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Innovation to Industry – Transferring Knowledge for Smart Ecosystems

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Abstract: Increased competitiveness of European industrial small and medium-sized enterprises (SMEs) requires intensive efforts on mainstreaming and embedding digitalisation and Industry 4.0. Related open innovation and co-creation competences as well as new skills update are seldom fully covered in the wider industry innovation ecosystem. In this paper we present an approach which provides added value to industries in general and SMEs in particular in two main action areas: 1) increasing links among universities, innovation platforms and other companies via collaborative spaces for intensified information sharing and concretisation, and 2) creating innovative concepts and prototypes tested and developed in innovation ecosystems within industry sector. Hence, quadruple helix stakeholders jointly can create demonstration environments for transferring knowledge for innovation through hands-on experimentation. The approach we describe offers a set of tools accelerating the deployment and application of innovative processes into industry in order to leverage competitiveness, ameliorate employability and manage innovation.

Keywords: Open innovation; innovation management; SME; competitiveness; employability; co-creation; innovation ecosystem; collaborative spaces; demonstration environments; knowledge transfer.

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1 Introduction

Increased competitiveness in European industrial small and medium-sized enterprises (SMEs) requires intensive efforts on mainstreaming and embedding digitalisation and Industry 4.0 (COM(2021) 118 Final); (COM(2021) 350 final). For many companies, especially SMEs, it is difficult to follow the pace of emerging technologies and innovative concepts which are being created, new ones appearing at continously increasing speed and with growing complexity. However, it is clear that many of these new trends could serve the SMEs to be better positioned in the market by accelerating the incorporation of new technologies in the process and product manufacturing cycles such as logistics, marketing, prototyping, etc. Industry 4.0 popularization among SMEs calls for important and intensive efforts in innovation management. Simultaneously, there is a need to open doors towards new mindsets which incorporate topics like green manufacturing, sustainability and responsibility, innovation management and commercialization, and intellectual property rigths. Therefore, it is essential to invest on people and the competences not sufficiently covered in industry innovation ecosystems: to increase open innovation, innovation management and co-creation capabilities as well as leverage new skills update and upgrade,

Innovation platforms in different forms (e.g. incubators, science and technology parks, FABLABs, entrepreneurs' hubs, Do It Yourself - DIY communities) are common in higher education institutions (HEIs) and, recently, they are also established and growing in other sectors of the society as non-profit organizations. Especially in the field of technology and engineering, the aforementioned platforms are seen mainly only as a complementary place where higher education students in the field of technology, design, innovation and engineering can create and develop their ideas and potentially turn them into business. Traditionally, these places are oriented towards two main audiences external to the universities themselves, namely entrepreneurs and hobbyists.

It is common that the adapted skills and competences developed during the participation in the activities within innovation platforms are not usually directly related to the labor market, except for the successful entrepreneurs, which are a minority. However, many of the activities led by innovation platforms together with higher education institutions (HEIs) can serve to train skilled workforce of existing companies and SMEs. In this way, they can support businesses, especially SME,s in their neccesary evolution to survive in the worldwide market. Innovation platforms facilitate them to take part in the smart ecosystems by taking advantage of services in the Cloud and other opportunities coming from the digital world.

Nowadays, it is commonly accepted that disruptive technologies will have a big impact in the future society such as Cloud systems, 3D printing, robotics, renewable technologies, automation of knowledge work, advance materials, advance genomics, and so on (McKinsey Global Institute, 2013). In parallel, a reformulation of traditional businesses is paving the way towards disruptive business models which are in turn powered by disruptive innovation and highly linked to disruptive technologies. This constitutes a disruptive loop or smart ecosystem composed of technology, business and innovation where new opportunities emerge. If not equipped with adequate knowledge and

competences, a wide number of companies (especially SMEs) may be risking their position in the market in the mid or in the long term.

This paper describes how innovation platforms and HEIs can support SMEs by providing different services supporting the acquisition of new competences and skills. These include e.g. change of mindset, new knowledge and innovation management capabilities, and creative ways of thinking regarding product development, fabrication, design. Specifically, this paper describes activities implemented in two scenarios in two countries: In Tampere University of Applied Sciences (TAMK) in Finland, and University of Valencia (UV) in Valencia, Spain. We will describe some of the similarities but also differences stemming from different geographical, structural and cultural operational environments, including the higher education institutions themselves and their surrounding innovation ecosystem landscapes.

In Section 2 of this paper, we give general insights into the state of the art of innovation platforms in smart ecosystems and the positions of different stakeholders involved. Section 3 describes ways how to facilitate innovation and knowledge transfer in industry. In Section 4 we discuss the implications, common development grounds and results originated by the collaboration so far. Finally, Section 5 briefly concludes the main takeaways from our experiences.

2 Insights into innovation platforms in smart ecosystems

In order to encourage and train individuals to take part in smart ecosystems, the first question we must address is how traditional education and training models and institutions can provide learning tools valid for the current and future changes to come. Currently, the reality shows that higher education institutions can hardly incorporate those new trends into their curricula. Traditional curricula are considered fully completed with contents considered as ‘essential’ for being the ground foundations of further professional skills and growth. This applies to many fields of knowledge, but it often appears to be highlighted especially in science&technology and business.

Being conscious of the growing gap between regular, traditional higher education studies and societal, econcomical and environmental needs, higher education institutions have created highly focused degree programmes. Furthermore, HEIs have included new units, facilities and extra-curricular activities as part of their service offering. These are often generally designated as innovation platforms or research and innovation infrastructures. In the framework of these new structures, those individuals interested in getting additional training have the possibility to participate in multiple activities in the form of extracurricular courses, working groups, multidisciplinary project-based activities, entrepreneurial and startup creation support, and many others. These actions can be designated in multiple forms depending on the institution. It is important to integrate especially the thematics related to disruptive trends and smart ecosystems.

Furthermore, the above mentioned topics should be addressed from a cross-disciplinary viewpoint, simultaneously ensuring that the most active teaching staff and motivated students can take part. Improved knowledge, competences and skills acquired during the

university studies and life-long learning activities, completed with participation in innovation platforms, has proven to increase employability. This operation contributes in creating highly trained individuals ready to be part, and even be the catalizators, of the society transformation towards the disruptive trends. The potential impact in society is devised as a key issue now, which is also evident in the fact that various institutions such as companies, local and regional authorities, and non-governmental organizations (NGO) have also created their own innovation platforms.

Specialized work force trained in HEIs and completing skills and comptences in innovation platforms is, however, not always getting enough attention among some of the main potential beneficiaries. For example, SMEs are often not aware of the benefits they can get by hiring those individuals ready to transform the company for long term sustainability of the business. Fortunately, though, many success stories are also occurring every day, giving evidence for positive benchmarking. There are, however, at least a couple of common assumptions that companies, especially SMEs, should overcome in order to take full advantage of the existing innovation platforms, e.g.:

- Lack of knowledge about how companies can benefit from innovation platform activities and services in practice.
- Conception that innovation platforms are only for students and entrepreneurs willing to create their own business, not for an existing company to incorporate innovations and competences related to their management.
- Impression of high required investment from companies' side.
- Lack of knowledge regarding accessibility of innovation platforms and related services hosted by higher education institutions.

There is a strong need to build a bridge between industry needs and activities developed in HEIs and innovation platforms. Therefore, a deep analysis of current conception of innovation platforms must be done. It is common that skills mismatches and gaps exist between activities and knowledge obtained in HEIs and innovation platforms, and those required by industry. In some sense, it is true that a strong push on entrepreneurial activities is provided by innovation platforms, not always in line with companies' needs. Nevertheless, it is also true that most of the concepts, knowledge and skills could be applied to industry with an adequate transformation.

In practice, companies, and especially SME's, are struggling to reach the current megatrends and modernization guidelines. However, they are often not able to find the right tools or places where they can get adequate support. Numerous sources of information, organisations and people involved in and developing innovation processes at all levels (management, business concepts, commercialization, manufacturing, logistics, etc.) exist. Commonly, even in the same organisations such as large HEIs, multiple actors are dedicated to related topics of innovation management support without knowledge of each other, creating relevant documentation, organising activities and support, etc. In this jungle, an external potential customer such as a company or SME might find it difficult to identify the right service or establishment who would be able to provide a solution to their needs.

3 How to facilitate innovation and knowledge transfer for industry

General framework for Innovation to Industry approach

With the current landscape of the innovation activities presented, the work described in this paper shows an example how two universities from two different EU Member States, individually and in mutual cooperation, are supporting industry to facilitate innovation management and knowledge transfer. Our approach has two main goals: 1) to provide companies (especially SMEs) with training and tools towards efficient and effective innovation, and 2) increase students' and professionals' innovation management capabilities, knowledge, skills and proactive mindset to ensure that they can be able to take part or lead the transformative change of companies.

Tampere University of Applied Sciences (TAMK) and University of Valencia (UV) have designed an approach that aims at providing better access to HEI's innovation infrastructures and platforms. It also offers more accessible information about the capabilities of HEIs and their innovation platforms to support industries in general, and SMEs in particular, in two main actuation areas: 1) Increasing links among universities, innovation platforms and companies via collaborative places for intensified information sharing and concretisation, and 2) Creating innovative concepts and prototypes tested and developed in innovation ecosystems within industry sector.

This approach provides tools to accelerate the application of innovative processes into industry, focused on the innovative processes that are considered as key elements for industries to adapt to future megatrends. These trends include e.g. increasing competitiveness by research, development and innovation (R+D+I), reducing waste and energy consumption, increasing safety and wellness of workers, reduce equipment maintenance and associated expenses, increase employability and manage generated knowledge. The concept fits perfectly in the framework of the quadruple and quintaple helix models developed by Leydesdorff (2012) and Carayannis et al. (2016).

TAMK's efforts emphasises the renewal and implementation of an agile process for co-creation and open innovation targeting high impact and genuine knowledge transfer among collaborating partners. The process exploits the benefits of co-creative Living Lab approach and the Knowledge Transfer Charter (KTC) developed and utilised in TAMK (Puurtinen et al., 2020; Siivonen et al., 2021). The main aim is to achieve sustainable value-based innovation management outcomes for the benefit of the whole smart industry ecosystem.

The design effort of the approach at UV is mainly focusing on fruitful collaboration with industrial companies in the area of influence where UV is located. The approach allows to detect the main needs and design a specific environment for smart ecosystems with a main aim to increase their level of autonomous research, development and innovation capabilities by using new disruptive technologies, mainly related to Industry 4.0.

Both institutions, TAMK and UV, have adopted their own specificities of the approach in order to target the characteristics of each institution. In this way, the local characteristics of the surrounding landscape of social, economic and industrial sectors are taken into account. In addition, both of the partners involved have oriented their individual

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approaches towards common goals and development needs to design a model which can be applied transnationally and in several contextual environments.

Platform to support innovation transfer pathway – TAMK

At Tampere University of Applied Sciences, the main place for co-creation and innovation support in the field of Industry 4.0 is TAMK FieldLab (https://sites.tuni.fi/fieldlab/). It is a testbed and innovation environment for Industry 4.0 related themes. TAMK FieldLab focuses on increasing links and promoting open innovation among universities, innovation platforms and companies via collaborative places. It serves as an important enabler for TAMK's endeavour to create and implement a transparent customer pathway for TAMK FieldLab. This activity is part of the Sustainable Industry X (SIX) initiative and constitutes an element to formulate *Test before invest* services in our European Digital Innovation Hub (EDIH). The main goal of SIX will be to support Finnish manufacturing SMEs and midcaps on their journey towards a sustainable, digital and responsible industry.

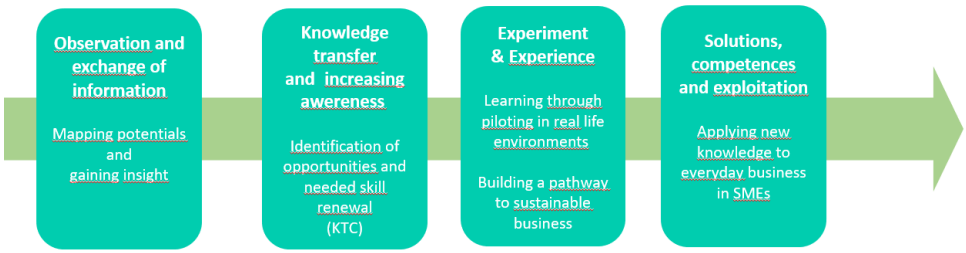

Figure 1 TAMK FieldLab Customer Pathway for SIX

The customer pathway depicted in Figure 1 provides an easy access to TAMK FieldLab for the external users such as companies, SMEs, public sector, entrepreneurs, hobbyists. It offers customer-oriented and co-creative guidance throughout the innovation and commercialisation pathway to gain optimal results for their innovations supported and facilitated by TAMK FieldLab infrastructure and its services.

Well-designed customer pathway together with Knowledge Transfer Charter process enables industrial companies and other users to create and test innovative new concepts and concrete prototypes in hands-on industry-like environment. Simultaneously, each organisation learns from the experiences, builds new competences, and maps potential business or use cases from piloted innovations. In addition, collaborators gain insight into possible further co-operation and growth targeting e.g., towards European funding and investments.

An example of a concrete case is *Ultrafast real-time control for additive manufacturing*, a project funded by Business Finland. The focus is to find interested companies to utilise and exploit the possibilities of industrial 5G-technology in their field of business and, in this way, enable their international growth. The selected concrete pilot application in the project is large-scale 3D-printed bio-composite parts. These 3D-printed parts are post-processed with a metal coating utilising cold spray process, i.e., a metallised thin surface is applied on designed areas such as functionally critical or decorative surfaces. Demonstration and pilot environment is set up in TAMK FieldLab environment for companies involved, which hereby gain real experience and ideas for innovation and business. As an additional benefit, they can build new business partnerships across traditional industry sectors such as 5G technologies and additive manufacturing.

Integrated approach to enhance university-industry collaboration – UV

At the University of Valencia, innovation transfer knowledge is mainly focused on increasing the technical capacities of companies in the region (mostly, SMEs). This goal was established after an analysis of the usual demands of the companies reaching the innovation platforms and related technological departments and R+D institutes.

Specifically, the main gap for most of the SMEs in the industrial sector was related to the creation of innovation departments (in some cases, research and development departments). Additionally, a gap was identified in technologies related to smart ecosystems (mostly, smart factories) as well as Industry 4.0 technologies and processes to keep the manufacturing process updated. Need for adopting the most recent techniques for prototyping, cloud services, data analysis (big data and artificial intelligence), and visualization interfaces for factory monitoring was also detected.

A good case example of this technology implementation where UV can support industry is quality control through advanced image inspection techniques and data analysis techniques. Quality inspection of the manufactured products in a factory is of paramount importance to avoid further problems and unnecessary costs in returns. In some cases, as food industry, it can also generate a public health problem for incorrect packaging or sealing. Currently, advanced 3D imaging reconstruction techniques and hyperspectral analysis provide detailed information and might be introduced in the production line to guarantee that every single product manufactured meets the quality requirements.

With the above-mentioned demands from external companies, the University of Valencia has designed an integrated approach in order to ease companies to find the right unit working on the field of interest of the company. However, UV has not created a new management and administrative structure causing more expenses and more human resources. Instead, the UV is also making use of innovative concepts and technologies to create an integrated tool where external users (mainly, companies) can find the right service. This tool is called OCT (STO in English - Scientific and Technological Offer, http://otriuv.es/oferta-cientifica/). And it is conceived as a search tool in the front-end with the user, including a powerful data analysis and advanced search tool into all issues related to units and persons working at the University of Valencia.

Thus, it is not needed to create and catalogue new information which demands time and human resources. The search tool automatically indexes all information existing in online

resources coming from scientific publications, research repositories, social networks, reports from units, contracts, published books, journal articles, public funded projects, and, in general, all related information existing in internal and external public online resources. This powerful search tool solves the current problem of the excess of information and multiple sources of information as different researchers use different online resources to disseminate their work, not requiring to manually replicate information, which was an often-used method before. The OCT tool directly addresses the contact details and offers general information about the services that can be obtained from the specific unit identified by the tool.

Other recent tools to disseminate the collaboration possibilities between UV and companies comes from dissemination in the most used online resources nowadays: specific social networks (ResearchGate, LinkedIn, etc.), video streaming tools (Multimedia channel of UV in YouTube and proprietary UV streaming server, https://www.youtube.com/user/UniversitatValencia and https://mmedia.uv.es/).

4 Current results and future implications for proposed innovation management ecosystem

The described approaches from two universities are supplementing each other very well. Firstly, they provide easy access to value-adding information and knowledge via front-end search tool and, secondly, they enable the use of innovation infrastructures and platforms via a well-defined customer pathway process. Individually, they have both shown an increase in requests from companies and individuals interested in boosting innovations. Hence, it is expected to be reflected in an increase in collaboration contracts and utilisation of innovation infrastructures. Furthermore, knowledge increase can be leveraged among various users and user organisations for example by offering tailored training courses for company employees.

Another important effect is the recruiting of students and recently graduated individuals who were previously developing some work or in touch with innovation units dealing with the topics in question. This fact shows that additional training in smart ecosystems and participation in innovation units (research groups, incubators, prototyping labs, etc.) provides additional skills and competences which are highly appreciated by companies. In turn, this is a win-win strategy as well-trained and creative individuals are able to find a job in the innovation ecosystem stakeholders, enriching their self-development and self-esteem. At the same time, companies can recruit well-prepared individuals who are ready to put the concepts learnt before into practice. This saves training time for the company, also reflected in saving costs. The individual equipped with up-to-date innovation capabilities is ready to complete innovative projects in reduced time when compared to other graduated students.

Furthermore, this approach helps to establish and maintain long-term connections and partnerships between higher education institutions and companies. The company relies on the HEI and regularly asks for advice, collaboration or hiring new people. Extending this support and collaboration in transnational context between HEIs and companies adds another level of benefits.

There are several common interests and customer focus areas identified in UV and TAMK during the co-creative design process of the approach. The services most requested by companies are often related to adaptation of new technologies as well as training and increased knowhow required for successful design and implementation of innovations and their management tools. Especially, knowledge and understanding related to the creation of company's innovation system and models to support and manage it effectively and efficiently are often called for.

Many companies, typically dedicated to produce certain products, do not have capacity to keep themselves updated in the product fabrication and keep the pace of industry in time to market production and anticipate market trends. Thus, they are interested in getting enough 'brain capacity' to generate 'in-house' innovation, thus protecting their core business from other competitors and creating their own product strategy. In order to do this, the University of Valencia offers a service for training in the required steps for creating a basic structure and team roles that must be assigned into the new department. Similarly, to expedite the in-house innovation in companies, TAMK organises innovation camps with employees and students mixed together targeting new out-of-the-box innovations in the pre-specified problem areas defined by the company.

Often a technical training usually required by companies is related to new product prototyping. The University of Valencia provides support for training related to the use of software tools and the required hardware, mainly, 3D printing and 3D scanning, allowing to create a complete product prototyping environment. In this case, the company receives the training, and they acquire the required resources, or they hire the human and material resources in order to meet their requirements. Similarly, TAMK implements the approach by providing hands-on learning and prototyping environment supported with specialist knowledge in present for companies and other innovators to gain experience, thus increasing knowledge.

The importance of industrial robotics in factory automation is continuously growing, especially with the new generation robots in multiple forms: multi-manipulators, flexible structures, collaborative (cobots), etc. Thus, new applications using these robots are developed every day. In this area, the main support to companies is given in the form of training for programming and simulation, as well as the joint deployment of application using the equipment available in the university so that companies can really appreciate the results before making a final decision on the acquisition.

It is proven that an optimal preparation before an automation process deployment saves time, which reflects in less expenditures for the company, less production line stop time, and improves the quality of work as they do not need to spend long periods in the manufacturing plant. By adequately using software for digital twins and virtual commissioning, it is possible to simulate and analyse the behaviour of an automation plant in the design desk before final deployment. The time of deployment is greatly reduced and possibility of errors during final implementation highly decreases.

Due to the immense possibilities opened by high communication networks (wired and wireless), it is now possible to acquire and store multitude of data from the manufacturing line. Those data can be stored in internal data servers, or even stored in the cloud. Detailed data of a process, together with adequate data analysis tools provide

information used for predictive maintenance, raw materials use, energy consumed, waste, safety control to avoid injuries, and multiple information concerning each part of the factory. The inclusion of sensors and data storage is becoming common these days, but SMEs require support in cloud data storage protocols and processes, as well as the use of artificial intelligence (AI) libraries for data analysis algorithms for prediction and classification.

The Industrial Internet of Things (IIoT) is highly connected with the previous item but includes the possibility to develop advanced visualisation environments. In this case, it can serve as a powerful tool to create new factory monitoring interfaces with custom data, accessible from multiple platforms and screen sizes, showing real time results of data analysis, and making use of augmented reality. A user-friendly design of such characteristics requires deep knowledge of web programming and algorithm development as well as remote data access protocols, including security to avoid intrusion. The research laboratories and innovation platforms available at the University of Valencia have already deployed the infrastructure. Jointly with TAMK FieldLab Industry 4.0 testbed they both are ready to show how they can really help companies in the future projects, saving time and costs for the initial exploration phase that a company requires.

5 Conclusions

This paper describes an approach able to transfer innovation knowledge to companies. The approach and working model emphasise that innovation knowledge is generated in different units of higher education institutions, especially in innovation platforms usually existing in HEIs, where easy access research and innovation infrastructures and front-end information search capabilities are playing a vital role. Thus, using an integrated approach to get in touch innovation units and companies has shown to increase the links between HEIs and companies. This is manifested by increased collaboration to develop joint projects by using the resources existing in HEIs for testing and prototyping, and by hiring highly specialized individuals, already trained in such innovation units. This approach can be applied to most of the HEIs having innovation units. Nevertheless, it must be tuned according characteristics of each institution individually as was seen for the case of TAMK and UV.

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