group (*Arbeitskreis* DQR) which comprises stakeholders from higher education, school education, VET, social partners, public institutions from education and the labour market as well as researchers and practitioners. Decisions are based on

([6]) 'One of the main concerns in the past 15 years in Germany is increased enrolment in the so-called 'transitional sector', where students stay for about 0.5-1.5 years; this includes different training schemes, which do not lead to full qualifications. A total of 70-80% of students move into the dual system or full-time vocational schools afterwards'.

consensus and each of the members works closely with their respective constituent institutions and organisations.

At the beginning of 2012 an agreement was reached to assign qualifications from VET and higher education to DQR levels ([7]). Additionally, a working group has developed 11 recommendations for inclusion of non-formal and informal learning in the DQR. In November 2012, the working group (*Arbeitskreis)* published a position paper with a proposal to establish a working group, which will align 'examples' of qualifications from the non-formal sector with the DQR ([8]).

On behalf of the BMBF, a DQR office (DQR *Büro*) was set up to provide technical and administrative support.

Framework implementation

The DQR is operational. Key documents and responsibilities for DQR implementation have been agreed among key stakeholders and published ([9]):

(a) joint resolution with complete list of allocated qualifications. A new DQR website and database was launched in mid-2014;

(b) DQR manual. It describes responsibilities, procedures ([10]), standards and methods of qualification allocation. It will be updated continuously. A description of the procedure for allocating qualifications from non-formal learning contexts will be added when agreed.

([7]) The relationship between initial vocational qualifications acquired in the dual system, secondary school leaving certificate giving access to universities (*Abitur*) and higher education qualifications has been at the heart of discussions for many months. Ultimately it was decided, that general education qualifications will be included after a five-year implementation period.

([8]) See *Empfehlungen der Arbeitsgruppen zur Einbeziehung nicht-formal und informell erworbener Kompetenzen in den DQR.* http://www.bvktp.de/files/empfehlungen_nicht-formales_informelles_lernen_ag1u2_kopie_.pdf [accessed 22.7.2014].

([9]) See *Gemeinsamer Beschluss der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, des Bundesministeriums für Bildung und Forschung, der Wirtschaftsministerkonferenz und des Bundesministeriums für Wirtschaft und Technologie zum Deutschen Qualifikationsrahmen für lebenslanges Lernen (DQR)*. http://www.bmbf.de/pubRD/Gemeinsamer_Beschluss_final_ohne_Unterschriften.pdf [accessed 22.7.2014].

([10]) See http://www.dqr.de/content/2445.php [accessed 22.7.2014].

The main body in charge of implementation is a coordination point for the German qualifications framework, set up by a joint initiative of the federal government and the *Länder*. It has six members, including representatives from BMBF and Federal Ministry of Economics and Technology and the KMK and the conference of Ministers for Economics of the *Länder*. Its main role is to monitor allocation of qualifications to ensure consistency in the overall DQR structure. Direct involvement of other ministries, social partners, representatives of business organisations and interested associations is, where their field of responsibility is concerned, ensured by the federal government/*Länder* coordination point for the German qualifications framework. The German qualifications framework working group remains active as an advisory body and retains its former composition (BMBF and KMK, 2013).

Main qualifications from VET and higher education have been included in the framework. An important characteristic of DQR is that each qualification level should always be accessible via various education pathways. Consequently, VET qualifications were allocated from levels 1 to 7. An example is allocation of the bachelor and master craftsman qualification to level 6, which shows that higher DQR levels are open to qualifications from different education sectors and regarded as equal ([11]). Qualifications from general education (including the general school leaving certificate, *Allgemeine Hochschulreife*) are not yet allocated and consequently not linked to the EQF. A decision on which level they will be included has been postponed and will be reviewed after a five-year period. Hhigher education levels and qualifications have been integrated into the DQR.

Currently, discussions are ongoing on assigning remaining qualifications from regulated further training to the DQR. Additionally, an expert group is starting to examine possibilities to allocate qualifications from a non-formal learning context to the DQR.

The DQR is a non-regulatory framework and its integration into policies of different education sectors is an evolutionary process. First references to the DQR and its categories have already been made in regulatory instruments of the formal sector and in curricula of the non-formal sector as in the new framework curricula for part-time vocational schools (*Berufsschule*) of the *Länder*. In addition, the DQR is used in the academic sector for development of accreditation procedures. BMBF with the Federal Institute for VET (Bundesinstitut für Berufsbildung) (BIBB), social partners and universities are currently exploring possibilities of joint offers at DQR level 5. The aim is to link VET better with

([11]) See http://www.bmbf.de/press/3574.php [accessed 22.7.2014].

higher education. Further, BIBB and the Institute for Quality in Education have agreed on further research work on strengthening learning outcomes approaches in VET and general education. The DQR, with its clear learning outcomes approach, also aims at improving opportunities for recognising informally-acquired learning outcomes and strengthening lifelong learning. Promoting permeability across subsystems is also an explicit aim of the framework (Büchter et al., 2012).

Level descriptors and learning outcomes

An eight-level structure has been adopted to cover all main types of German qualifications.

Level descriptors describe the competences required to obtain a qualification. The overall structure is guided by the established German terminological and conceptual approach referring to the ability to act (*Handlungskompetenz)*. The DQR differentiates between two categories of competence: professional and personal. The term competence lies at the heart of the DQR and signals readiness to use knowledge, skills and personal, social and methodological competences in work or study situations and for occupational and personal development. Competence is understood in this sense as comprehensive action competence (see Table 1). Methodological competence is understood as a transversal competence and is not separately stated in the DQR matrix. The German DQR expresses only selected characteristics; the comprehensive and integrated notion of competence, underlying the DQR has a strong humanistic and educational dimension ([12]).

Descriptors are expressed as alternatives, such as 'field of study or work' and 'specialised field of study or field of occupational activity'. The table of level descriptors (DQR matrix) and a glossary are included in the DQR outline.

The broad and inclusive nature of level descriptors, using parallel formulations, makes it possible to open up all levels to different kinds of qualifications. This means that higher levels are not restricted to qualifications awarded within the Bologna process.

([12]) The ability to act (*Handlungskompetenz)* in vocational school curricula is not restricted to the world of work, but implies individual ability and readiness to act adequately socially and be individually responsible.

Table 1 **Level descriptors in the German qualifications framework for lifelong learning**

Level indicator ([13])			
Structure of requirements			
Professional competence		**Personal competence**	
Knowledge	Skills	Social competence	Autonomy
Depth and breadth	Instrumental and systemic skills, judgment	Team/leadership skills, involvement and communication	Autonomous responsibility, reflectiveness and learning competence

Source: DQR (2011).

Each reference level maps comparable, rather than homogeneous, qualifications. One key principle of DQR is that 'alignment takes place in accordance with the principle that each qualification level should always be accessible via various educational pathways' (DQR, 2011, p. 6).

Orientation to learning outcomes is increasingly becoming standard in education, vocational training and higher education (BMBF and KMK, 2013, p. 96).

In VET, continuous development of the ability to act concept (*Handlungskompetenz*), introduced in the 1990s, has gradually assumed a key role in a qualifications definition, with clear input requirements about place, duration and content of learning. Competence-based training regulations and framework curricula with 'learning field' have been developed.

Competence orientation is also characteristic of the reform process in general education and development of national educational standards (*Bildungsstandards)*. They currently exist for German and mathematics in primary education (*Hauptschule*); German, mathematics and first foreign language for the intermediate leaving certificate (*Realschule*); and German, mathematics and foreign language for the upper secondary school leaving certificate (*Abitur*) (ibid. p. 98). In higher education, the modular structure and a learning outcome-oriented description of study modules are key prerequisites for approval of a study course.

([13]) This is just the analytical differentiation; the interdependence between different aspects of competence is emphasised (DQR, 2011 p. 5).

Validating non-formal and informal learning and links to the NQF ([14])

Germany does not have an overall strategy for validation. Development of the NQF has, however strengthened work on validation. A working group is examining how to link learning outcomes of non-formal education to the DQR ([15]).

There are, however, various arrangements that permit full or partial recognition of informally or non-formally acquired competences.

Legislation for validation of non-formal and informal learning is in place in VET. This includes the external students' examination under paragraph 45 (2) of the Vocational Training Act and paragraph 37 (2) of the Crafts Code. These arrangements lead to award of a full qualification (equal to those formally acquired) in a recognised apprenticeship trade. Admission to the external exam is subject to specific employment requirements (1.5 times the length of the formal programme). The Vocational Qualifications Assessment Law (BQFG), introduced in April 2012, provides individuals with the right to have their foreign acquired qualifications matched to a German qualification by a competent authority. Appropriate work experience can be used for recognition where formal certificates are missing (see BQFG paragraph 3, Section 1), although the law focuses on comparison of formal qualifications. General education school leaving certificates can be also acquired through an external examination (*Schulfremdenprüfung, Externenprüfung)* in all *Länders*, fulfilling the residence and minimum age requirements as well as evidence of appropriate examination preparation.

In higher education, two decisions of the KMK provide the basis for validation. The first refers to access to higher education for qualified workers and is in place since March 2009. People that hold certain vocational qualifications, without a proper upper secondary qualification, can be admitted to higher education. The second refers to granting credits for competence acquired at work. Procedures to credit non-formal and informal learning were developed and tested in the 'transitions from VET to higher education (*Übergänge von der beruflichen in die hochschulische Bildung*) (ANKOM) initiative ([16]). According to these decisions, knowledge and skills acquired outside the higher education

([14]) This section draws mainly on input from European Commission et al., forthcoming.

([15]) See http://www.dqr.de/content/2321.php [accessed 22.7.2014].

([16]) See http://ankom.his.de/beschluesse [accessed 22.7.2014].

system can be recognised up to a maximum of 50% if content and level are equal to the equivalent of formal qualifications.

There are also several initiatives below legislative level, in form of projects or different stakeholders' programmes. These relate mainly to identification and documentation of learning outcomes and are not generally linked to NQF developments. One of the most successful initiatives is the ProfilPASS system. It is a system of counselling and documentation of learning outcomes based on biographical methods. A working group was set up by the BMBF to explore possible ways of creating a systematic approach to validation, including a possibility of further developing ProfilPASS into a validation instrument. The German Federal Council (Bundesrat) clarified that a decision on whether, when and how to implement arrangements for validation will be decided at national level (see Bundesrat, 2012).

Referencing to the EQF

The joint steering committee set up by the federal government and the *Länder* in 2007 is in charge of referencing, supported by the DQR office. The referencing report was presented in December 2012.

Gradually from January 2014 EQF and NQF levels feature on VET certificates and higher education diploma supplements. German master craftsperson certificates show corresponding NQF and EQF levels. Like the bachelor's degree, they are related to level 6. From an education and training policy perspective, this is considered a milestone ([17]). Allocation to level and reference on certificates signal the high value and quality of this qualification. In Germany, VET qualifications are placed on nearly all NQF/EQF levels with three-year apprenticeships leading to level 4.

([17]) See http://www.bmbf.de/press/3574.php [accessed 22.7.2014].

Table 2 **Level correspondence established between the DQR and the EQF**

DQR	EQF
Level 8	Level 8
Level 7	Level 7
Level 6	Level 6
Level 5	Level 5
Level 4	Level 4
Level 3	Level 3
Level 2	Level 2
Level 1	Level 1

Source: BMBF and KMK, 2013.

Important lessons and future plans

First, development of the DQR is embedded in a broader context of reforms to strengthen outcomes-based orientation of German education and training. It is also linked to initiatives to support permeability within VET and between VET and higher education, such as the ANKOM initiative ([18]), that involves stakeholders from VET and higher education to support recognition of learning outcomes.

Second, development of the DQR is also characterised by a comprehensive vision and coherent set of level descriptors, spanning all levels of education and training. This approach makes it possible to identify and understand better similarities and differences between qualifications in different areas of education and training. A permeable system with better horizontal and vertical progression possibilities is at the heart of DQR developments, as is parity of esteem between VET and general education and efforts to include non-formal and informal leaning.

Third, there are intense discussions about the influence the new paradigm may have on the *Beruf* as the main organising principle in German VET and on the labour market. It is feared that a learning outcomes approach could split VET qualifications into different levels, leading to their fragmentation and

([18]) For more information see http://ankom.his.de [accessed 22.7.2014].

individualisation. Other concerns are that NQF might undermine the value of qualifications by creating confusion, mixing different spaces of recognition and blurring the distinction between different types of knowledge (Hanf, 2011, p. 66; Gehmlich, 2009, pp. 736-754).

Fourth, NQF development is also characterised by a strong and broad involvement of stakeholders from all subsystems of education and training (general education, school and work-based VET, higher education), and from the labour market, ministries and *Länder*.

Fifth, stakeholders also agreed that alignment of qualifications within German education to reference levels of the DQR should not replace the existing system of access. Achieving a reference level of the DQR does not provide automatic entitlement to access the next level. Achievement of a reference level has also not been considered in conjunction with implications for collective wage bargaining and the Law on Remuneration (BMBF; KMK, 2011, pp. 5-6). These are issues to be discussed in coming years.

A five-year implementation phase with scientific evaluation is planned.

Main sources of information
[Urls accessed 22.7.2014]

The federal government/*Länder* coordination point assumes functions of the EQF NCP. Information on DQR development is available at:
http://www.dqr.de/content/2445.php

Table 3 **The national qualification framework in Germany**

DQR levels	Qualifications	EQF levels
8	Doctoral studies	8
7	Master, strategic IT professional (certified)* *Strategischer IT Professional (Geprüfter)*	7
6	Bachelor, commercial specialist (certified) (*Fachkaufmann (Geprüfter)*), business management specialist (certified) (*Fachwirt (Geprüfter)),* master craftsman (certified), *(Meister (Geprüfter)),* operative IT professional (certified)]* (*Operativer IT Professional (Geprüfter)),* Fachschule (State-certified…), *Fachschule* (*(Staatlich Geprüfter…)*)	6
5	IT specialist (certified) (*IT-Spezialist (Zertifizierter)*), service technician (certified)* (*Service-techniker (Geprüfter)*)	5
4	Dual VET (three-year and three-and-a-half-year training courses), full-time vocational school (assistant occupations) (*Berufsfachschule*), full vocational qualification (full-time vocational school) (*Berufsfachschule*)	4
3	Dual VET (two-year training courses), full-time vocational school (general education school leaving certificate obtained on completion of grade 10 at *Realschule* or, under certain circumstances, at other lower secondary school types) (*Berufsfachschule*) *(Mittlerer Schulabschluss)*	3
2	Vocational training preparation (*Berufsausbildungsvorbereitung*), employment agency measures (*Maßnahmen der Arbeitsagentur*), year of pre-vocational training (Berufsvorbereitungsjahr), introductory training for young people (*Einstiegsqualifizierung*), full-time vocational school (*Berufsfachschule*), basic vocational training, (*Berufliche Grundbildung*)	2
1	Vocational training preparation (*Berufsausbildungsvorbereitung*), employment agency measures (vocational preparation schemes) (*Maßnahmen der Arbeitsagentur (Berufsvorbereitende Bildungsmaßnahmen*), year of pre-vocational training (*Berufsvorbereitungsjahr*)	1

(*) The *Arbeitskreis* DQR agreed that additional further vocational training qualifications should be allocated in accordance with the procedures described in the DQR manual.

Source: BMBF and KMK, 2013.

List of abbreviations

ANKOM	Übergänge von der beruflichen in die hochschulische Bildung [transitions from vocational high school education]
BIBB	Bundesinstitut für Berufsbildung [Federal Institute for VET]
BMBF	Bundesministerium für Bildung und Forschung [Federal Ministry of Education and Research]
BQFG	Vocational Qualifications Assessment Law
DQR	Deutsche Qualifikationsrahmen für lebenslanges Lernen [German qualifications framework for lifelong learning]
IT	information technology
KMK	Kultusminister Konferenz [Standing Conference of the Ministers for Education and Cultural Affairs of the *Länder*]
NQF	national qualifications framework
VET	vocational education and training

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(Urls accessed 22.7.2014)

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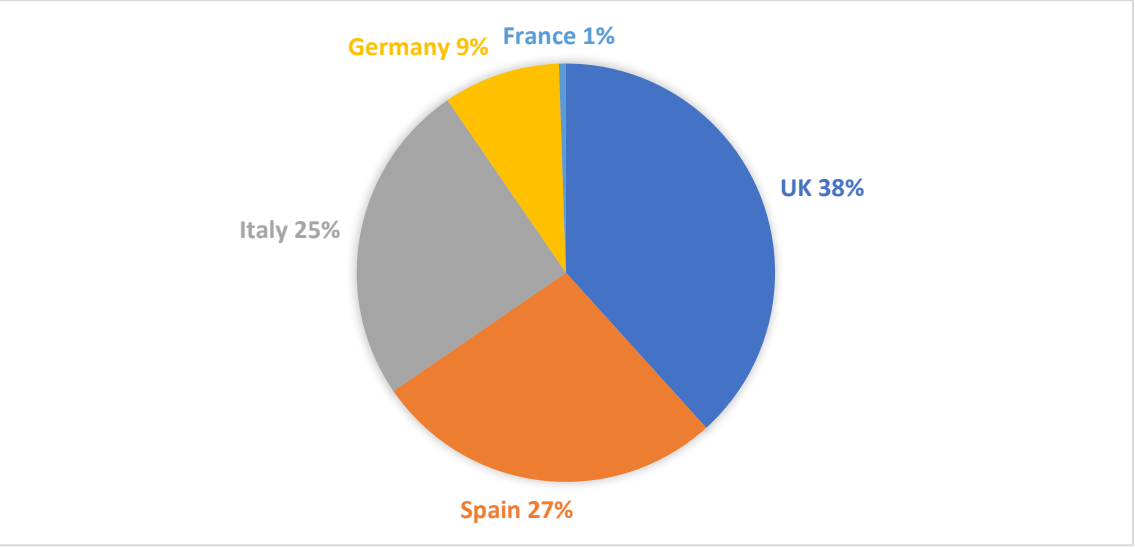
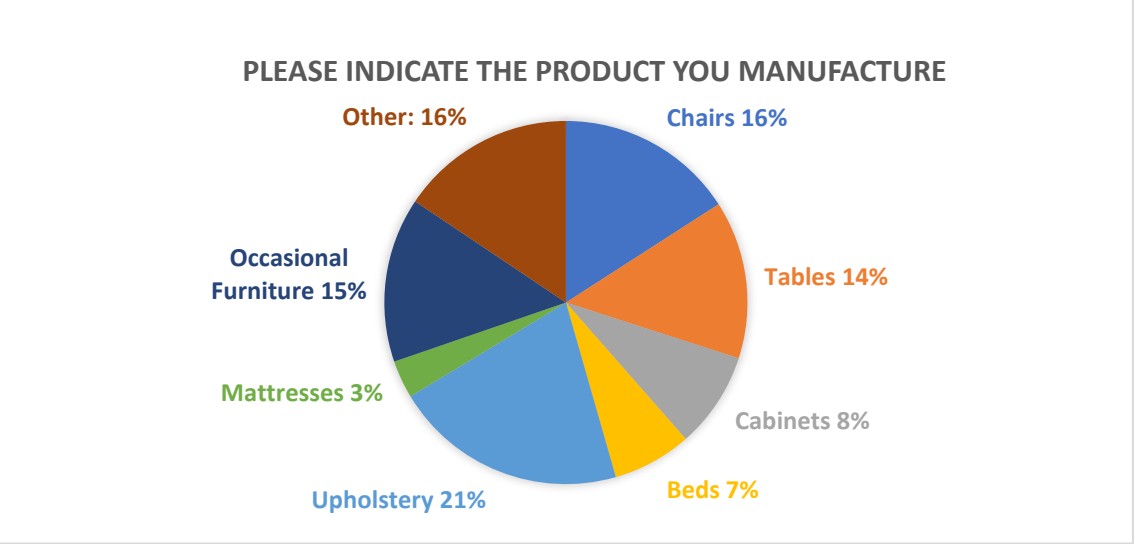
General Information

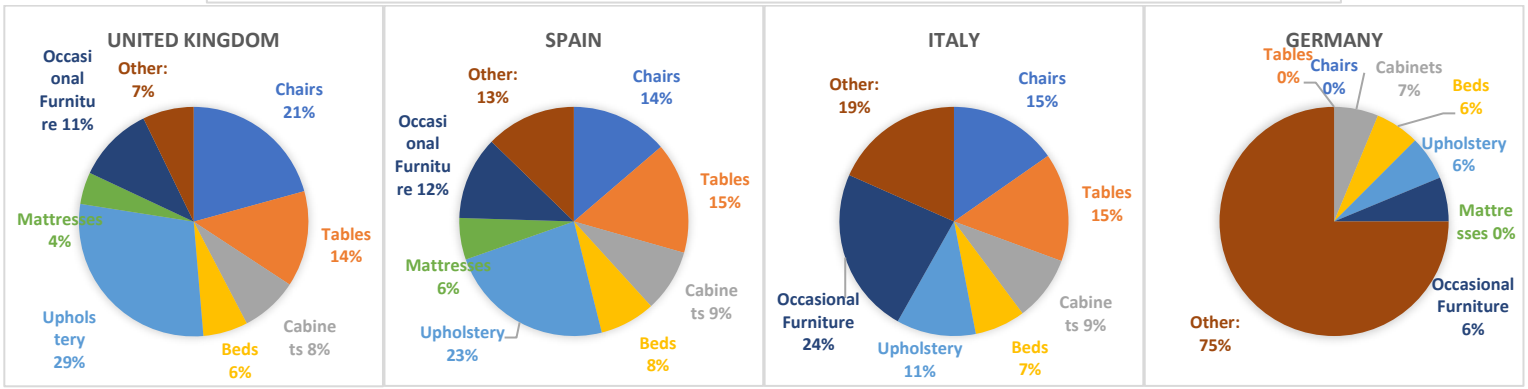
Origin of the respondents



Graphic 1: Origin of the respondents.

Typology of production

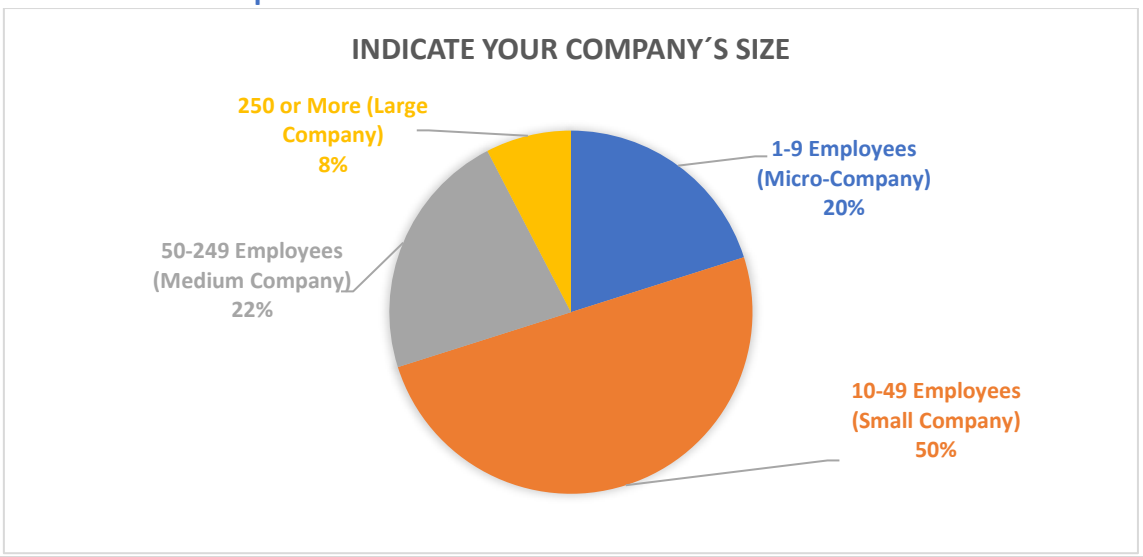


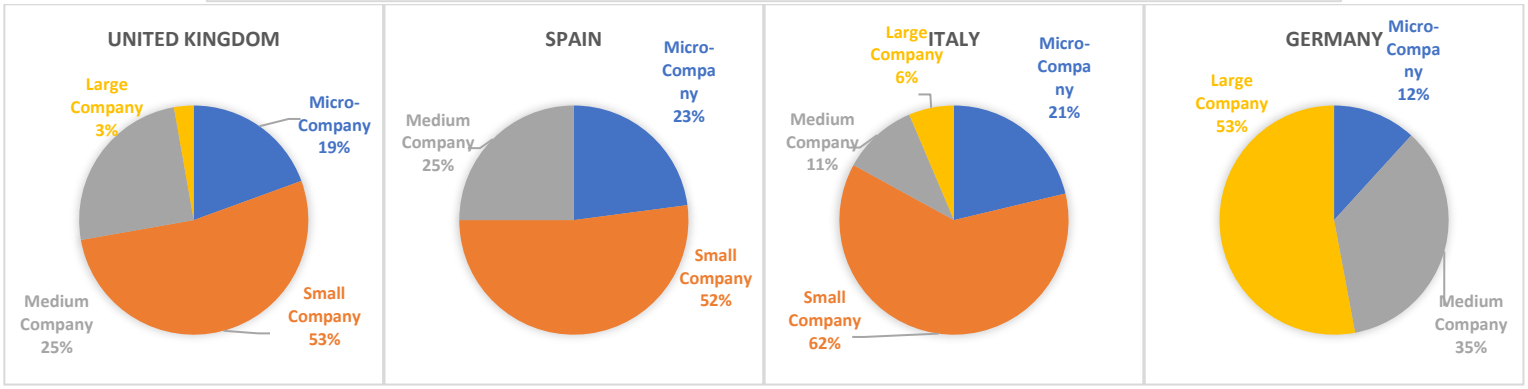


Graphic 2: Typology of production.

This project has been funded by the action Sector Skills Alliances in Vocational Education and Training from the Erasmus+ Programme.
Project Number 575853-EPP-1-2016-ES-EPPKA2-SSA
Funded by the Erasmus+ Programme of the European Union

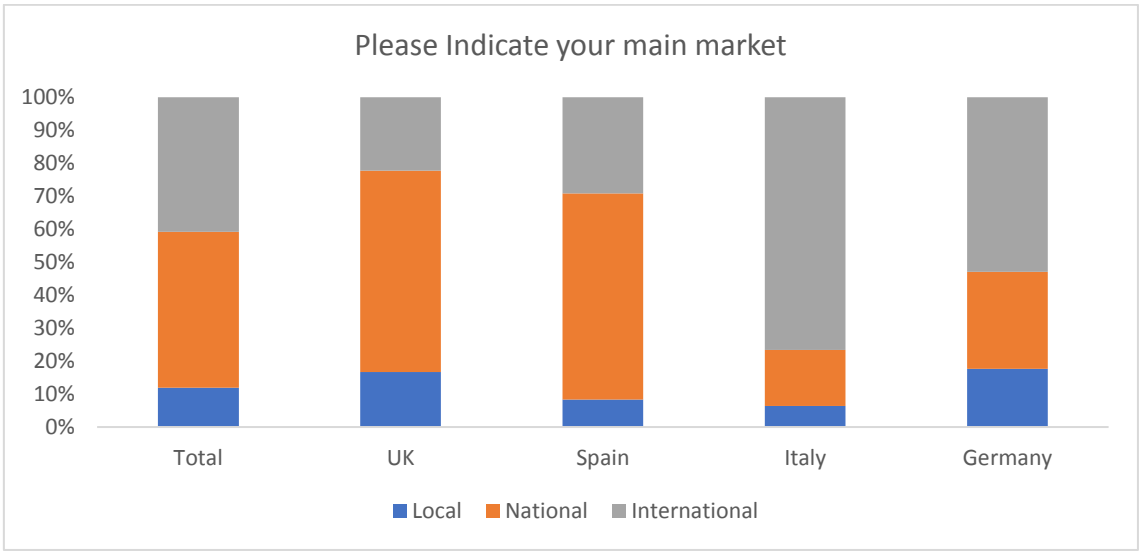
Size of the companies





Graphic 3: Size of companies

Main Markets



Graphic 4: Main markets.

This project has been funded by the action Sector Skills Alliances in Vocational Education and Training from the Erasmus+ Programme.
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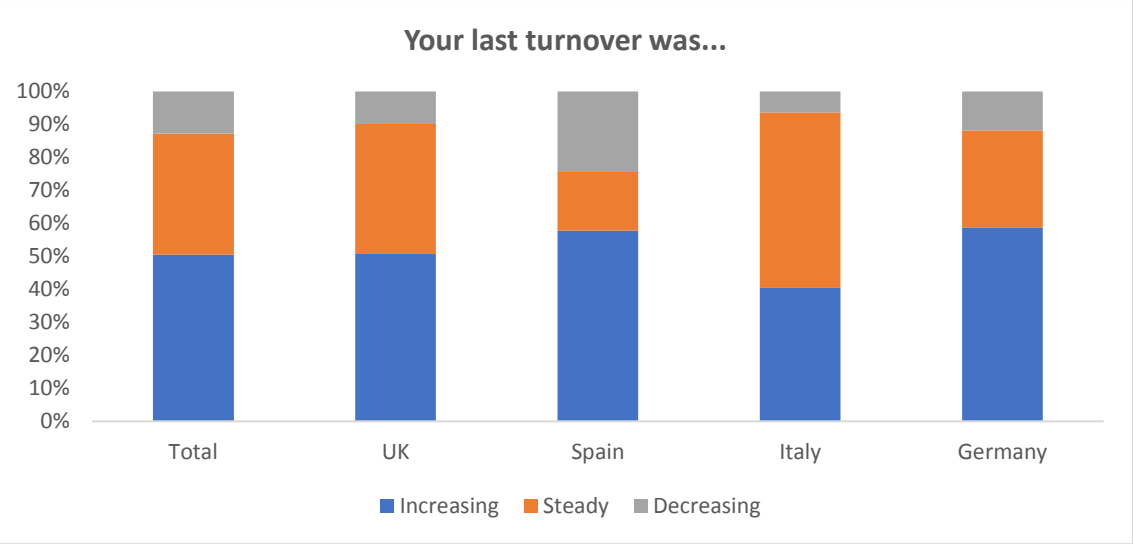
Funded by the Erasmus+ Programme of the European Union

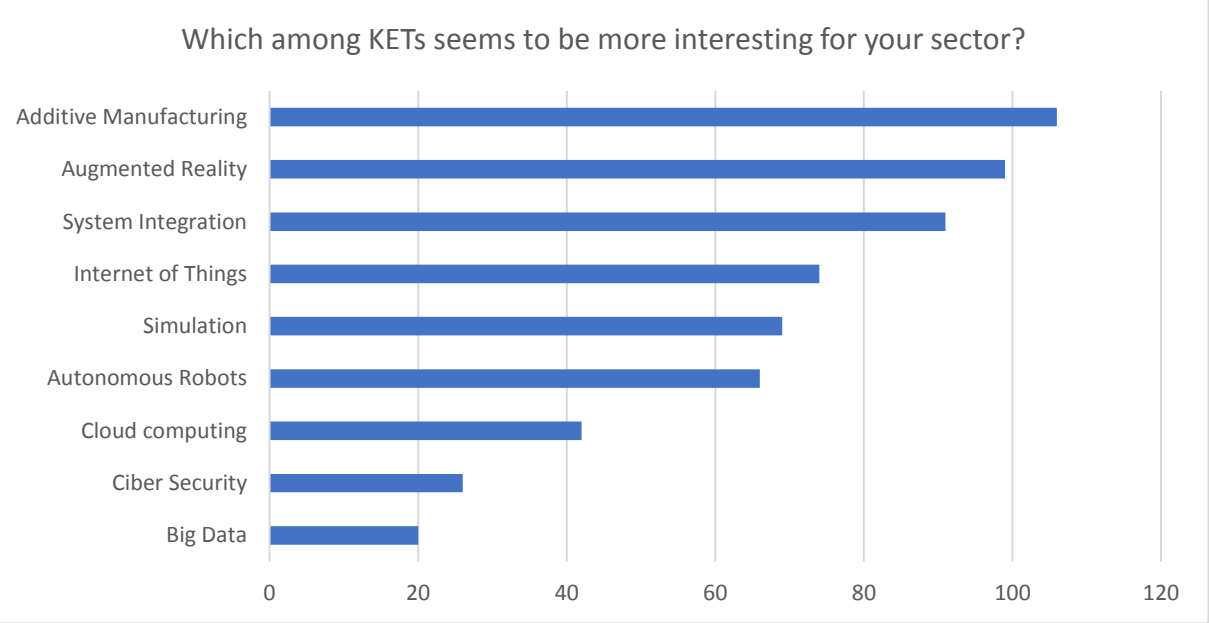
Turnover

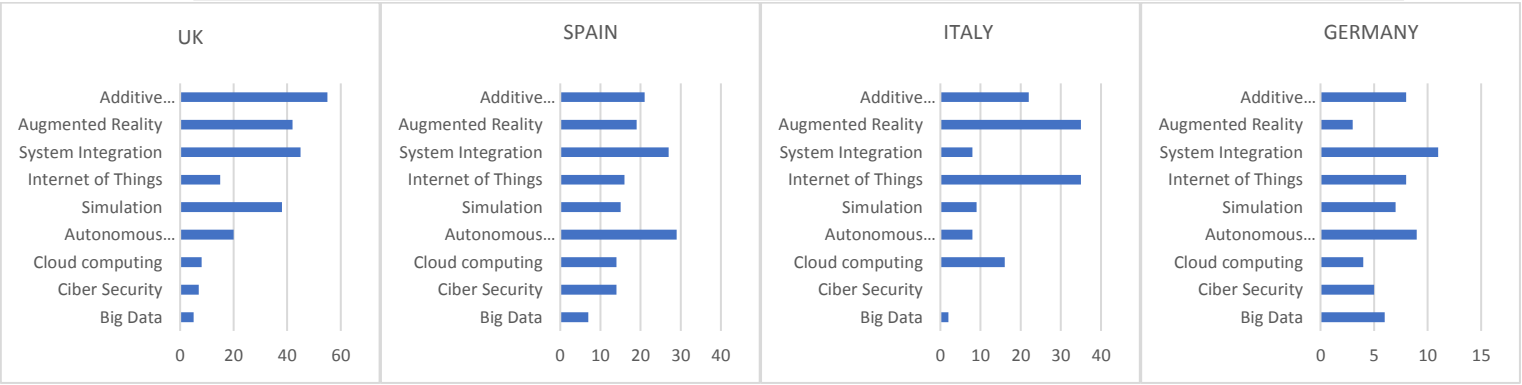


Graphic 5: Turnover

Industry 4.0 technologies and related perception

Key Enabling Technologies Interesting for the sector





Graphic 6: Interesting KETs in the Furniture Sector.

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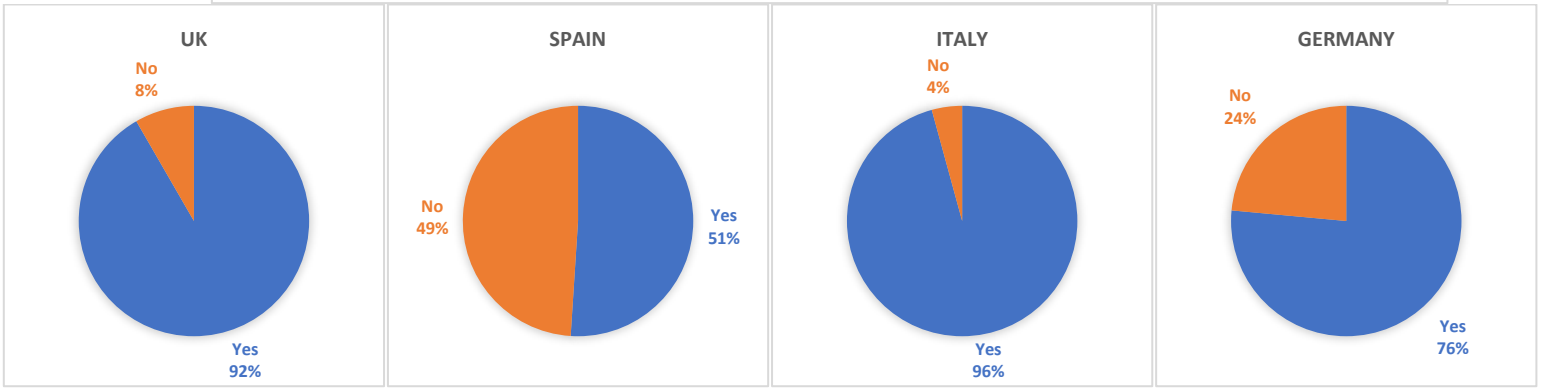
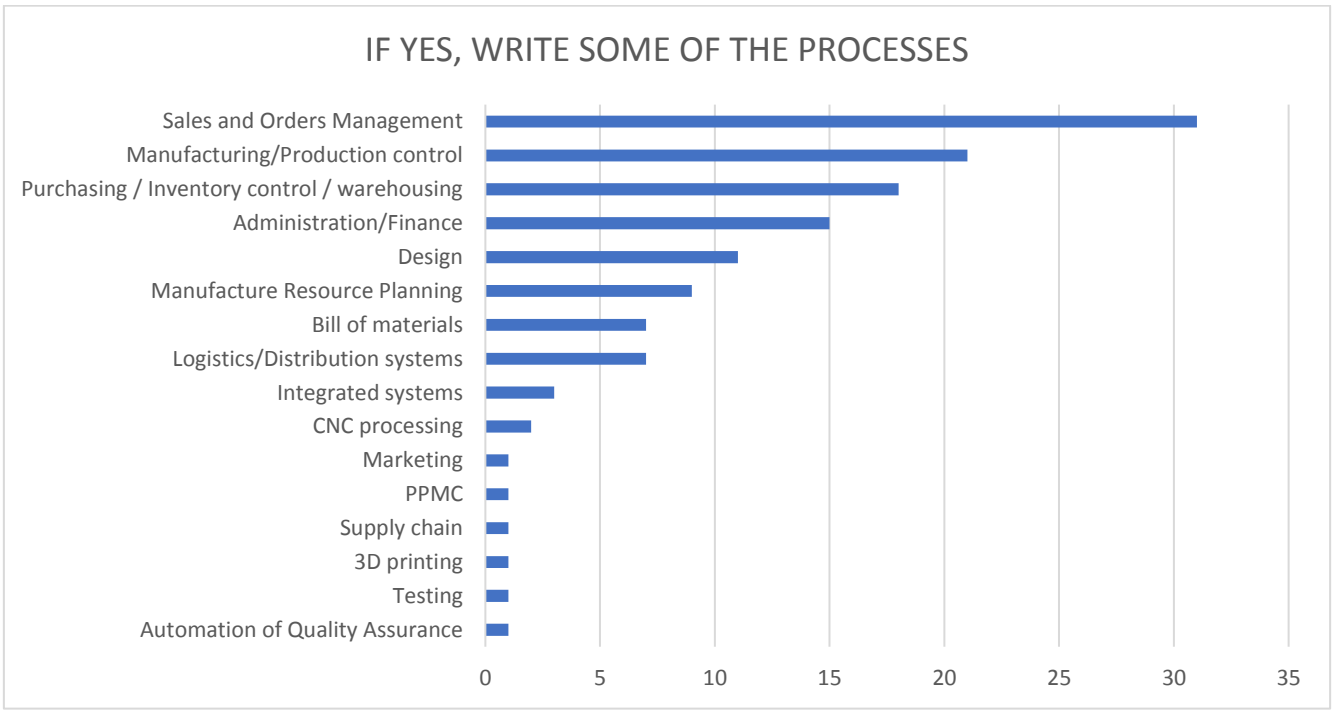
Computer support in production processes



Graphic 7: Use of computer support in furniture production processes.



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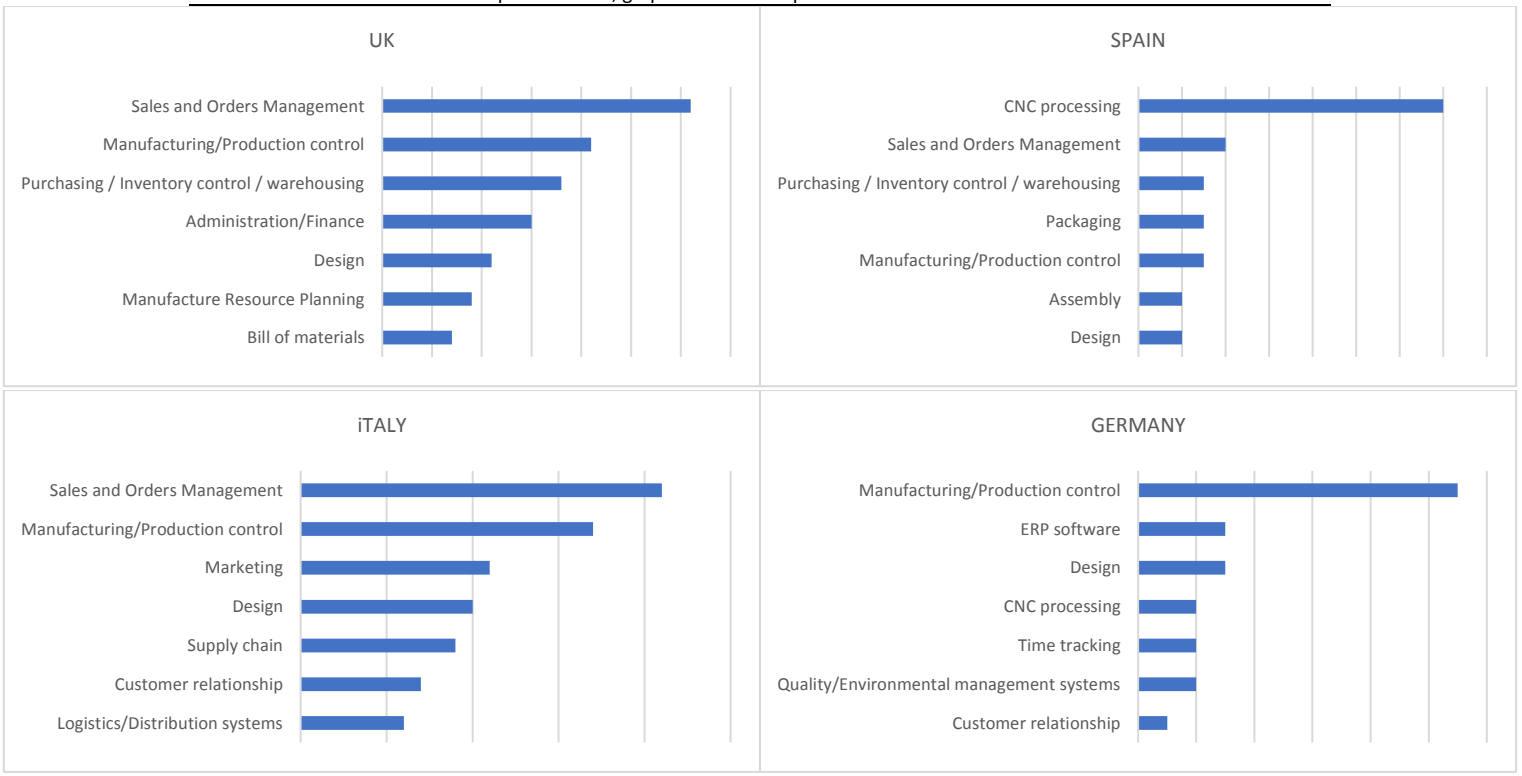
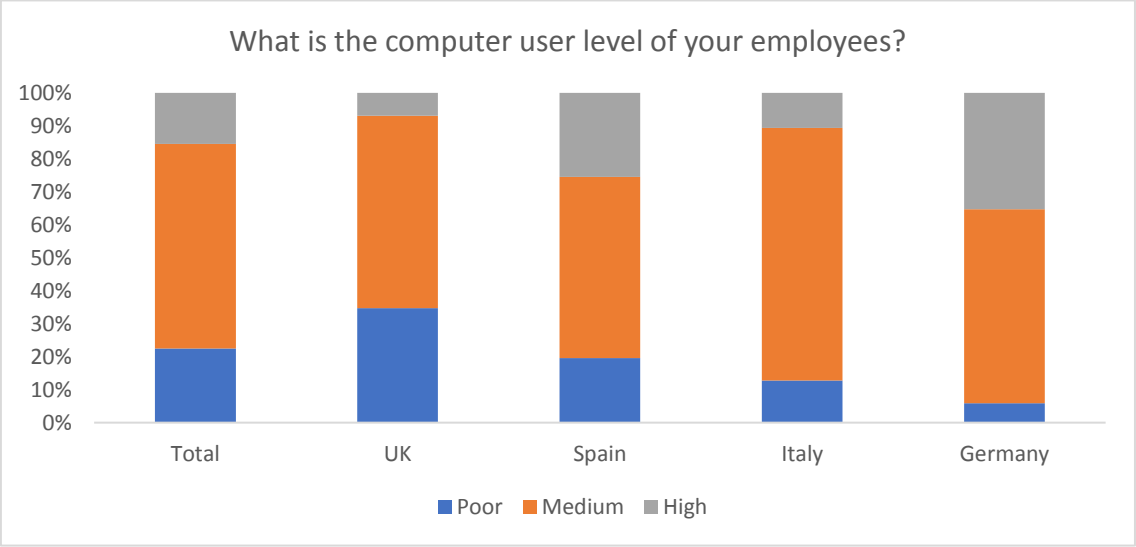


Graphic 8: Use of computer support in furniture production processes

Computer user level of Furniture employees



Graphic 9: Computer user level of furniture employees.

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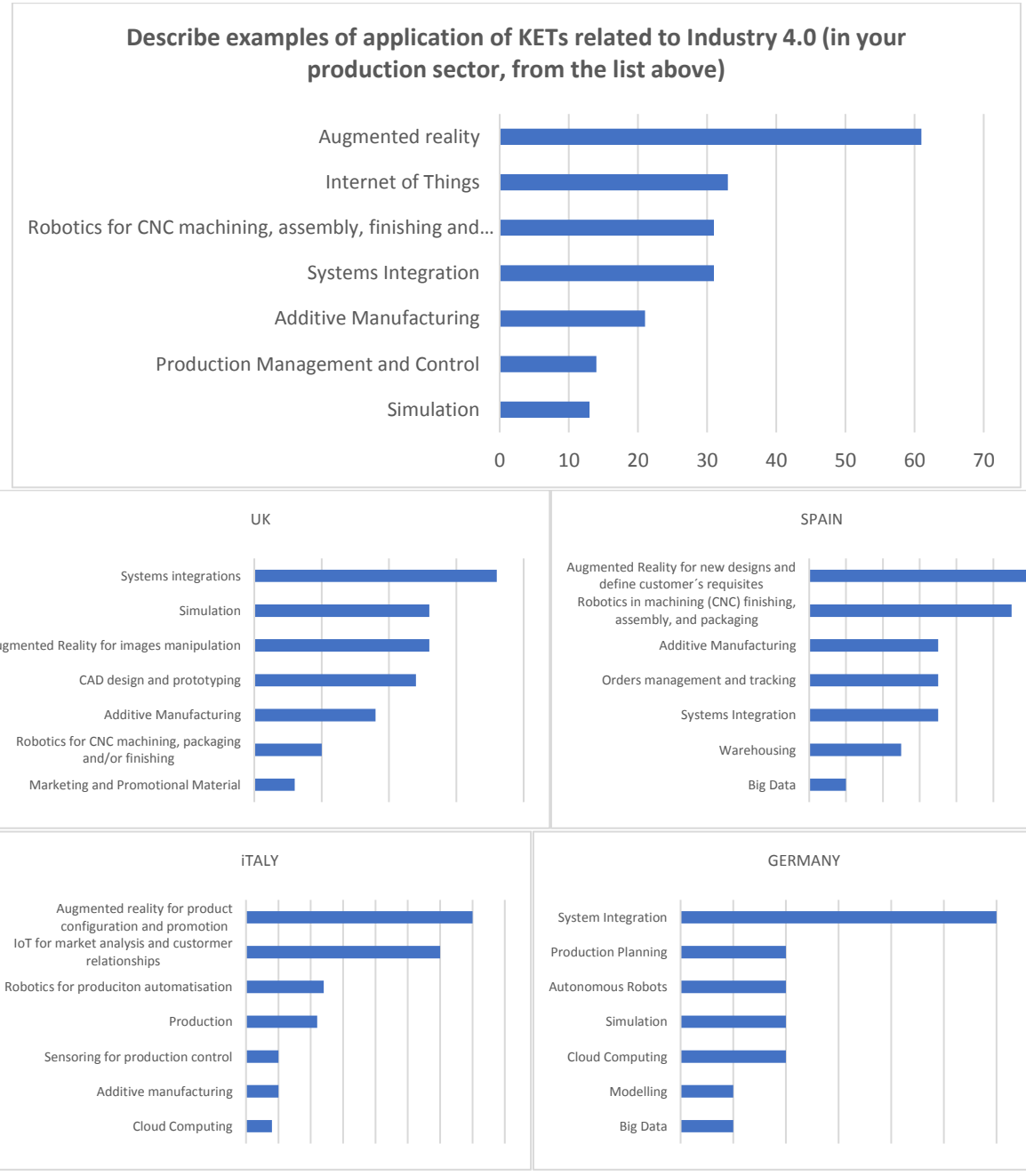
Examples of KETS in the furniture sector



Graphic 10: Examples of KETs in the furniture sector.

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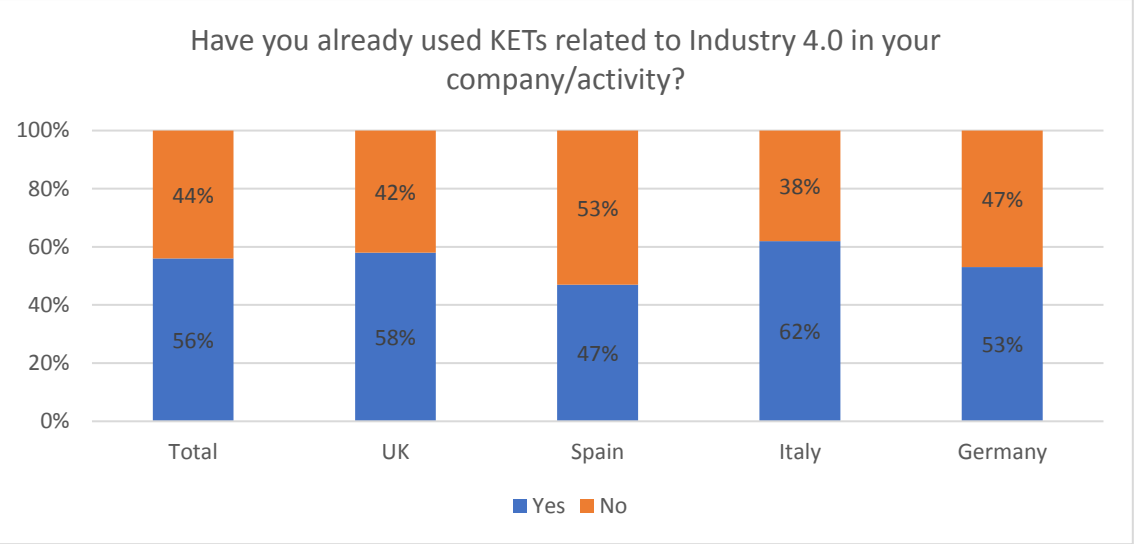
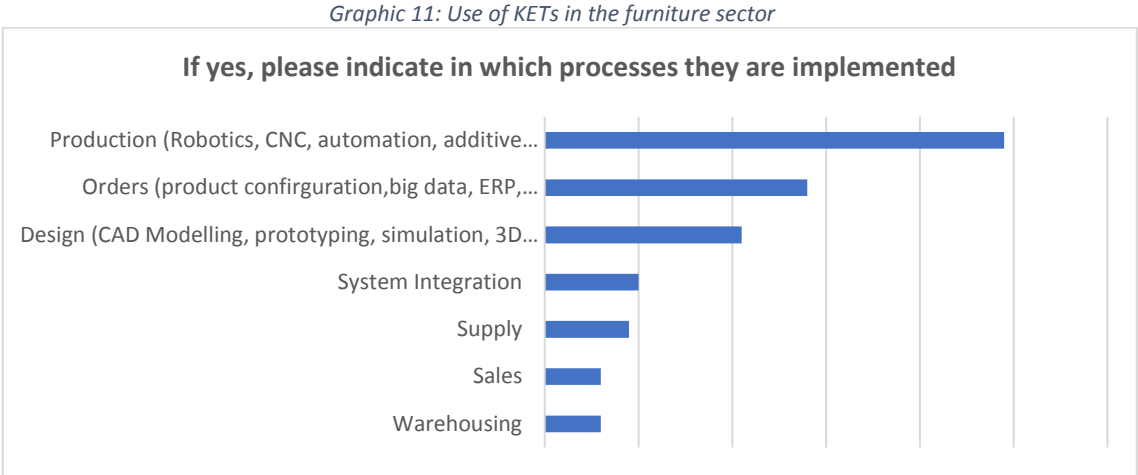
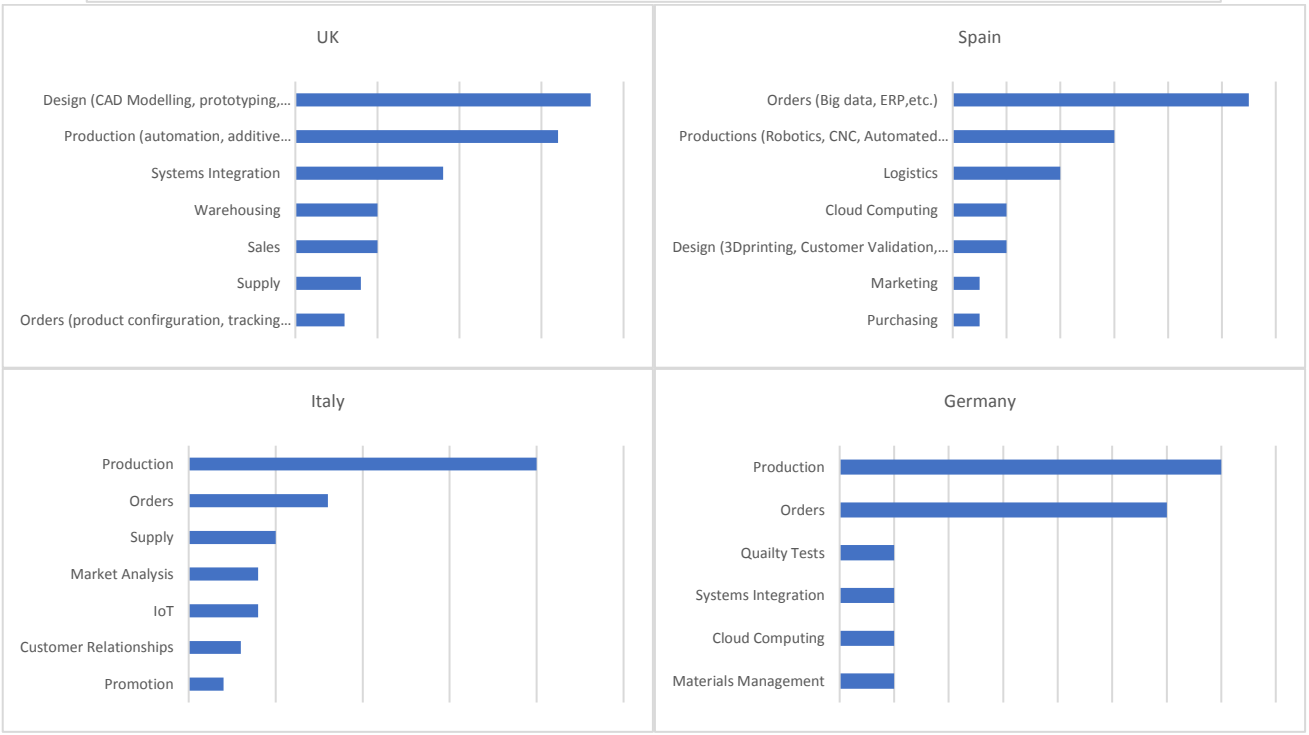
Use of KETS in the furniture sector



Graphic 11: Use of KETs in the furniture sector





Graphic 12: Main KETs used in the furniture and woodworking sectors.

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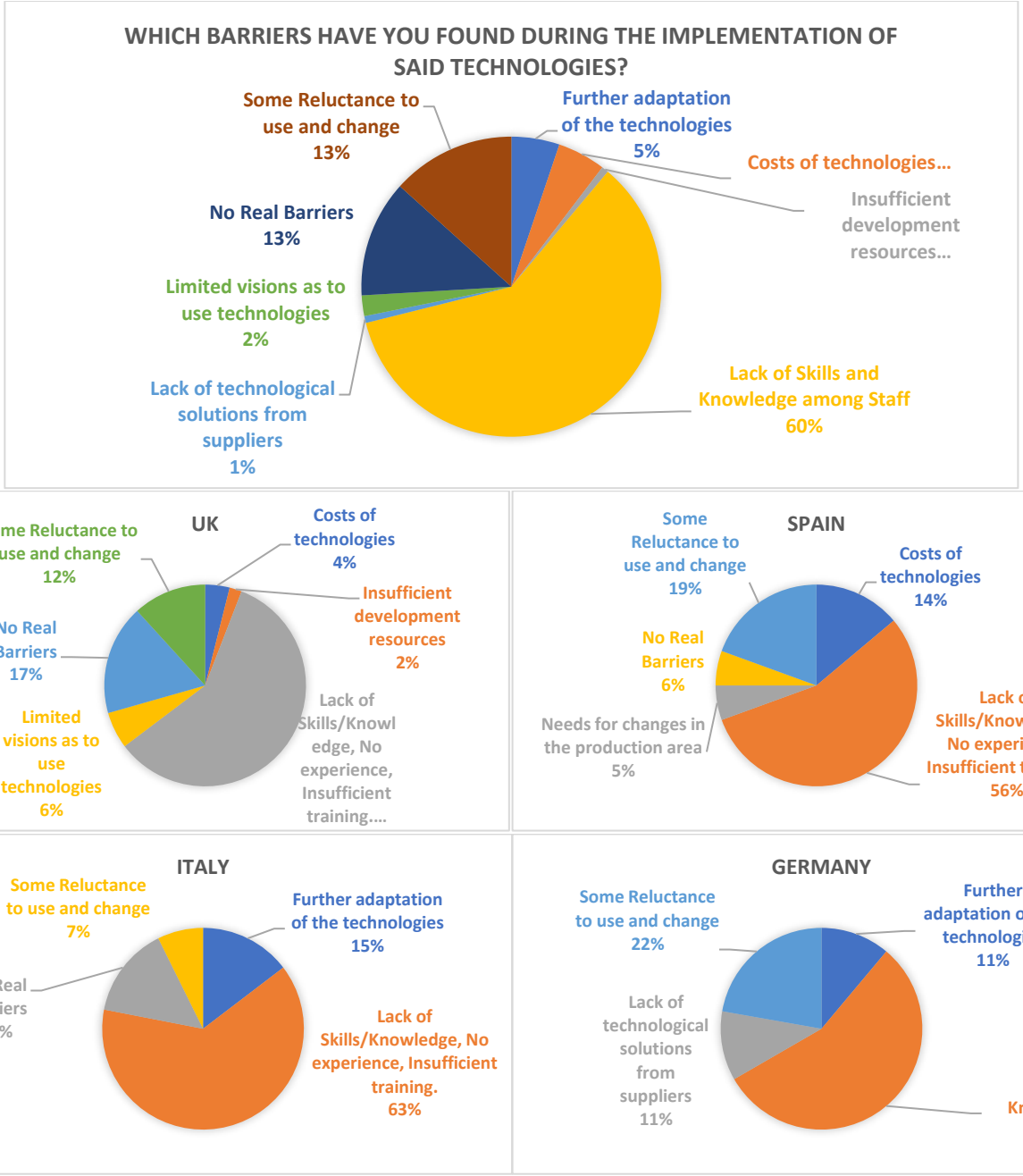
Barriers at implementing KETs in the Furniture and Woodworking Industries



Graphic 13: Barriers at implementing KETs in Furniture and Woodworking Industries.

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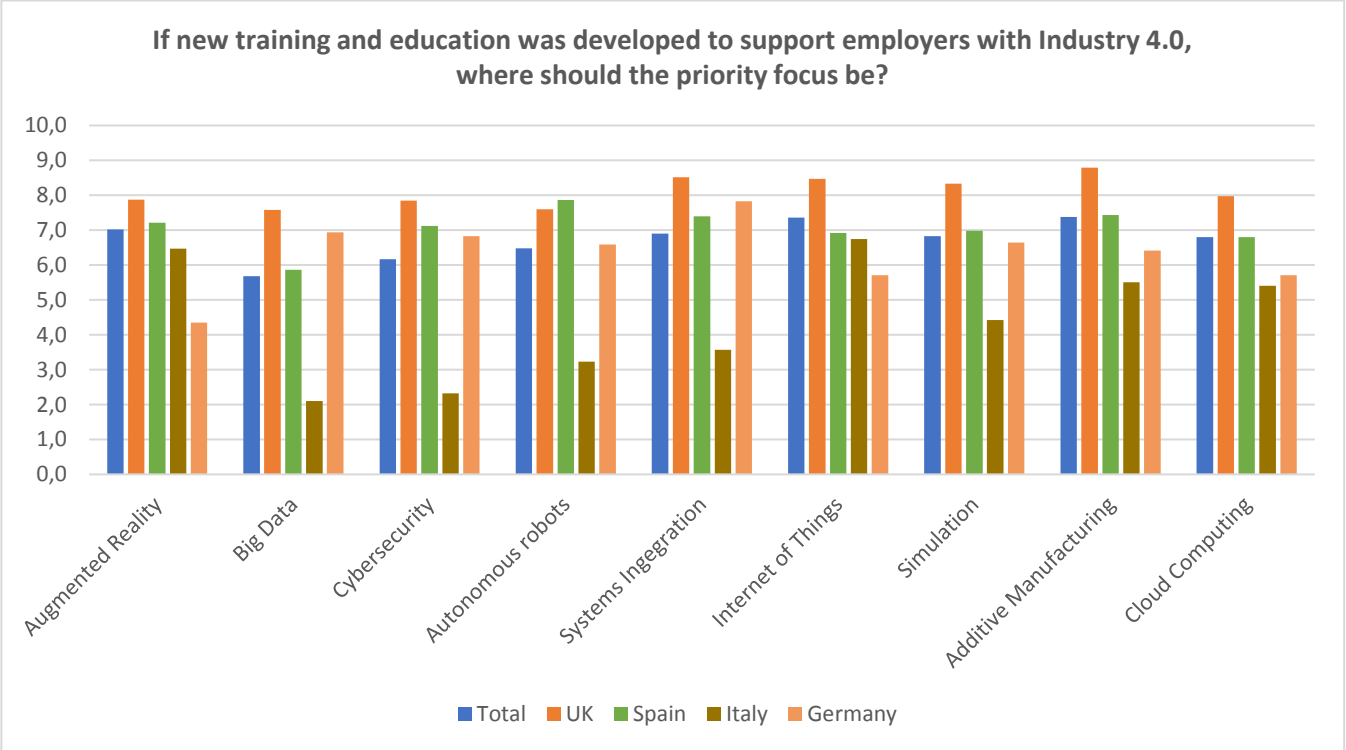
Worker´s skills

Graphic 14: Furniture workers employees and KET skills.

Priorities in training and education about I4.0 to support employers



Graphic 15:Priorities in training and education about I4.0 to support employers.

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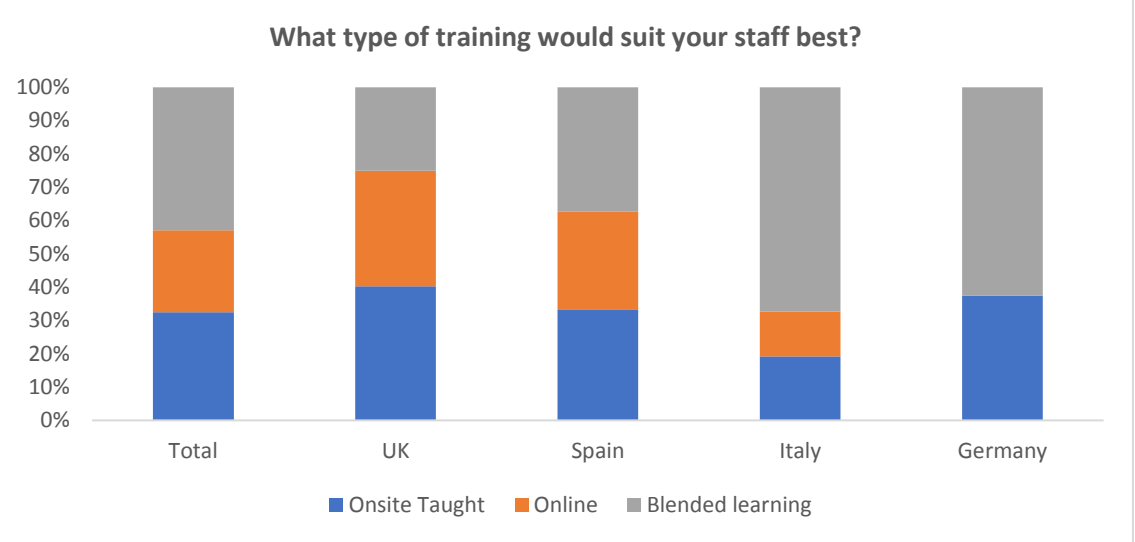
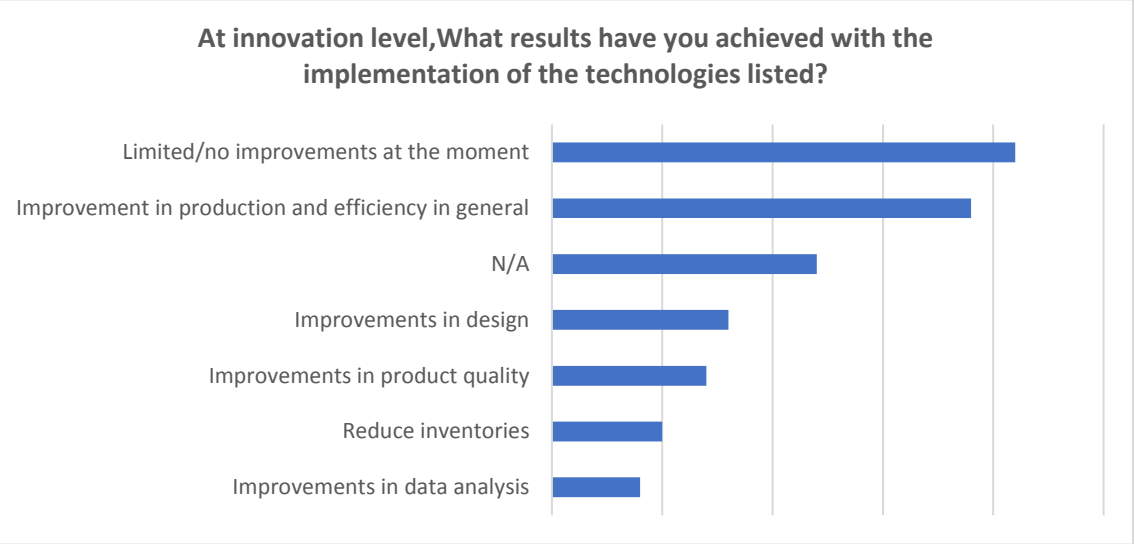
Training types preferences



Graphic 16: Training types preferences.

Achieved results with the implementation of KETs



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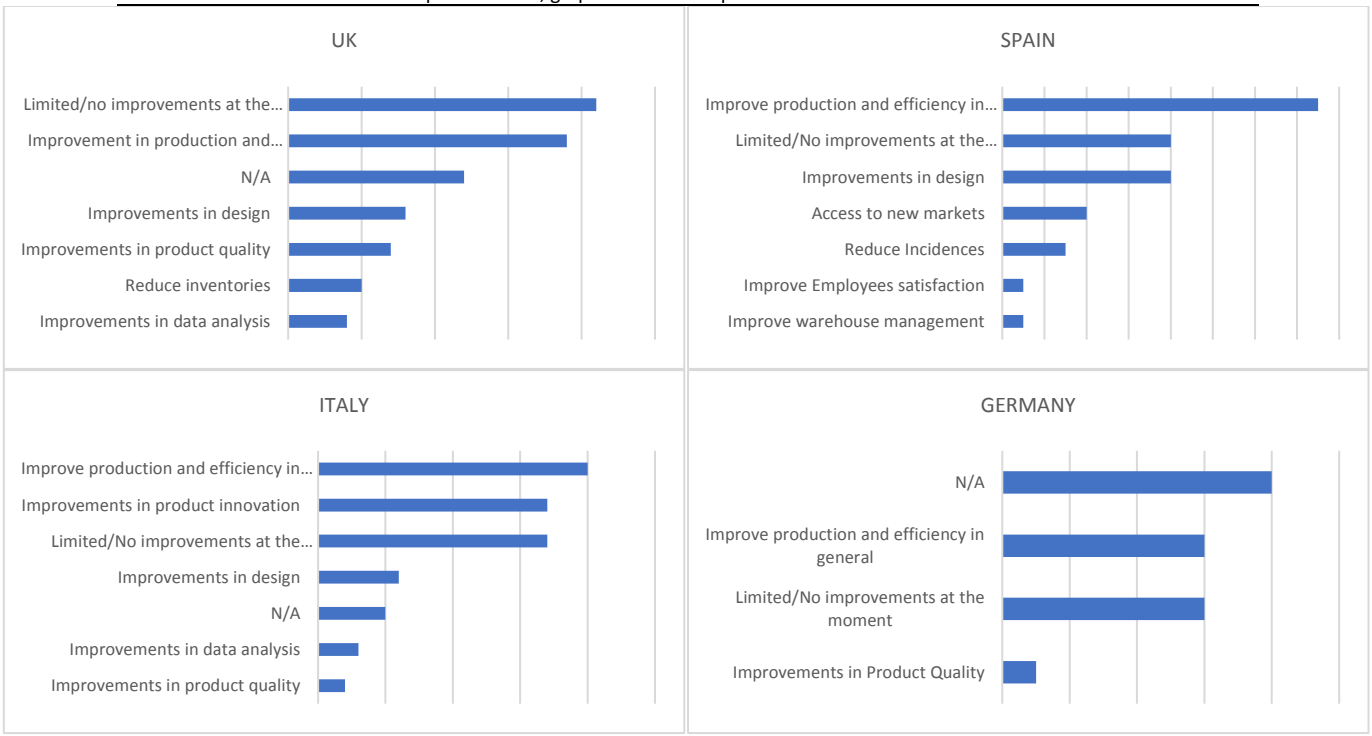
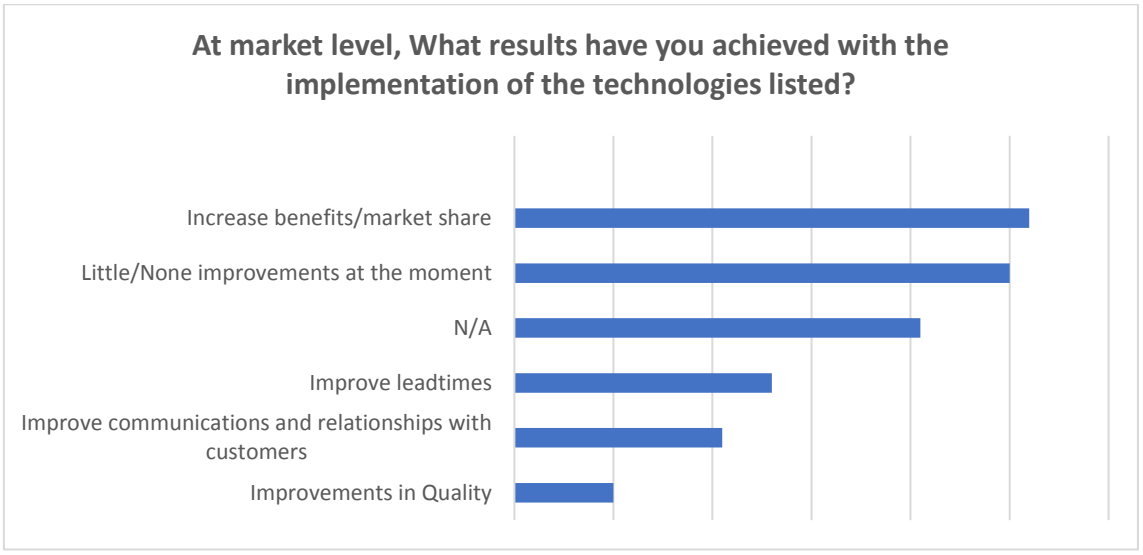


Graphic 17: Results at Innovation Level.



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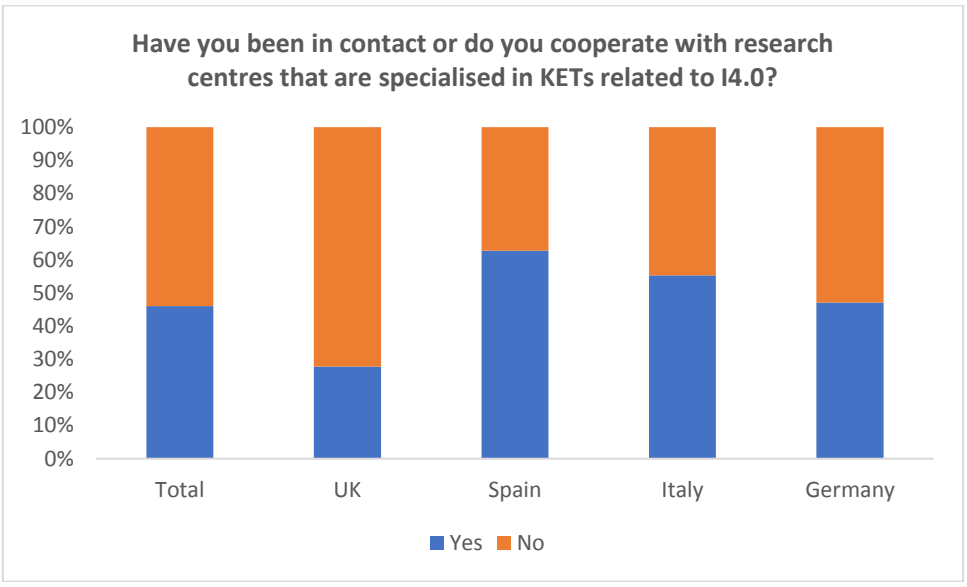
Graphic 18: Results at Market level.

Cooperation with entities specialized in I4.0



Graphic 19: Cooperation with entities specialized in I4.0.

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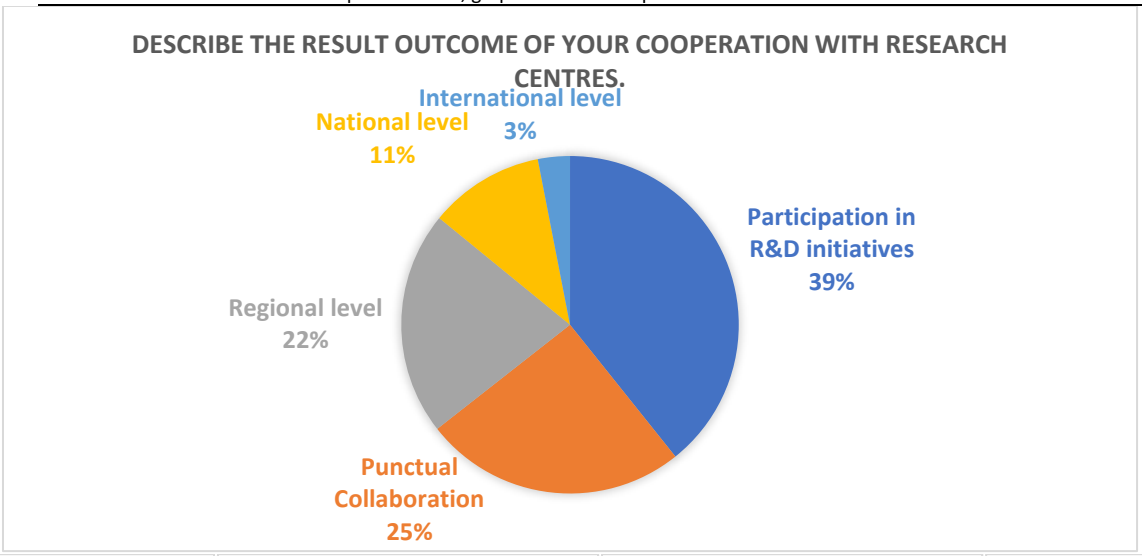
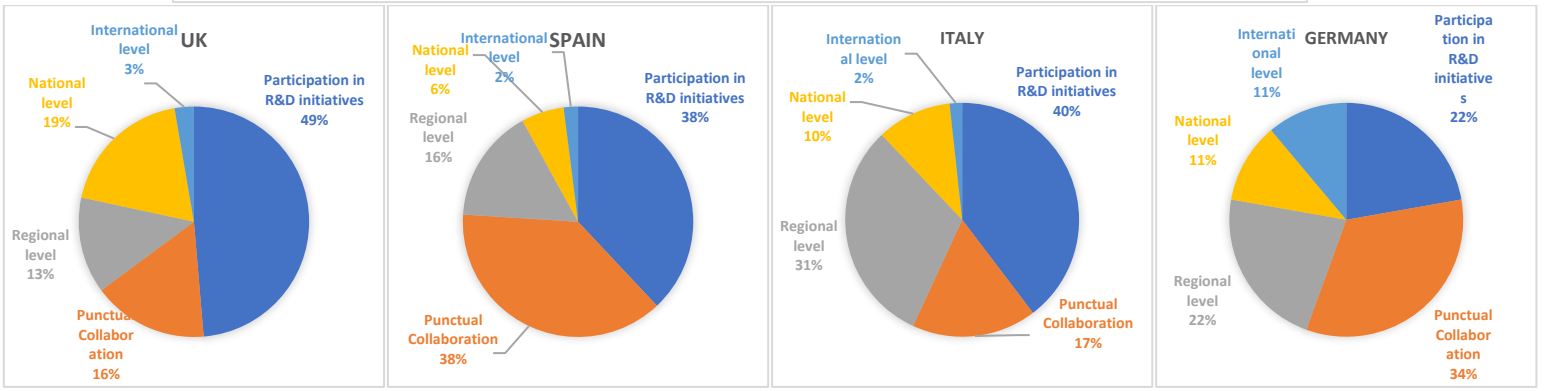
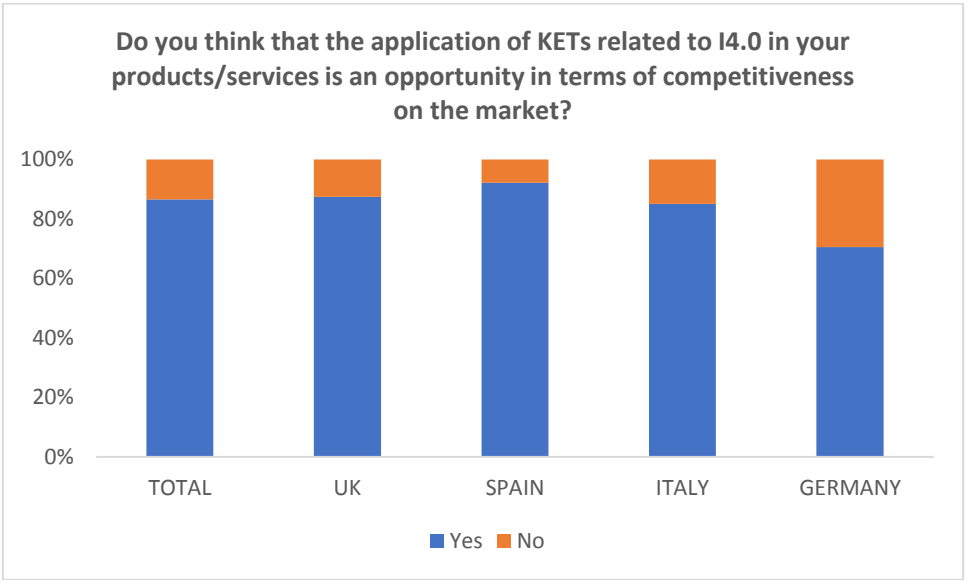




Graphic 20: Types of cooperation between furniture industries and R&D centres.

I4.0 and the competitiveness in the market



Graphic 21: I4.0 and Market Competitiviness.

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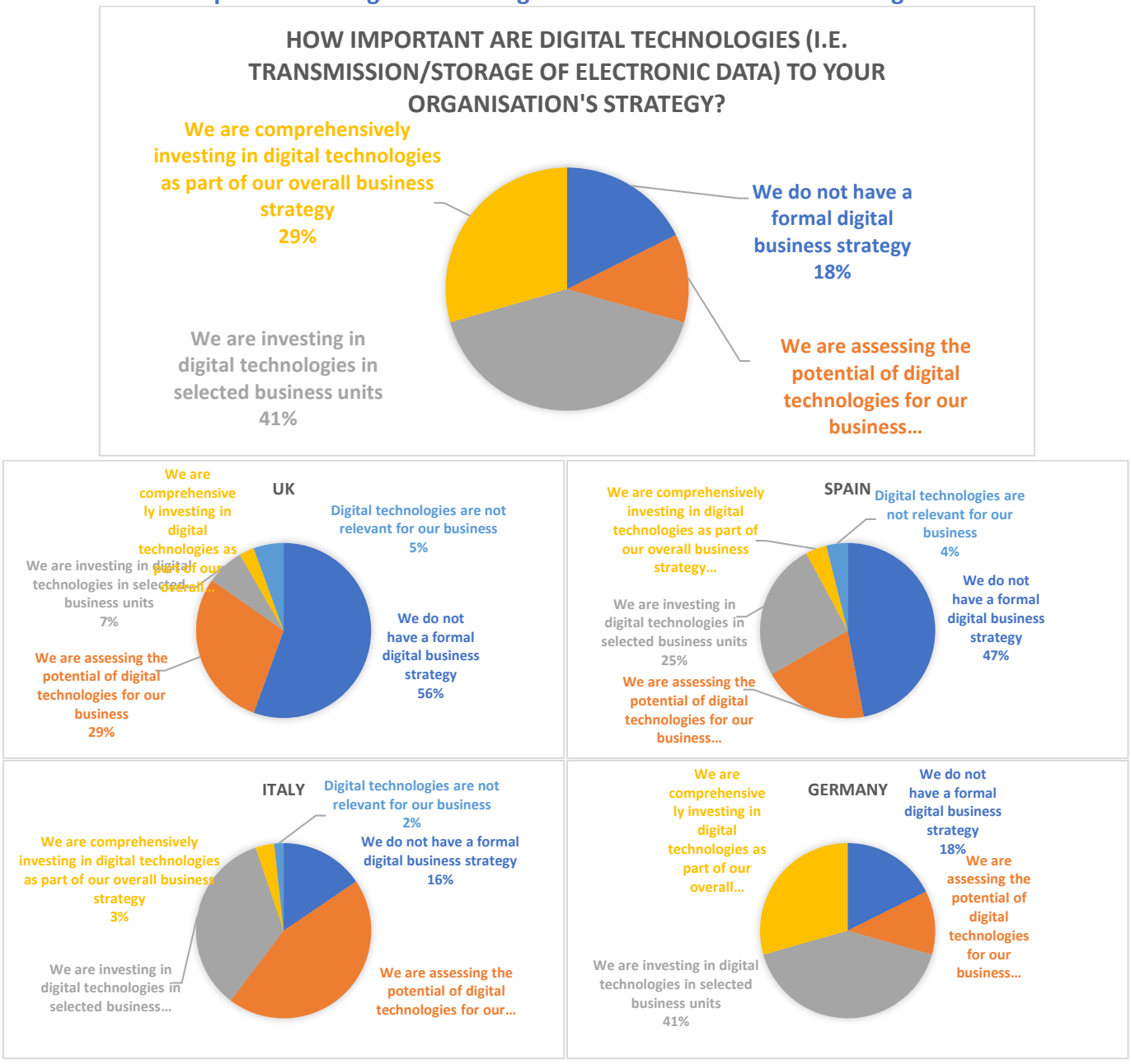
Focus on ICT

The importance of digital technologies in Furniture and Woodworking Industries



Graphic 22: The importance of digital technologies in Furniture and Woodworking Industries.

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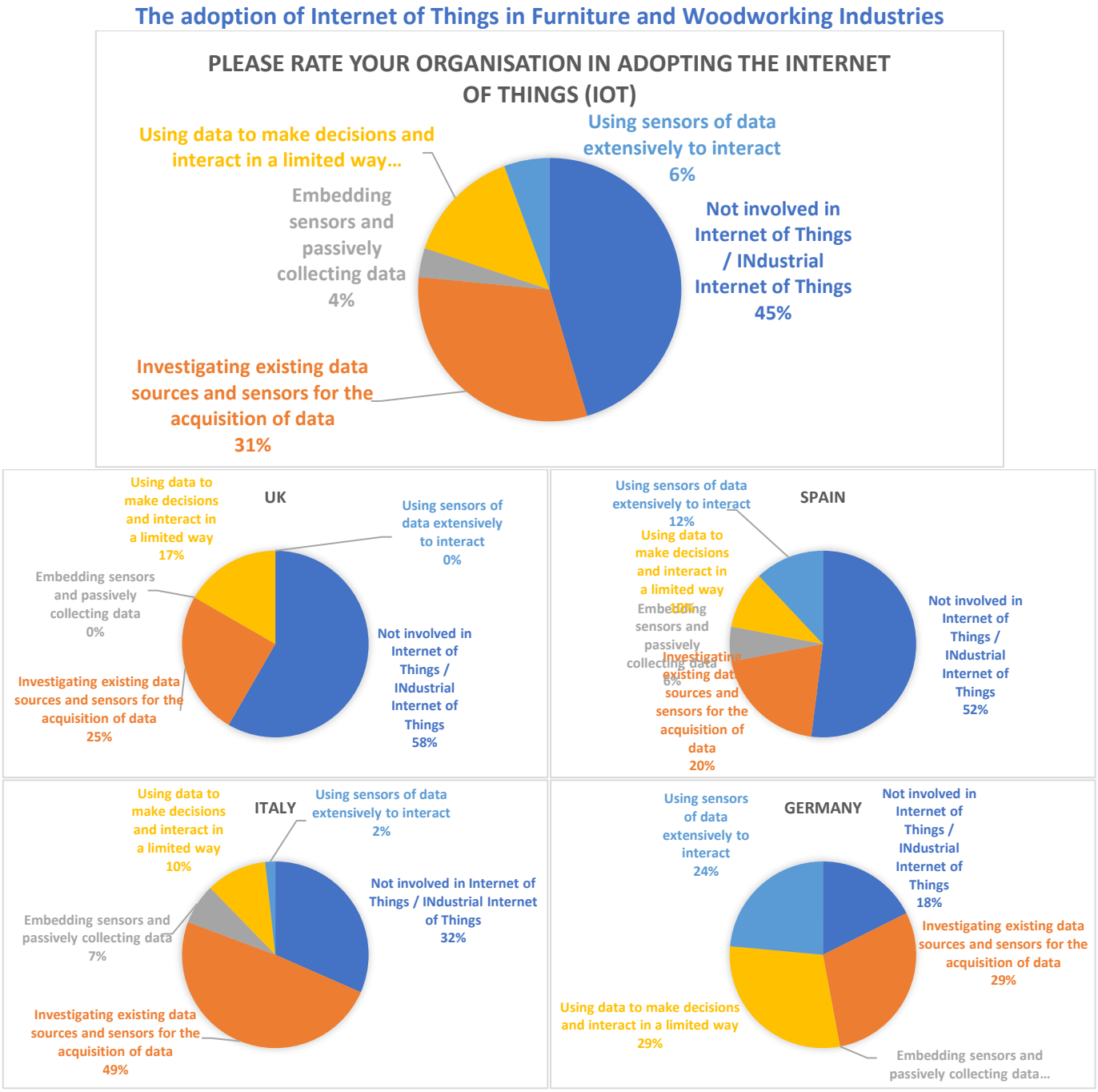

Graphic 23: The adoption of Internet of Things in Furniture and Woodworking Industries.

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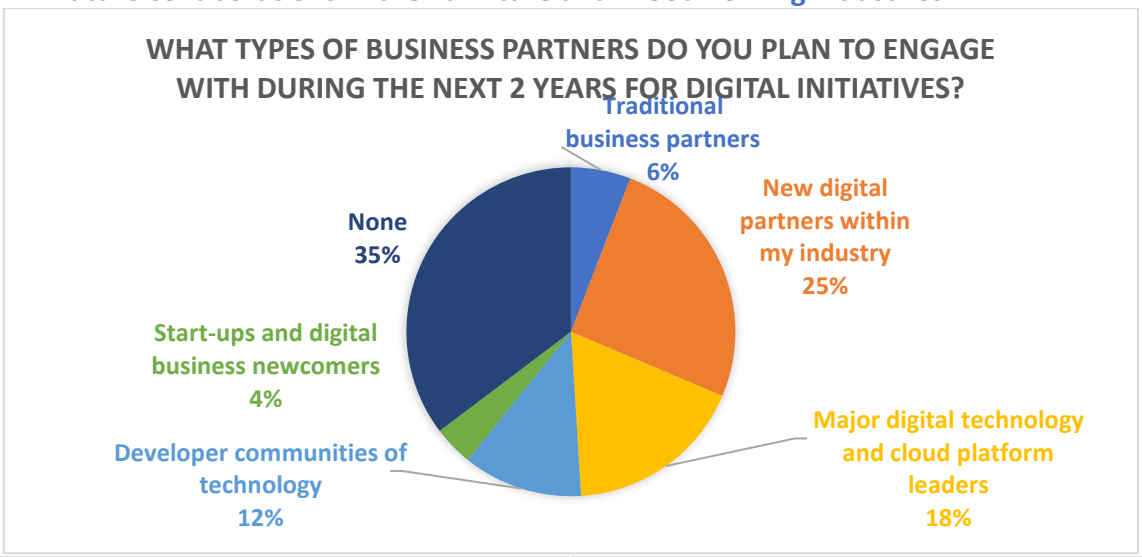
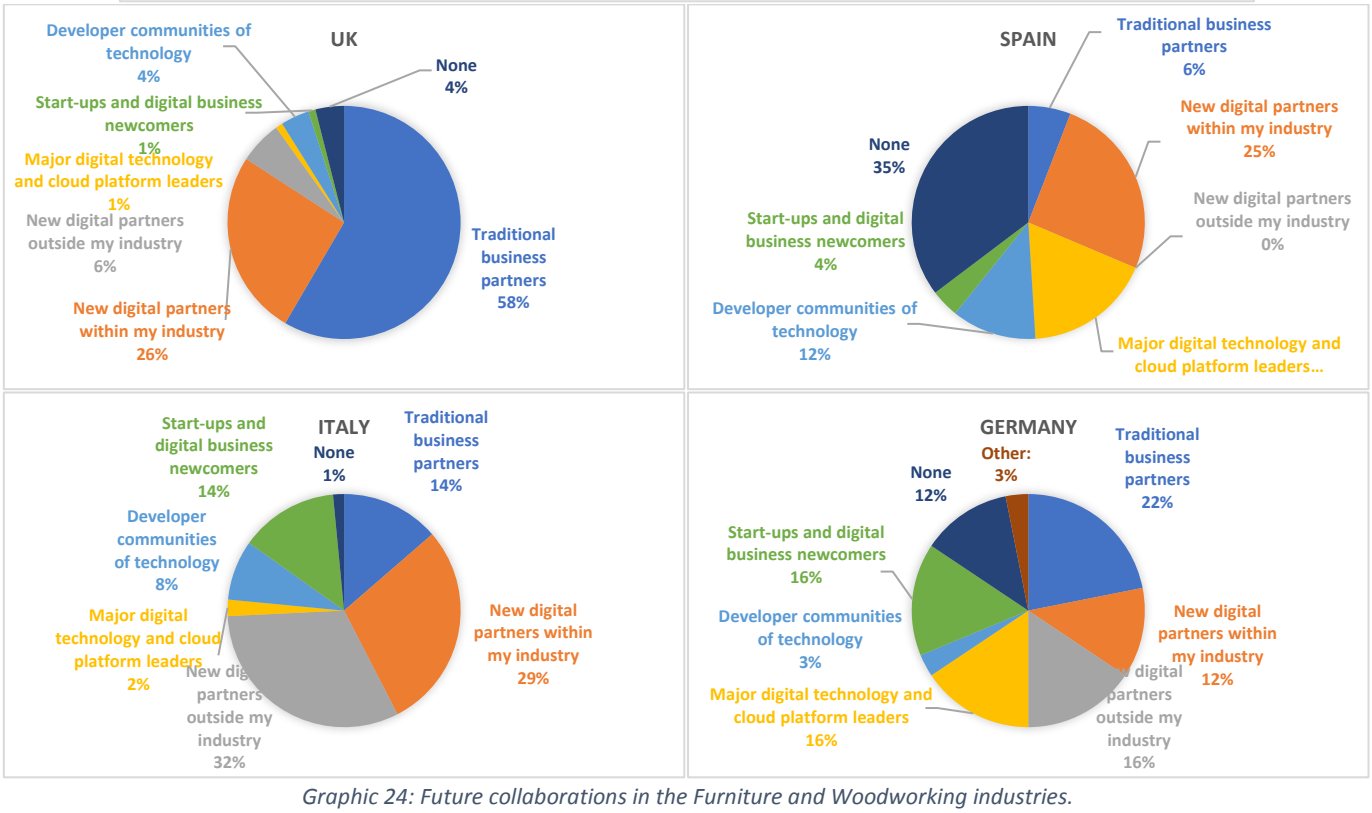
Future collaborations in the Furniture and Woodworking industries





Graphic 24: Future collaborations in the Furniture and Woodworking industries.

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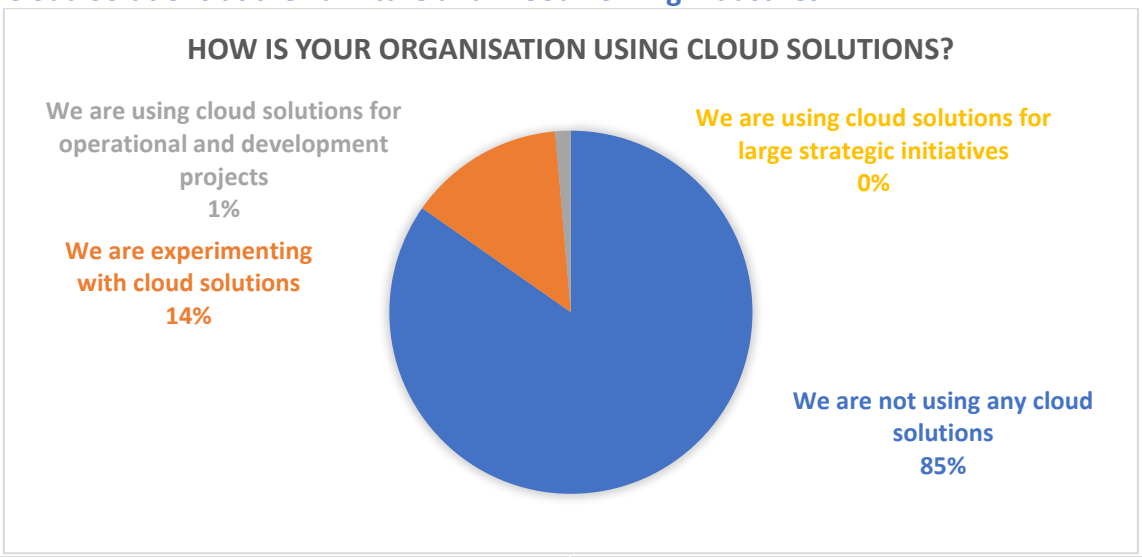
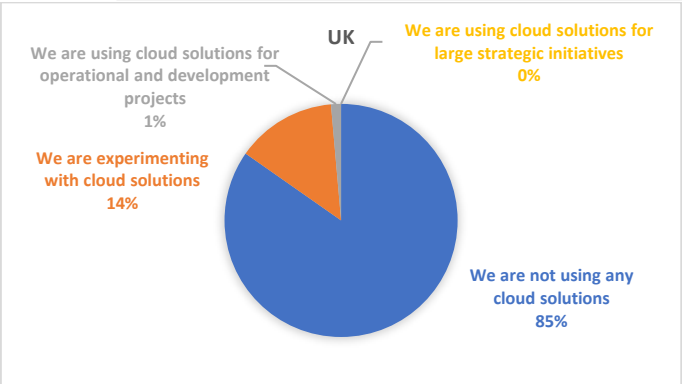
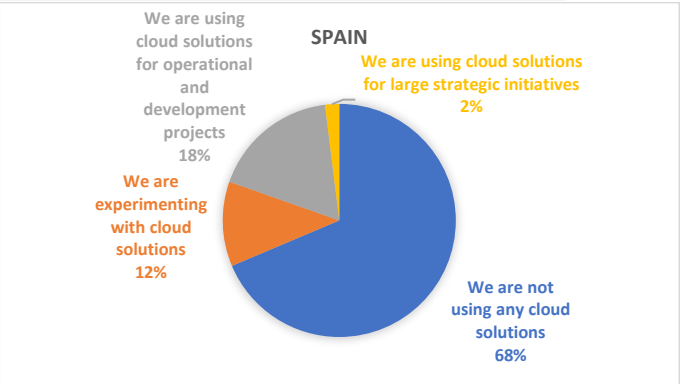
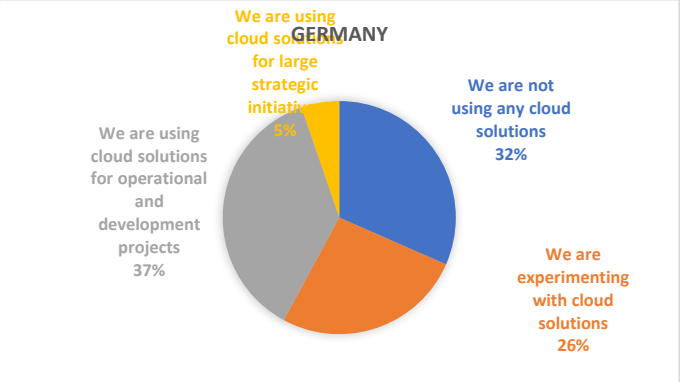
Cloud Solutions at the Furniture and Woodworking Industries









Graphic 25: Cloud Solutions at the Furniture and Woodworking Industries.

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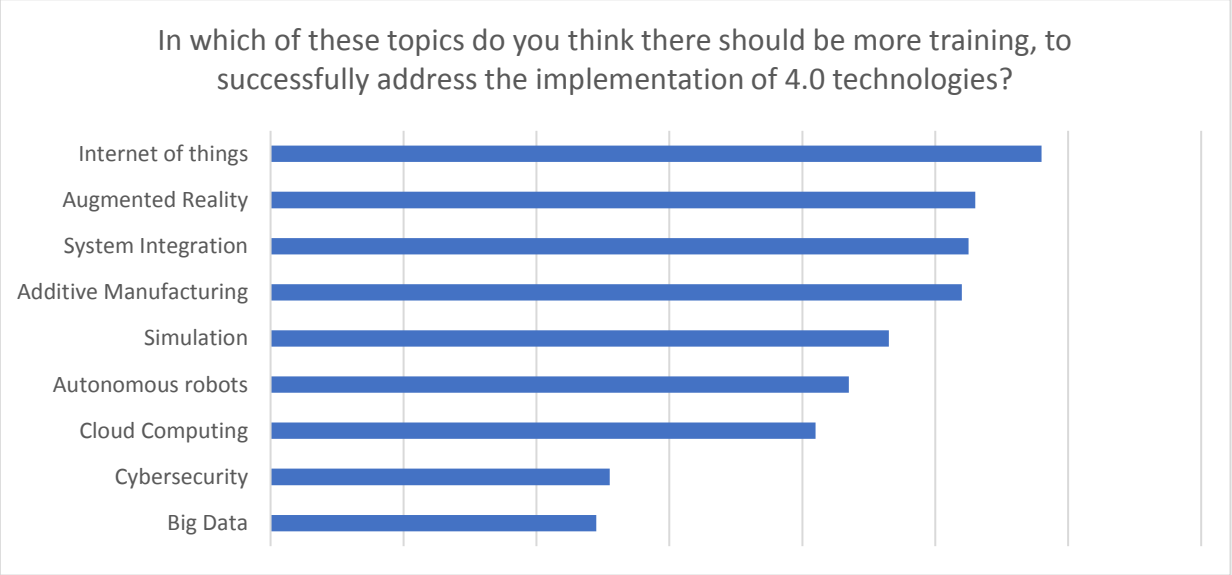
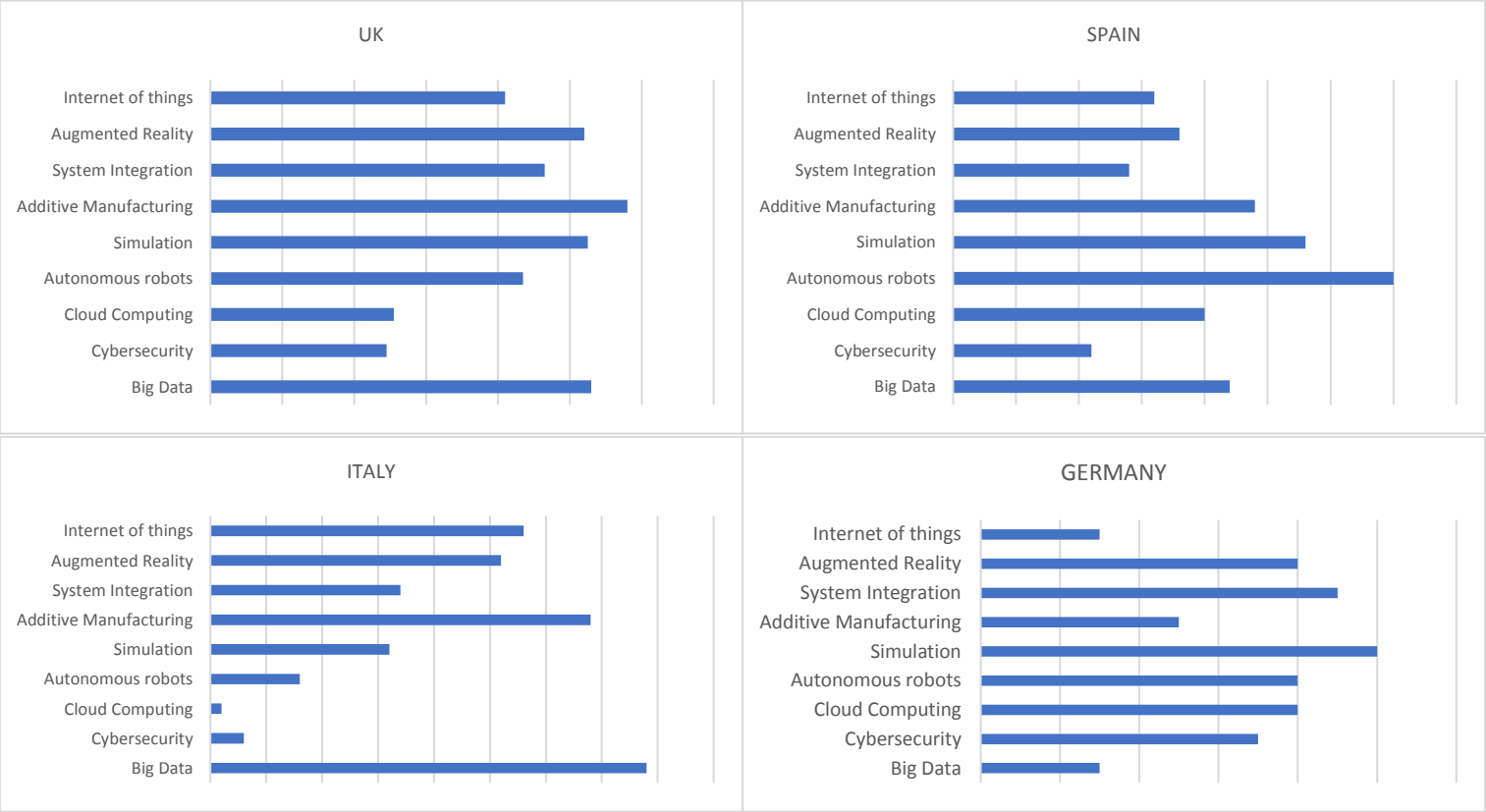
Training topics for the implementation of I4.0 technologies in the furniture industry.





Graphic 26: Training preferences on Industry 4.0 within the furniture and woodworking industries.

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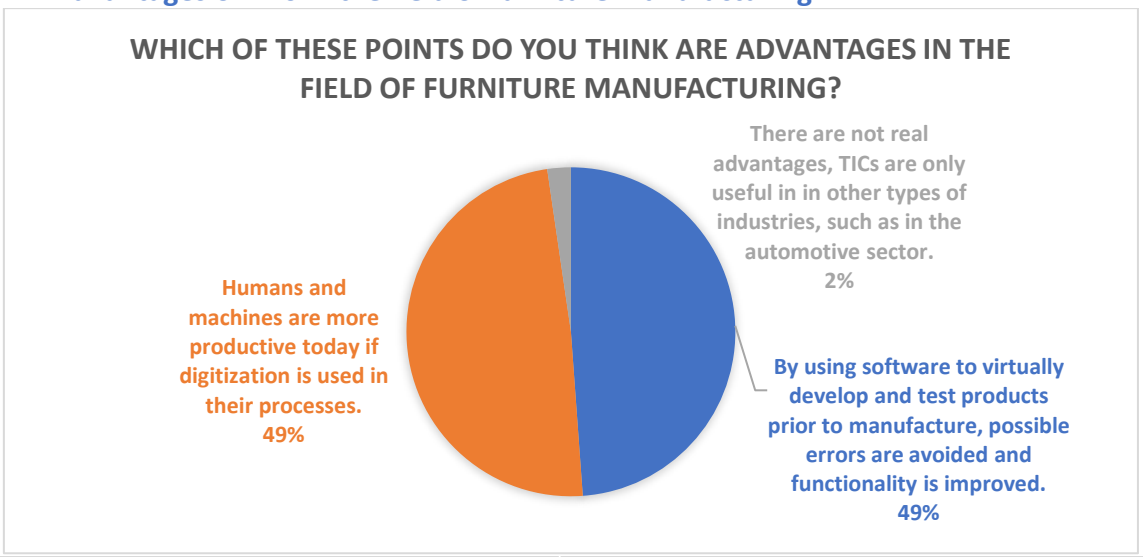
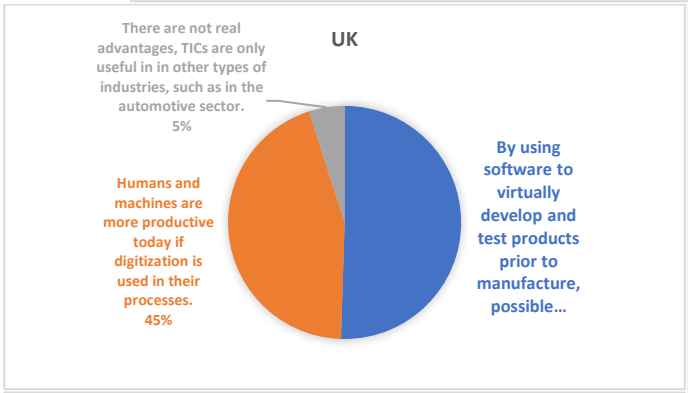
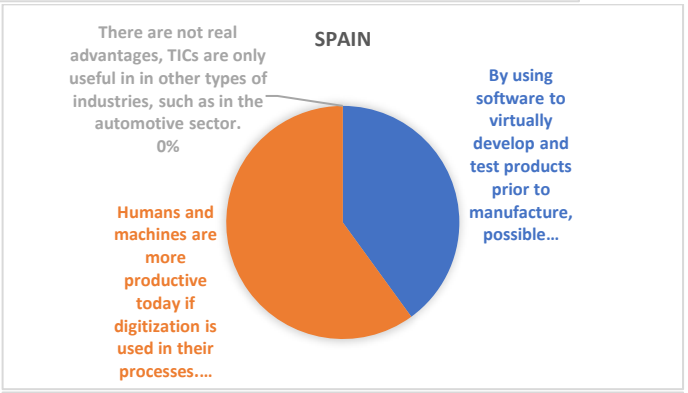
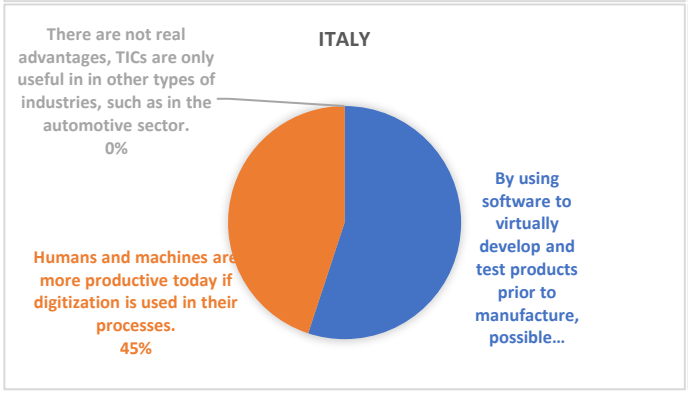
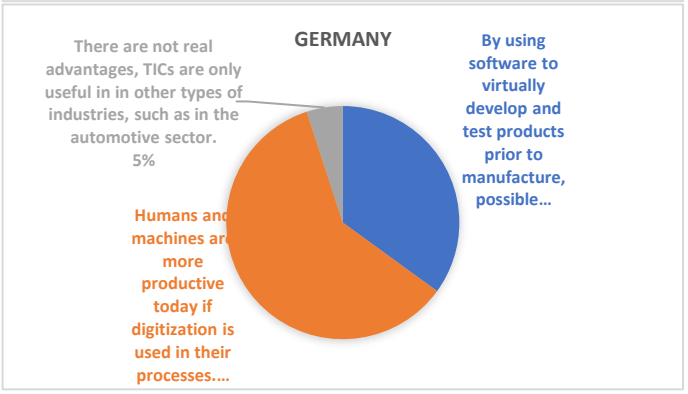
Advantages of I4.0 in the field of furniture manufacturing











Graphic 27: Advantages of I4.0 in the field of furniture manufacturing.

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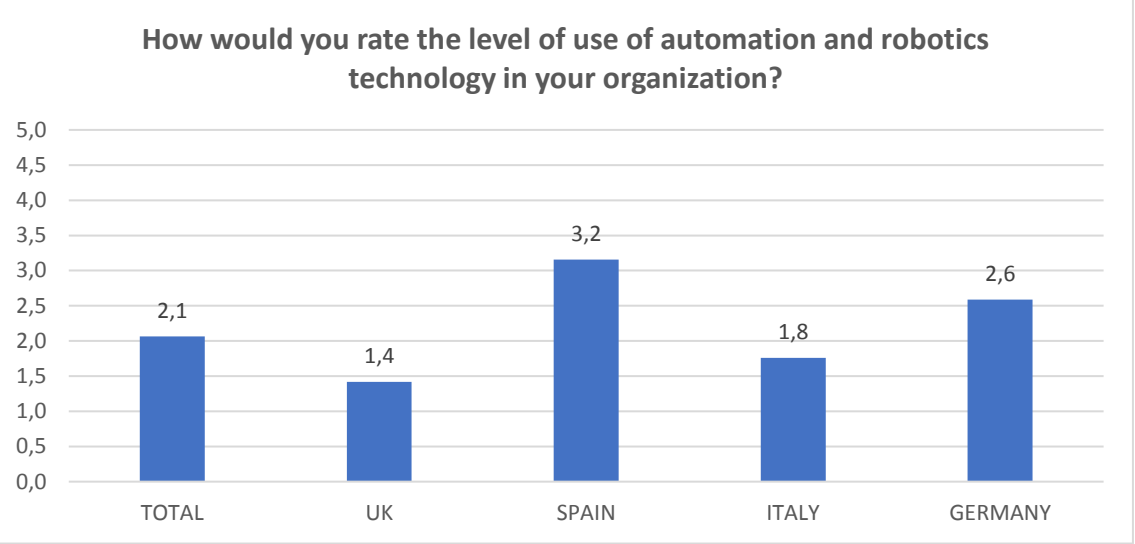
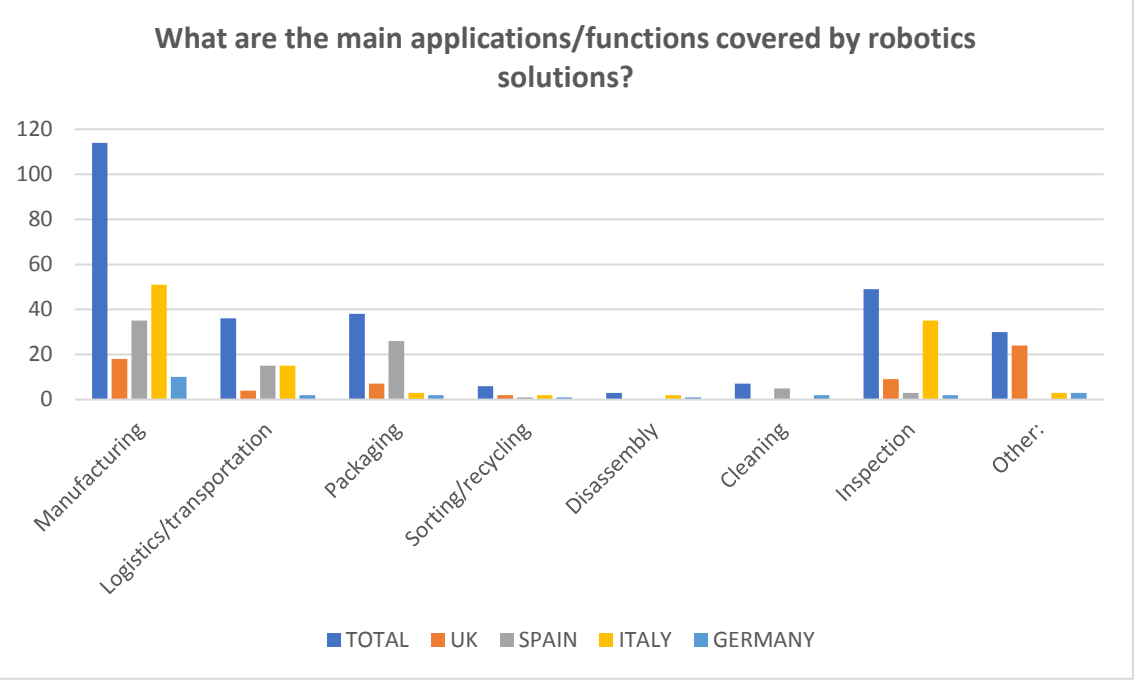
Focus on Robotics

Level of automation and robotics technology in furniture industries



Graphic 28:Level of automation and robotics technology in furniture industries.

The main applications that robotics solutions cover



Graphic 29: The main applications that robotics solutions cover.

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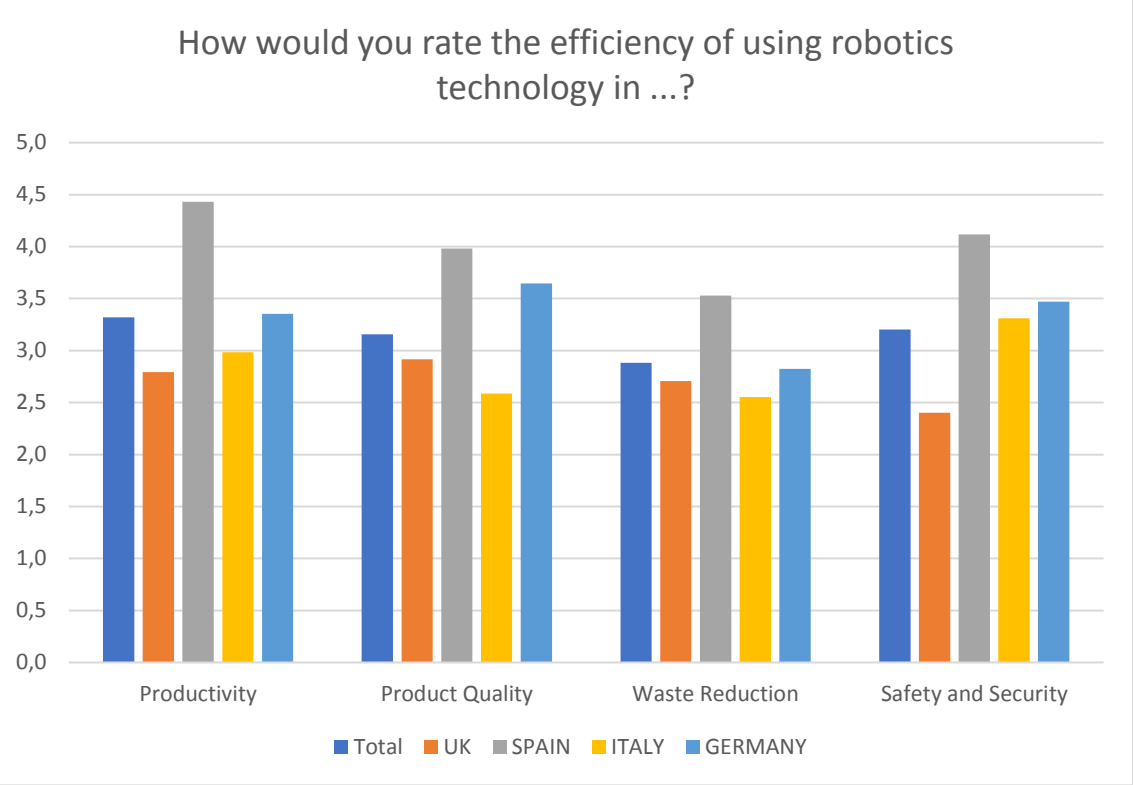
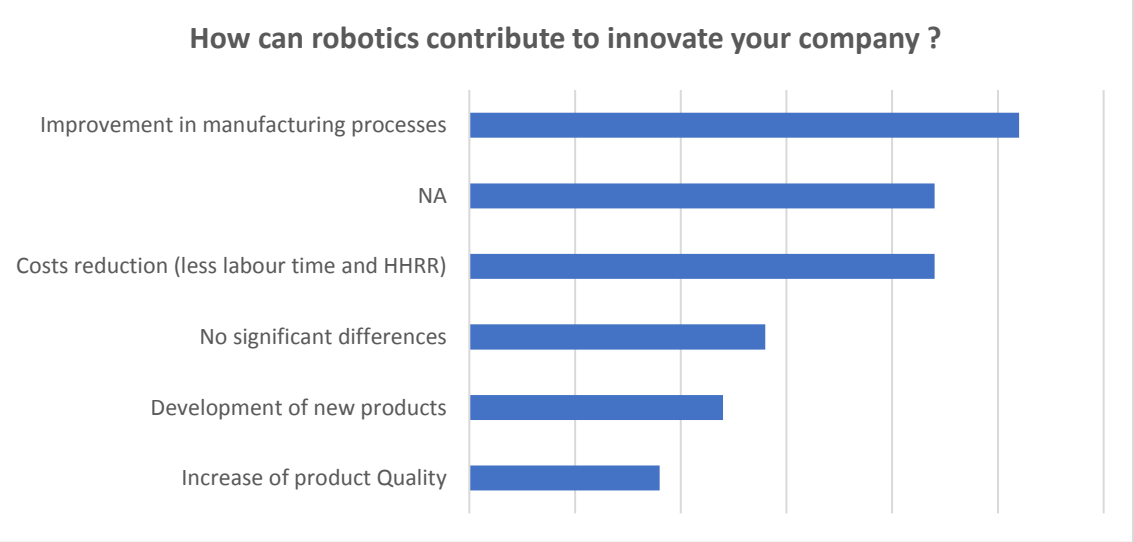
Efficiency of using robotics technology



Graphic 30: Efficiency of using robotics technology.

Robotics and Innovation within the furniture and woodworking industries.



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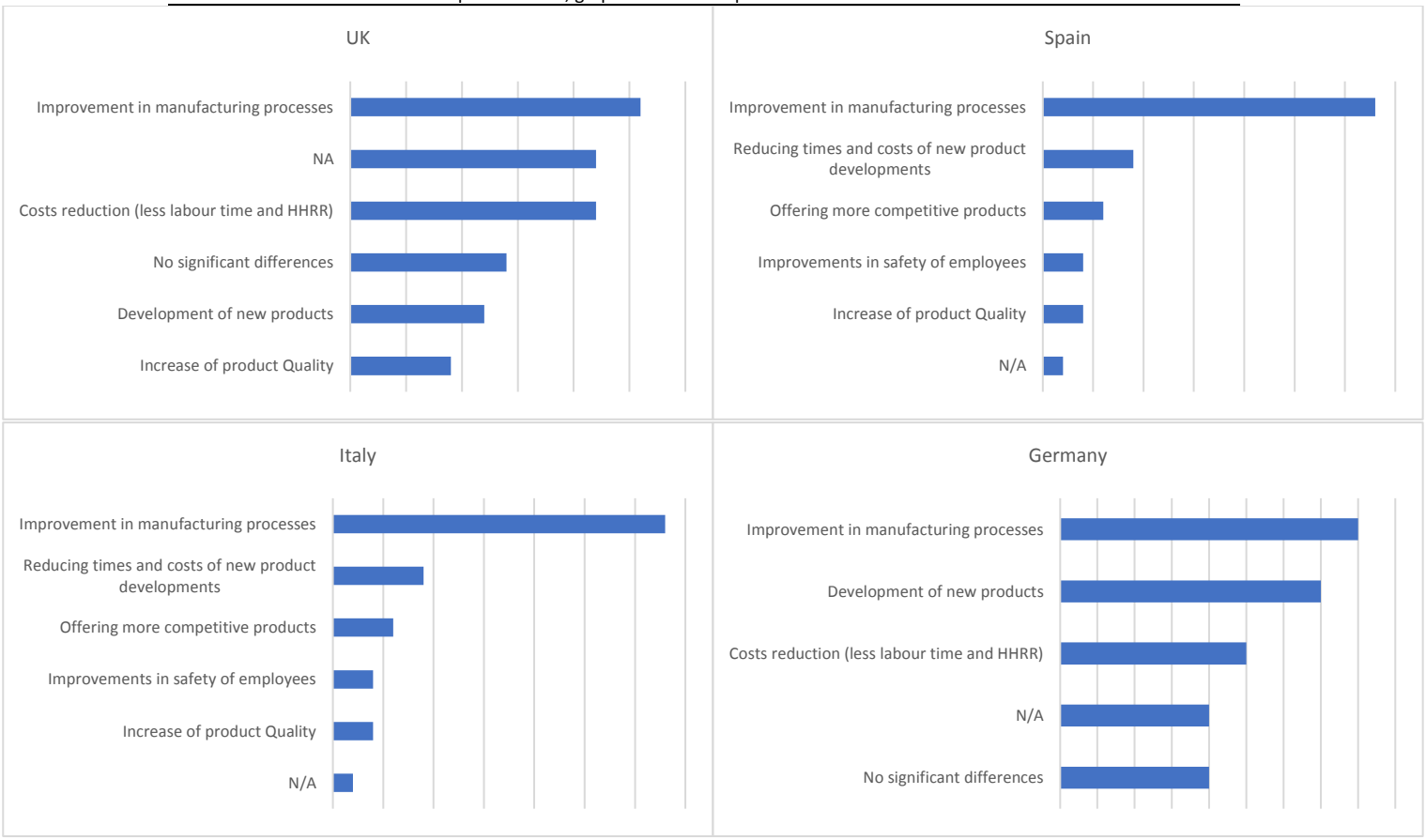
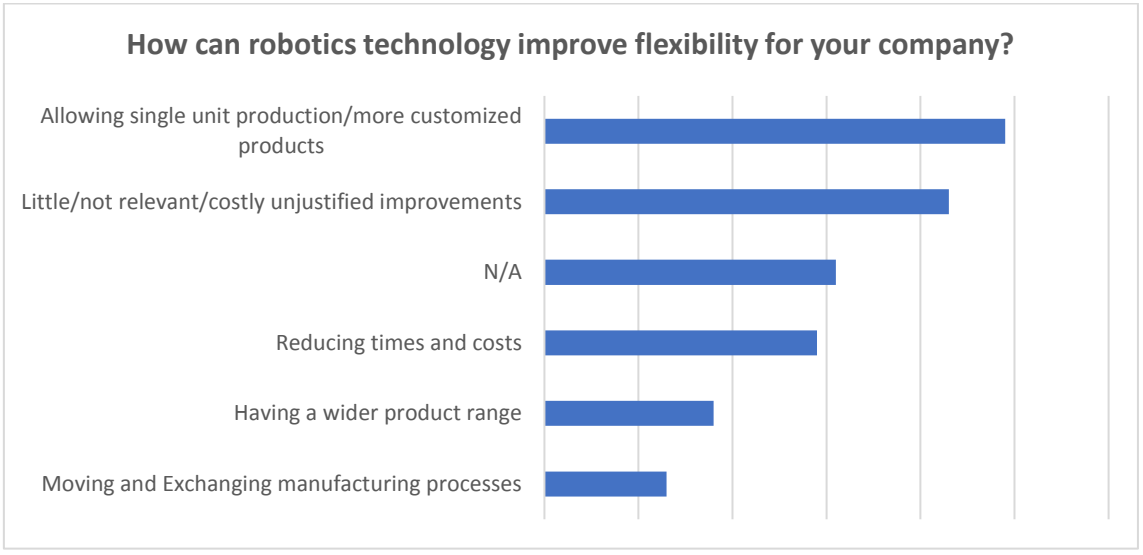


Graphic 31:Robotics and Innovation within the furniture and woodworking industries.

Robotics and Flexibility within the furniture and woodworking industries.



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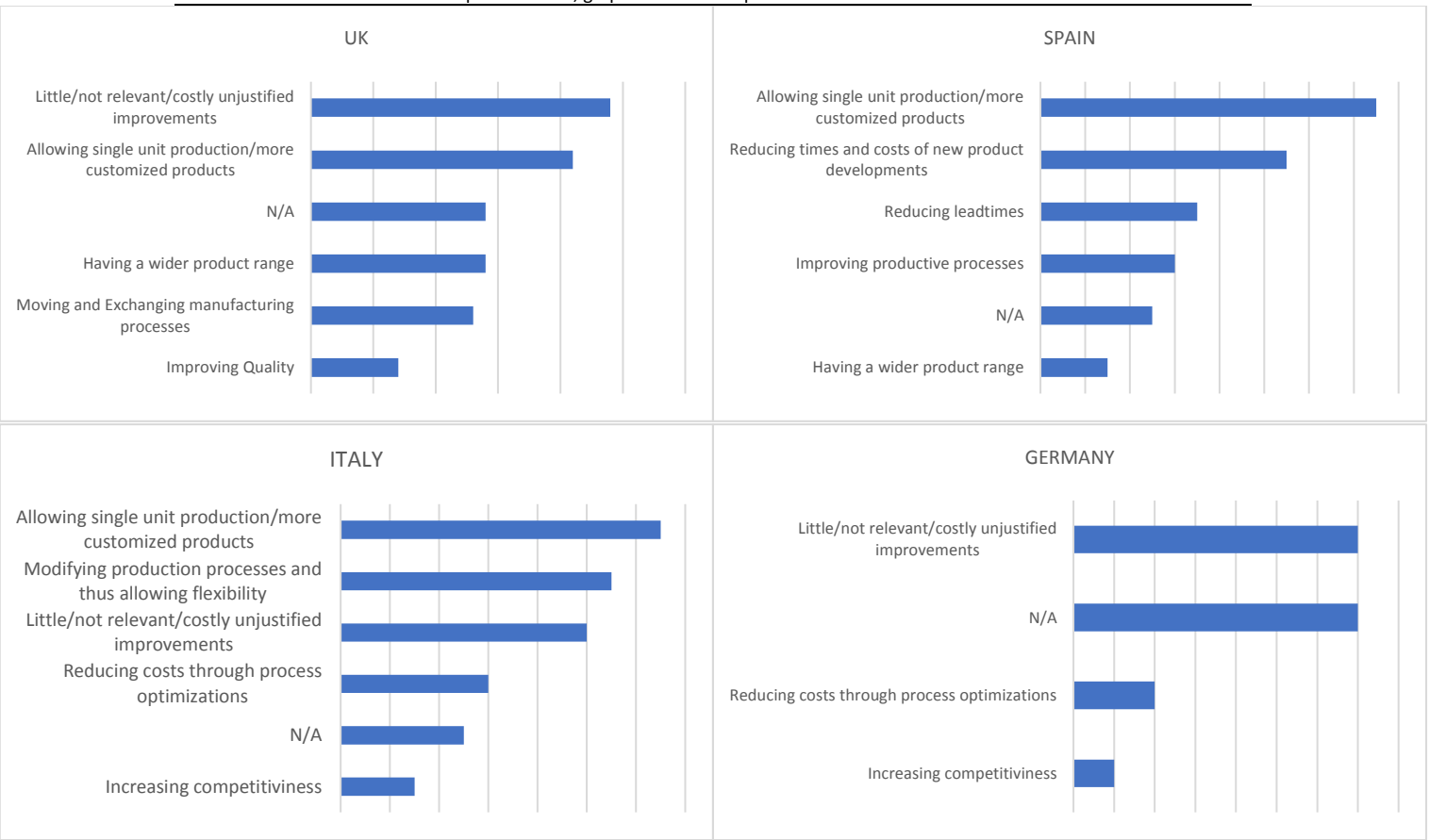
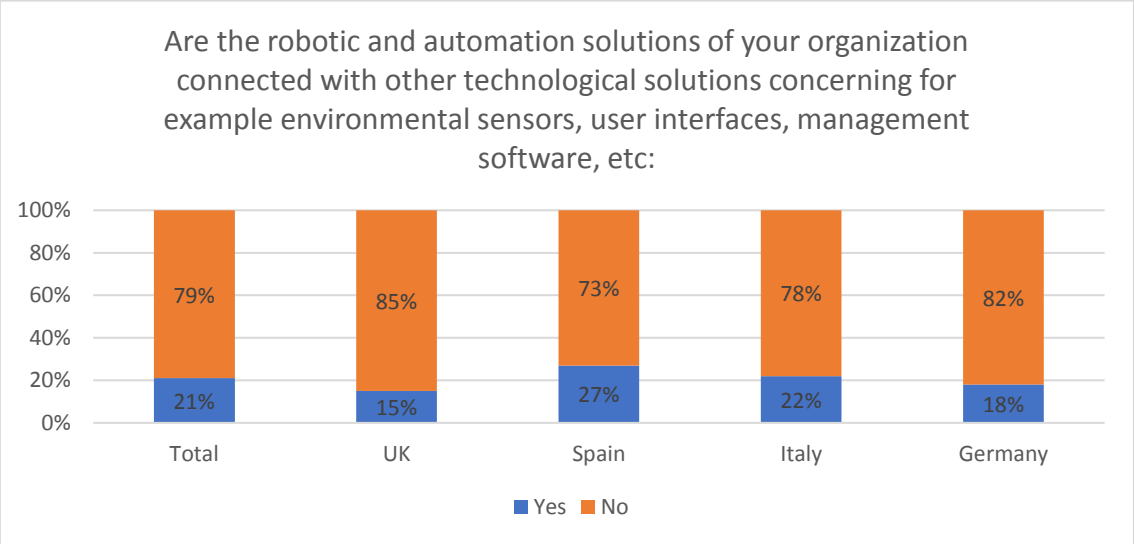


Graphic 32: Robotics and Flexibility within the furniture and woodworking industries.

Robotics and its interconnection with other technological solutions within the furniture and woodworking industries.



Graphic 33:Robotics and its interconnection with other technological solutions within the furniture and woodworking industries.

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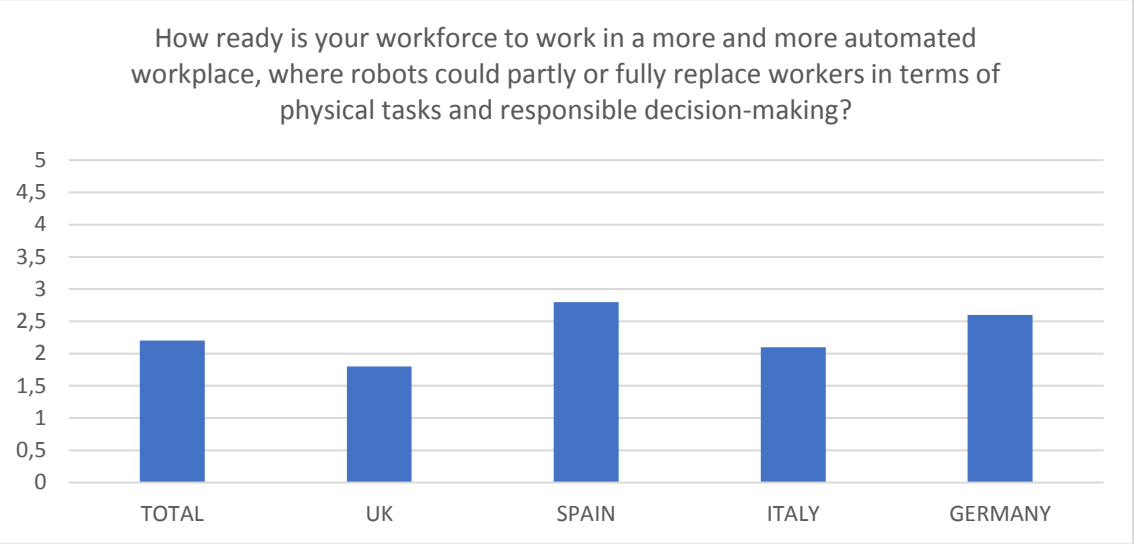
Robotics and workforce readiness within the furniture and woodworking industries.



Graphic 34:Robotics and workforce readiness within the furniture and woodworking industries.

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