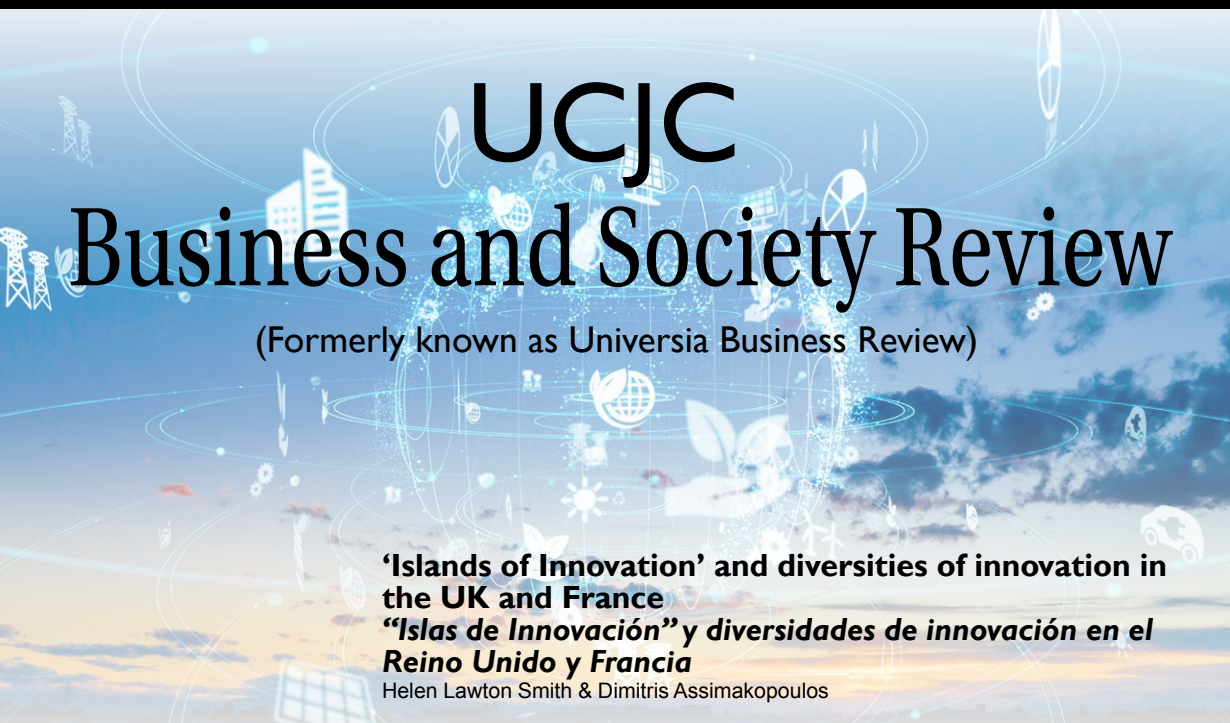




UCJC

Business and Society Review

(Formerly known as Universia Business Review)

'Islands of Innovation' and diversities of innovation in the UK and France

"Islas de Innovación" y diversidades de innovación en el Reino Unido y Francia

Helen Lawton Smith & Dimitris Assimakopoulos

Nº 66

Segundo trimestre /

Second Quarter

2020

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eInnovation: The importance of context

eInnovación: La importancia del contexto

Bill O'Gorman & Willie Donnelly

The Italian experience in implementing Industry 4.0

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High skilled workers mobility in Spain and Europe: motivations and implications

Movilidad de trabajadores altamente cualificados en España y Europa: motivaciones e implicaciones

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CARTA DEL DIRECTOR

NÚMERO 66 BUSINESS AND SOCIETY REVIEW

Estimados lectores, les presento el número 66 (segundo trimestre de 2020) de la revista UCJC Business & Society Review.

El mundo avanza hacia una profunda recesión provocada por la crisis sanitaria desencadenada por la propagación del Covid-19. La capacidad de innovación del tejido empresarial será una de las principales base de la recuperación económica. Las medidas de fortalecimiento de esta capacidad de innovación deberán tener en cuenta que no existe un único proceso de innovación, sino que la innovación es un proceso diverso y contingente a lugares y momentos determinados.

Al igual que el número anterior, este número de UCJC Business & Society Review se centra sobre la diversidad de la innovación. La innovación se aborda con frecuencia desde una perspectiva muy monolítica que hace que con frecuencia se olvide los distintos contextos en los que se producen los procesos de innovación.

Esta visión contingente de la innovación se desarrolla también en el número 66 de UCJC Business & Society Review. En este número, los profesores Lawton-Smith y Assimakopoulos comparan el desarrollo de polos de innovación en el Oxfordshire del Reino Unido y en Grenoble en Francia. El trabajo explica como un factor clave para entender las diferencias entre ambos lugares son los mecanismos por los que se generan y gobiernan las relaciones entre los participantes de estos ecosistemas de innovación. Asimismo, se analiza cómo las políticas públicas actúan sobre estos mecanismos. Los profesores O’Gorman y Donnelly analizan la importancia del contexto para determinar las dinámicas de innovación. En este sentido, los autores describen como las pautas actuales de innovación se explican por una más compleja interacción entre industria, sociedad y educación, superándose el tradicional modelo de innovación basada en productos. Los investigadores Gaddi, Garibaldo y Garbellini describen los retos que se plantean para los trabajadores y para la gestión de los recursos humanos a partir de la introducción de las tecnologías digitales vinculadas al concepto de Industria 4.0 en Italia. El trabajo realiza un análisis crítico de la estrategia nacional desarrollada por el gobierno italiano para adaptarse a la Industria 4.0, planteando oportunidades y debilidades de dicho plan. Finalmente, los profesores Giménez y Sandulli analizan las pautas de movilidad en España y la Unión Europea de científicos e ingenieros. El trabajo identifica dos mecanismos diferentes de movilidad. Por un lado, islas de innovación nacionales que son el polo de atracción de la movilidad nacional de trabajadores altamente cualificados dentro de un país y por otro lado, valles de innovación que se caracterizan por flujos internacionales de estos trabajadores entre regiones altamente innovadoras interconectadas entre ellas. Respecto a los factores que explican la movilidad, en los casos analizados los autores sugieren una mayor importancia de las diferencias interregionales en términos de oportunidades de desarrollo profesional a largo plazo que de las diferencias salariales interregionales.

Francesco Sandulli,
Director UCJC Business & Society Review,
30 de junio 2020

LETTER FROM THE EDITOR IN CHIEF NUMBER 66 BUSINESS AND SOCIETY REVIEW

Dear readers, I present to you the 66th (second quarter of 2020) of UCJC Business & Society Review.

The world is moving into a deep recession caused by the health crisis triggered by the spread of Covid-19. The innovation capacity of the economies will be one of the main foundations of economic recovery. Measures to strengthen this innovation capacity should take into account that there is no single innovation process, but innovation is a diverse and contingent process to specific places and times.

Like the previous issue, this issue of UCJC Business & Society Review focuses on the diversity of innovation. Innovation is often addressed from a very monolithic perspective that often forgets the different contexts in which innovation processes occur.

This contingent vision of innovation also takes place at number 66 in UCJC Business & Society Review. In this issue, Professors Lawton-Smith and Assimakopoulos compare the development of innovation hubs in the Oxfordshire in the United Kingdom and Grenoble in France. The work explains that the mechanisms by which relationships between participants in these innovation ecosystems are generated and governed are a key factor in understanding the differences between these two locations. In addition, the paper discusses how public policies may shape these mechanisms. Professors O'Gorman and Donnelly discuss the importance of context in determining innovation dynamics. In this sense, the authors describe how the current patterns of innovation are explained by a more complex interaction between industry, society and education, overcoming the traditional model of product-based innovation. Researchers Gaddi, Garibaldo and Garbellini describe the challenges that arise for workers and for the management of human resources by introducing digital technologies linked to the concept of Industry 4.0 in Italy. The work performs a critical analysis of the national strategy developed by the Italian government to adapt to Industry 4.0, describing opportunities and weaknesses of this plan. Finally, Professors Giménez and Sandulli analyse mobility patterns in Spain and the European Union of scientists and engineers. The work identifies two different mobility mechanisms. On the one hand, national innovation islands that are the pole of attraction of inter-regional mobility of highly skilled workers within one country and on the other hand, innovation valleys that are characterized by international flows of these workers between highly innovative regions interconnected between them. With regard to the factors that explain mobility, in the cases analyzed the authors find a greater importance of interregional differences in terms of long-term professional development opportunities than interregional wage differences.

Francesco Sandulli,
UCJC Business & Society Review Director,
30 June 2020

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UCJC Business and Society Review (Formerly known as Universia Business Review) no es una publicación exclusiva del mundo académico en sentido estricto, sino que su misión principal **es trasladar a quienes tienen la responsabilidad de dirigir empresas y negocios las ideas y desarrollos más innovadores que el ámbito científico y académico sea capaz de generar.**

Por otro lado, *UCJC Business and Society Review (Formerly known as Universia Business Review)* no renuncia a dar servicio a la comunidad universitaria y científica como la publicación de referencia, en la que los especialistas puedan efectuar un seguimiento sistemático de las aportaciones novedosas de los colegas de su misma especialidad. En particular, esta revista pretende ser un vehículo de unión y comunicación de las comunidades universitarias de habla latinoamericana dedicadas al estudio de la Empresa.

PROCEDIMIENTO EDITORIAL

Los originales recibidos y admitidos por el Comité de Dirección, serán enviados al Editor del área correspondiente para que analice si el trabajo debe continuar el proceso editorial y ser remitido a dos evaluadores anónimos (expertos ajenos a la entidad editora), de reconocido prestigio en el campo de estudio. Para desarrollar su labor se le envía el listado de evaluadores de los últimos años, pudiendo seleccionar e incluir aquellos nuevos revisores que el Editor de Área considere más acorde con el trabajo para su evaluación.

Una vez recibidas las dos evaluaciones el Editor de Área elevará al Comité de Dirección su propuesta de aceptar o rechazar el artículo para su publicación en UCJC BSR. Se pretende que, mediante la implantación de sucesivos “filtros” de calidad, el lector obtenga garantías de que la revista publica sólo aportaciones de nivel y de actualidad.

NORMAS PARA LOS ARTÍCULOS

UCJC BSR está abierta a la recepción para su publicación de originales preparados por miembros del mundo universitario, escuelas de negocios de todo el mundo, directivos y empresarios. Para que los trabajos puedan ser publicados los autores deberán atenerse a las siguientes normas:

- **Los artículos, que serán inéditos**, tendrán una extensión alrededor de 5.000 palabras, incluyendo notas a pie de página y bibliografía. **No deberá utilizarse un número excesivo de referencias bibliográficas.** Se considera que no deben superar las veinticinco.

- El artículo debe estar redactado de forma que facilite la lectura y comprensión de los contenidos a un público no académico. Se **debe evitar utilizar un lenguaje de corte excesivamente especializado**, en beneficio de una más fácil comprensión de las ideas expuestas y en la medida de lo posible, el abuso de términos muy académicos (metodología, hipótesis, etc.) y funciones matemáticas, aunque esto haya podido servir para que los evaluadores analicen el alcance de su investigación. Las **conclusiones no deben ser un resumen del trabajo**, sino una aplicación, una lección que se está trasladando a los responsables de las empresas para que estos la puedan considerar como un “buen consejo”, y lo que es más importante, que lo puedan entender y aplicar.

Si es necesario, o el evaluador lo requiere, se puede adjuntar como un fichero complementario (o anexo) todos los datos, técnicas econométricas, etc..., que hayan podido utilizar los autores para alcanzar las conclusiones de su investigación.

Una vez dado el visto bueno al trabajo, dicho fichero (o anexo) no se incorporaría en el artículo editado. Los autores deben hacer un esfuerzo para adaptar su trabajo a nuestros lectores, a los empresarios y directivos, no sólo al mundo académico.

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As stated in our mission, *UCJC Business and Society Review* (Formerly known as *Universia Business Review*) is not a publication dedicated strictly and exclusively to the academic world; its primary mission is **to transmit the most innovative ideas and developments generated by the scientific and academic communities to business leaders.**

Nevertheless, UCJC BSR does not neglect to provide a service to the university and scientific community, as a publication of reference through which specialists can systematically follow the latest contributions made by colleagues in their field. In particular, the journal seeks to be a vehicle of communication and union among university communities that speak Latin American languages and are dedicated to the study of Business.

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The originals received and accepted by the Management Board will be sent to the Associate Editor for the relevant area who will determine whether the work should proceed through the editorial process and be forwarded to two anonymous evaluators (experts external to the publishing entity), renowned for their work in the field. The list of evaluators from the last few years is provided to support their work by enabling them to select and include new reviewers that the Associate Editor considers most appropriate for evaluation of the work.

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If necessary or required by the evaluator, all of the data, econometric techniques, etc. that may have been used by the authors to reach the conclusions of their research may be attached as a supplementary file (or annex).

Once the work has been approved, the file (or annex) will not be incorporated as part of the edited article. The authors must make an effort to adapt their work to our readers –business owners and executives– not just the academic world.

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- Directorio, Catálogo e Índice **LATINDEX** (cumpliendo el 100% de los 33 criterios de calidad).
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- **Web of Science, Emerging Sources Citation Index (ESCI)** January 2016. Universia Business Review has been indexed, 2008-12, in the Journal Citation Report-Social Sciences Citation Index (Category: Business). 2010 Impact Factor: 0,228; 2011 Impact Factor: 0,150; 2012 Impact Factor: 0,138 (June 2013).
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‘Islands of Innovation’ and diversities of innovation in the UK and France

“Islas de Innovación” y diversidades de
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I. INTRODUCTION

This paper compares the development over the last thirty years of Oxfordshire in the UK and Grenoble in France as Islands of Innovation (Hilpert 1992). These twin towns, have at the core both research intensive universities and a high density of government research laboratories. Both host nuclear energy laboratories. Their respective research bases provide the starting point for analyses of why they have had several periods of innovation, dating back to the 1920s in France and the 1950s in Oxfordshire.

Since the early 2000s, there have been a number of changes in national policies. These have had a direct effect on the dynamics of local technology-led economic development, particularly those concerning to inter-relationships between the national laboratories and major local firms ‘anchor organisations’. We show that a major difference lies in the orchestration of research-based networking in Grenoble as a consequence of French cluster policy, whereas in Oxfordshire the government’s direct role of funding the research base remains that of sustaining the engagement. Hence, different forms of coordination are found. Thus we show that there is evidence that diversities of innovation are a necessary outcome of different processes at both locations.



EXECUTIVE SUMMARY

This paper explores diverging patterns of innovation and regional development in two 'islands of innovation'. In the early 2000s the growth trajectories of Grenoble and Oxfordshire were compared (Lawton Smith 2003). The focus was on national laboratories as territorial actors in the clustering of high-tech firms. Building on longitudinal data collected since 2003 the theme shifts in this study to the forms that government intervention takes through investments in knowledge organisations in high tech economies and how that leads to particular specialisations of technological advance. While there are many similarities, there are differences in starting points and structures, leading to diversities in innovation. The analysis shows how both are embedded in their national situations and opportunities for development.

We focus on two key elements in sustaining clusters of innovation, those of highly skilled labour and networks. We show that in Grenoble, the clusters are orchestrated information and project-based while in Oxfordshire they are labour market dominated and organic. We demonstrate complementary relationships between the national and regional level policy formation and implementation. In both cases importance of place is sustained over time but for different reasons.

RESUMEN DEL ARTÍCULO

Este documento explora patrones divergentes de innovación y desarrollo regional en dos "islas de innovación". A principios de la década de 2000 se compararon las trayectorias de crecimiento de Grenoble y Oxfordshire (Lawton Smith 2003). La atención se centró en los laboratorios nacionales como actores territoriales en la agrupación de empresas de alta tecnología. Basándose en los datos longitudinales recopilados desde 2003, el objeto de análisis cambia en este estudio a las formas que la intervención gubernamental adopta a través de inversiones en organizaciones de conocimiento en sectores de alta tecnología y cómo eso conduce a especializaciones particulares del avance tecnológico. Si bien hay muchas similitudes, hay diferencias en los puntos de partida y las estructuras, lo que conduce a las diversidades en la innovación. El análisis muestra cómo ambos están integrados en sus situaciones nacionales y oportunidades de desarrollo.

Nos centramos en dos elementos clave para sostener grupos de innovación, los de trabajadores altamente cualificados y redes. Demostramos que en Grenoble, los clusters se organizan entorno a la información y proyectos, mientras que en Oxfordshire están dominados por el mercado de trabajo y son de carácter orgánico. Demostramos relaciones complementarias entre la formación y aplicación de políticas a nivel nacional y regional. En ambos casos, la importancia del lugar se mantiene en el tiempo, pero por diferentes razones.

2. ISLANDS OF INNOVATION, CLUSTERS AND REGIONAL INNOVATION-LED GROWTH

Islands of Innovation are centres of competence where knowledge is applied or the kind of new knowledge is generated which again maintains both their position as islands and their situation within the networks (Hilpert 2012). Clusters can be seen as agglomeration of opportunities, some of which are taken while others are missed. While many islands of innovation appear to start spontaneously, in practice in many their emergence is associated with various forms of state investment in Oxford and Grenoble as has also as in the US's Silicon Valley (Lawton Smith 2003). This relationship does

*...there is evidence
that diversities of
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different processes at
both locations.*

not always hold: for example Lowe and Feldman (2015) have shown that in the case of the bioscience cluster in the North Carolina Research Triangle, knowledge and practice improve when industrial recruitment and entrepreneurial development intentionally and institutionally cooperate.

We start with public policy and the creation and function of anchor organisations (e.g. national laboratories, universities, and major firms). These are of primary importance as territorial actors in creating innovation-led places. We then review labour markets as key components of the functioning of successful clusters. Finally, we examine the conditions under which linkages and networks are an outcome of geographical coincidence or purposeful brokerage

2.1. Islands of innovation and the location of research and expertise

Public sector organisations, such as national laboratories and universities, are conceptually important with respect to relationships between two organisations. Smallbone et al. (2015) note that the concept of 'anchor institution' emerged in the 2000s as a new way of understanding the role that place-based institutions could play in building successful local economies and communities. Their characteristics include spatial immobility; embeddedness in the local economy and community; and having a large resource base that is manifested in local purchasing, employment and business support across large and small actors alike.

Feldman (2003) introduced the concept of 'anchor firms' to explore the locational concentration and specialisation of the emerging biotech industry. Existing firms can serve as anchors that attract

skilled labour pools, as specialised intermediate industries and as providers of knowledge spillovers that benefit new technology intensive firms in the region.

Anchors may have a formal coordinating role, an indirect role of promoting two-way relationships or both. Within the scientific and technological based region, big science facilities often take an anchor role. Autio (2014) categorised them into, on the one hand, research-oriented and service-oriented missions; and on the other, fundamental research and solutions-oriented missions. In practice, while many big-science facilities exhibit elements of each, the emphasis is likely to vary over time. Thus, these organisations provide information resources through interactive relationships of various kinds. For example, in the UK as elsewhere, public sector research organisations' roles have moved beyond that of pure science with some 'leakage' in the form of local recruitment (OECD 2011). Such developments are at the heart of understanding broader patterns of technological advance and how they are localised and embedded in the local community driving economic outcomes, such as product and service innovations.

KEY WORDS

Technological Change, Regional Innovation Systems, Clusters, Research and Innovation Policy.

PALABRAS CLAVE

Cambio Tecnológico, Sistemas Regionales de Innovación, Clústers, Política de Investigación e Innovación.

2.2 Islands of innovation, labour mobility and networking

Kasabov and Sundaram (2016) conceptualise clusters as dynamic and path-dependent pools of skills. A pool of skills enables places to sustain the economic ability to withstand external adverse factors and go through periods of development and transformation. Those with high skill sets are potentially able to create superior value. Thus, building bodies of knowledge through regional innovative labour market are fundamental to processes of innovation (Hilpert 2014, Huggins and Thompson 2017). For places to become islands of innovation, their organizations have to embrace all kinds of talent, knowledge and capabilities that are needed to deliver high value to customers with respect to key emerging technologies (KETs) (see Assimakopoulos et al. 2016, Evangelista et al. 2018). These highly innovative technologies are knowledge and capital intensive, linked with the intensity of R&D, swift and integrated innovation cycles and require high skill employment. For this reason, networks of knowledge flows are needed in order to bring together complementary expertise and resources, and to promote cooperation (or/and competition) among companies, academic

institutions and public authorities. Innovation networks are a major source for acquiring new information and knowledge, supporting innovation processes (Koschatzky et al. 2001).

Networks involved in the creation and diffusion of technology operate both locally and across geographical distances. A key factor is that islands of innovation are simultaneously involved in exchanges of personnel with other places in the world rather than the labour being bound to one place (see Hilpert 2014, Trippi 2014). Both the quality of the labour market and inter-organisational mobility are fundamental for network development and functioning because of their coordinating roles in innovation at the regional level (Lawton Smith and Waters 2011). Specific human capital refers to skills or knowledge that increases a worker's productivity overall though possibly differentially in different tasks, organizations, and situations. The concept of human capital has been broadened to competences as well as knowledge and skills (Gillies 2017). Thus, in the context of anchor organisations and their knowledge exchange relationships, their role goes beyond users of skills into the production of new competences, for example, for innovation and the mobility of that knowledge. At the same time, networks are heterogeneous in timing and function, sometimes meeting short-term goals and sometimes establishing long-term networks.

In summary, two strands represent the framework for understanding the different types of agency involved in clustering of innovative activity. These are:

- o The capacity for public policy to play a role in building successful regional economies.
- o Labour skills and mobility and networking in underpinning relationships

3. THE STUDY: ISLANDS OF INNOVATION: GRENOBLE AND OXFORDSHIRE

Each has both public and private sector anchor institutions and increasingly highly qualified labour markets. **Table 1** shows the science base in Grenoble and **Table 2** that in Oxfordshire.



3.1 Anchor institutions and their labour markets

In 2014, Grenoble was ranked the second most innovative city in Europe¹ and in 2013 the fifth most innovative city in the world. Grenoble stands out for its focus of research, university and industry, its partnerships with successful manufacturers, internationally renowned research laboratories and higher education courses.

Table 1. **Grenoble’s research base**

GRENOBLE		
LABORATORIES AND UNIVERSITIES	EMPLOYMENT	SCIENTIFIC RESEARCH ACTIVITIES
Atomic Energy Agency (CEA) CEA LETI, Laboratoire d' électronique des technologies de l'information' LETI	1,700 scientist and engineers, more than 250 graduate research students.	Nanotechnologies and their applications, within a broad range from wireless devices and systems, to biology, healthcare, energy and photonics.
Centre National de la Recherche Scientifique (CNRS)	32,544 staff members located in laboratories throughout France	Nine scientific institutes, focusing on Mathematics, Nuclear Physics, Chemistry, Biology, Science of Universe, System Engineering, Information and Interactions, Humanities, and Environment.
Université Joseph Fourier (UJF), (now part of the University of Grenoble Alps),	5000 students per year	Science and medicine
Major firm		
STMicroelectronics STM	c. 8,700 people working in its eighty R&D facilities worldwide.	Electronics – semiconductor solutions

The concentration of expertise means that it has a very highly skilled labour market. The Grenoble science base as a whole (four universities, five EPIC laboratories, 10 engineering schools and five European research centres) employs almost 10,000 public researchers. Over time, universities, laboratories and firms have increased their demand and supply of labour thus increasing the quality and diversity of the local labour market.

The Oxfordshire research base includes Oxford University, with outstanding research and teaching, and Oxford Brookes University. The county also has a unique grouping in the UK of government funded ‘big science’ and other research facilities. It also has a number of leading high tech (anchor) firms², three of which were chosen as case studies.

The organisation of the science base had already begun to change by 2003, with the privatization of some public laboratories following the introduction of the successful Public Sector Research Exploitation Fund in 2001³. Thus, as in Grenoble, there has been a blurring of the roles of big-science facilities as missions have changed (Autio, 2014).

Table 2. The Oxfordshire science base

OXFORDSHIRE		
LABORATORIES AND UNIVERSITIES	EMPLOYMENT 2014/5	SCIENTIFIC RESEARCH ACTIVITIES
Rutherford Appleton laboratory (RAL) Science and Technology Facilities Council (STFC) (a government research funding body)	c1200	Applied and fundamental science supports work in a range of areas including space science and astronomy, particle physics, nanotechnology and developing new materials, Diamond Light Source, the UK's synchrotron facility. ISIS, a centre for research in the physical and life sciences, the Medical Research Council's facilities, and the Satellite Applications Catapult Centre.
Harwell United Kingdom Atomic Energy Authority (UKAEA)		UKAEA was restructured in the 1990s, following the launch in 1989 of AEA Technology (AEAT) as its commercial arm, which was then privatised in 1996. UKAEA is now responsible for managing the environmental restoration programmes including decommissioning redundant nuclear facilities and the managing radioactive wastes from decommissioning, remediation of contaminated land and management and development of land and property assets. Renamed as Harwell Science and Innovation campus in 2006. Other laboratories on the Harwell site or nearby include the former National Radiological Protection Board now part of Public Health England; NERC Centre for Ecology & Hydrology and MRC Harwell.
Culham Centre for Fusion Energy (CCFE) (formerly UKAEA Culham)	150	UK's national fusion research laboratory
JET	500	Facilities are collectively used by European fusion scientists
Oxford University	Total 22,602 students Total 12,510 staff	Mathematical, Physical and Life Sciences
Oxford Brookes University	Total 17,864 students Total 3000 staff	Subjects allied to medicine e.g. nursing and advanced engineering e.g. motorsport

Case study firms		
Oxford Instruments PCL Established 1959	330 (over 2000 worldwide) (335 in 1987) (456 in 2002/3).	Leading provider of high-technology tools and systems for industry and research specialised in cryogenics. It is the industrial founder of Oxfordshire cryogenics cluster, 'cryogenics valley'. Has spun-out a number of companies including Oxford Magnet Technology, Oxford Analytical Instruments, and Oxford Medical. Oxford Metrics and Oxford Research Systems also have their origins in Oxford Instruments.
Siemens Magnet Technology (SMT)		Oxford Magnet Technology (OMT), a spin-out from Oxford Instruments, became a joint venture between Siemens (51%) and Oxford Instruments (49%). In 2003 Siemens bought the remaining 49% and it became (SMT). SMT is the world's leading designer and manufacturer of superconducting magnetic resonance imaging magnets for medical applications.
Sophos	480 (1600 worldwide)	Antivirus software

This grouping including Culham forms part of Science Vale UK, a partnership of two local district councils (Vale of White Horse and South Oxfordshire), the Oxfordshire Local Economic Partnership, Oxfordshire County Council and STFC⁴. It includes another important business park, Milton Park hosting more than 160 companies that form one of the UK's foremost science communities. The 6,500 people on the site work for companies of all sizes and ambitions, from start-ups to world-class public limited companies, with particular strengths in the biotech and ICT sectors. It is home to 13,800 jobs and is the only location in the country with two Enterprise Zones - designated areas providing tax breaks and government support. Other major locations are the Oxford Science Park and Oxford University's science park at Begbroke.

The pattern of high tech activity in Oxfordshire is one of specialization in a relatively small range of sectors: publishing, motor vehicles, computer/electronic equipment/ instruments (including medical instrumentation). Of particular relevance to this discussion is the exceptional concentration of cryogenics, a KET that evolved around Oxford and is unmatched anywhere else in the world, which has resulted in sought-after specialists at all levels. Oxfordshire has pioneered cryogenic-enabled developments such as MRI scanners, and is playing a leading role in the new technologies⁵.

The two universities in Oxford and the 7 public sector laboratories collectively employed 18,500 nearly twice as many as in Grenoble. In student populations there was a similar disparity, this time in Grenoble's favour. Grenoble had 55,000 students compared to Oxfordshire's 35,000. The main difference was that Oxfordshire's nuclear laboratories have far fewer students.

3.2. Relationships

Grenoble

Four research institutions in Grenoble which were known to have strong ties with the CEA were selected – LETI, CNRS, UJF and STM. These organisations form major relationships with it (and among themselves) for the creation, sharing and diffusion of knowledge inside a local innovation system and in particular, within its MINALOGIC cluster. As innovation becomes more collaborative, networks and partnerships have grown in strategic importance⁶. Since 2005, the cluster has given birth to emerging technologies fuelling growth for large and small companies alike.

All have CEA LETI as one half of partnerships. CNRS has worked closely with CEA LETI for decades in major public research projects; a combination of central and regional forces. Thus both national and regional policies interact in the Rhone-Alps region in order to promote innovation in the field of semiconductors and embedded software. STM, an anchor firm, has been described as a leading meta-national innovator (Doz et al. 2001).

Relationship no.1: CEA-LETI and CNRS

CNRS is active in maintaining partnerships in projects with important knowledge creating institutions (as the University of Grenoble). Its EU and international partnerships are part of the portfolio of wider CNRS research organizations at the national and European levels. In this partnership CNRS is an integral part of the national research centre/NIS, while CEA LETI is the local/regional anchor fairly independent from other parts of the CEA (they specialize in other types of KETs). CNRS research activities and projects are often complementary to those of CEA LETI. As a result, they interchangeably lead and co-ordinate numerous collaborative projects taking place under the MINALOGIC aegis. They also participate both in many EU and international projects and in the diffusion



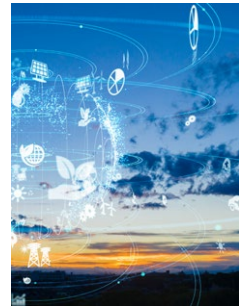
of scientific knowledge within the cluster and across regional boundaries to other leading European clusters, such as the one focusing on micro-electronics and nano-technologies in Dresden, Germany. This allows them to cooperate, coordinate and participate in collaborative projects independently from each other.

CEA LETI intensively promotes the cooperation with local SMEs within the MINALOGIC cluster. CNRS cooperates more with big industrial groups and a range of large and small companies. CNRS appears as the national innovation system in the region, concentrating knowledge from big firms (national and international). CEA LETI includes more local small and medium firms, fostering further development of the local innovation system. When these two research organizations cooperate, they create and share expertise for the production of new knowledge in KETs. As they cooperate widely their direct ties are surrounded by a large number of additional ties, facilitating knowledge flows inside the region and multiple paths connecting an array of other players in the MINALOGIC cluster.

Partnership no.2: CEA LETI and STM

STM has established a strong culture of partnership and a far reaching network of strategic alliances with important customers, suppliers, competitors, and universities and research institutes around the world. It has a wide product portfolio with customers across the spectrum of micro- and nano-electronic applications with innovative semiconductor solutions in technological areas for smart devices, MEMs, health, etc. This is supported by its extended series of emerging technologies, design expertise and the combination of an intellectual property portfolio, strategic partnerships and manufacturing strengths in many countries.

The largest research and new product design and development facility is still located in Grenoble with more than one thousand scientists and engineers, coupled with a large state of the art manufacturing fabrication facility. The latter is a 3 billion euro joint venture of STM with Philips semiconductors and IBM. STM has recently focused its product strategy on sensor and power technologies, automotive products and embedded processing solutions. The Grenoble division of STM is the largest industrial employer in ICT in the region (both CapGemini in software, consulting and services and Schneider Electric in electrical and





electronics engineering have gradually moved to Hong Kong). In this partnership a leading public research lab (CEA LETI) has helped form a multinational industrial group, specialised in the design and production of semiconductors. The cooperation of CEA LETI and STM ensures the encouragement of the private sector in knowledge production with a clear market orientation for developing knowledge near to the market and the commercialization of products. The participation of local SMEs and smaller industrial groups is encouraged by MINALOGIC. This is further enhanced because CEA LETI is supporting the local firms, and STM's business units located in Grenoble outsource the development of several designs and components to local small firms.

This encourages the transfer of knowledge inside the cluster between private and public institutions in a two directional flow through multiple paths, thus changing the structure of networks and positions of actors within them (Ferraro and Iovanella 2017). Various programmes have enabled employees to start their own firms, receiving support from STM for the first few years and, in case of failure, they are offered their previous job back at STM. Its existence facilitates the creation of flows of knowledge inside the region and worldwide. This can increase the participation of local firms in knowledge creation and reinforce CEA LETI as a knowledge broker. Without this relationship, private actors could miss out on local and international knowledge production and transfer processes. Another possible consequence could be an isolation of entire industrial projects.

Partnership no. 3: CEA LETI and UJF

UJF is one of the leading French universities in science, technology and healthcare related disciplines. UJF is now part of the University of Grenoble Alps. It has fifty laboratories in all fields related to medicine, science and technology, as well as close partnerships with national and international research universities. It has three research foundations with foci on nanoscience and nano-electronics, innovations in infectious diseases and disability, as well as neurology and cognitive science. It promotes the research outputs through a private subsidiary, which manages the university-industry relationships. In the last fifteen years, 35 start-ups have been created by UJF scientists and researchers.

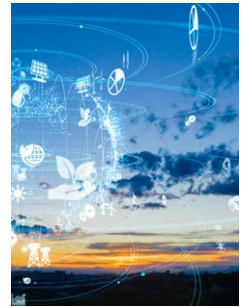
In this relationship, there is CEA LETI as a public research centre and the UJF as a leading academic institution. The university adds co-operations with national and international academic institutions, and some local SMEs. UJF is a broker of the academic knowledge encouraging flows towards research centres and from them to industry, or directly to the local firms. Projects in which they both participate involve local firms, either SMEs or industrial groups, as well as other French universities. Hence UJF is an indispensable node in the network and a collaborator of CEA LETI, facilitating MINALOGIC in collecting the knowledge produced in academia. To summarise, the combination in partnerships and networks of public actors, either with other research centres or universities, produces expanded networks that can reach almost 80% of the entire cluster network. The combination of a research centre and a university produces networks that can connect the most peripheral parts of the initial network.

Oxfordshire

Partnership no. 1: Oxford Instruments and Oxfordshire's research institutions

Oxford Instruments' relationships with the big research laboratories are variously of labour market exchanges, customer-suppliers, and knowledge generation and exchange based on innovation. For example, Oxford Instruments and STFC (and its predecessors) have collaborated for over 30 years on the development of many KETs including superconducting wire and magnets, particle accelerators and applications of cryogenic technology (STFC 2017). For the company, these relationships are now more important than in 2003. This is a change in approach from big science to a more commercial operation. The company built the world's largest Tesla magnet; which resulted in a 2006 decision to double the business size through new products and acquisition.

Skilled labour and access to universities and research institutions are the bases for current relationships rather than knowledge transfer. The most important relationship is recruitment. The firms' workforce is highly skilled: over half have at least first degrees. A recent interest in life sciences has changed the profile of the company's workforce. It recruits strongly from the local labour market, especially for production skills having a stable local recruitment pattern. The company has a graduate programme



designed to encourage mobility within the firm, increasingly bringing in overseas talent. A feature of the local labour market is poaching from the local laboratories, Harwell, Culham, RAL and SMT. Links with universities as a whole have stayed the same over time but those with Oxford University have declined: only one joint project is with Oxford.

Partnership no.2: SMT and Oxfordshire Research Laboratories

The company is a centrally important company in the Oxfordshire cryogenics cluster. The company benefits from local knowledge excellence and access to skilled labour necessary to produce and develop its products. Its relationships take the form of market relationships with its former parent company (Oxford Instruments), local recruitment, and knowledge exchange with local research institutions.

The Oxfordshire site is the design authority for all products and services. Components for magnets are bought in and assembled in Oxfordshire. The main collaboration with local firms is through buyer-supplier relationships. A policy in mid-1990s was of sole supplier relationships with about 50 local firms. Over time local subcontracting has decreased substantially. Two thirds of production is now carried out in Oxfordshire with the rest in Shenzhen, China.

The company recruits undergraduate interns: many are then employed permanently. It also recruits 10-15% of its engineers and cryogenicists from overseas, while 75% of the shop floor and white collar staff are recruited from within Oxfordshire.

Relationship no.3: Sophos and Oxford University

Sophos has grown continuously over the three decades becoming a multinational data security company producing anti-virus software. It was established by 2 post-docs in the Department of Engineering, Oxford University, and became a PLC in 1993. The underlying driver for growth has been innovation which has enabled Sophos to introduce new products, often based on new technologies.

Its main relationships within the county are through recruitment. The Oxfordshire workforce includes about half who are software developers or malware analysts, an area where Sophos is continually seeking staff. Frequently, new recruits have been previously employed in the Thames Valley, where labour markets for both software engineers and commercial staff have been created



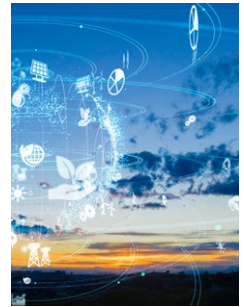
by European HQs of major US companies such as Oracle and Microsoft. Some 15-20% of staff are recruited internationally. Links with local universities and research centres are limited to the University of Oxford and University Oxford Brookes. In the former case, the connection is enduring network relations (Klaster et al. 2017), based on the company founders' links with academics, some part-time lecturers working in the company and academics on the board. In the case of Oxford Brookes, the connection is shorter-term based on links with the university career service. Sophos has no formal collaboration with Oxfordshire-based firms, has never subcontracted activities to Oxfordshire-based firms and does not belong to any business network. As well as being the home location, other cluster benefits as in Cambridge (Huber 2012) are to do with branding and reputation. Most of the physical growth of the company is now likely to be outside Oxfordshire, especially since in 2019 the company was acquired by US group Thomas Bravo. By then it had 3,400 employees worldwide⁷.

4. DISCUSSION AND CONCLUSIONS

This paper focused on diversities of innovation in two 'islands of innovation', one in the UK (Oxford) and one in France (Grenoble). The evidence shows that such diverging patterns of innovation and consequent regional development are a necessary outcome of the different processes at both locations. In both cases, the importance of place as sites of agglomerations of opportunities is sustained over time but for different reasons.

We suggest that explanations for how innovation processes have diverged lie in how relationships are formed and coordinated, having both positive effects and limitations. In these two contexts, differing patterns are connected to the ways that anchor institutions and firms (Smallbone et al. 2015, Feldman 2003) function as a consequence of national policy agenda for sustaining innovation in KETs. At the same time, divergence is associated with changing characteristics of the individual places (e.g. the knowledge base, labour markets, collaboration and networking).

Major differences are found in the structure of networks and positions of actors within them (Ferraro and Iovanella 2017). While in each location networks which provide knowledge and information resources are important, they are the primary focus



of relationships only in Grenoble, particularly through the role of MINALOGIC, a construct of public policy as the creator of anchors and communication.

In Oxfordshire local recruitment is the main driver of relationships in all three cases with knowledge and information resources and networks being less important. Here as in Grenoble, links with the group of research laboratories have remained important relationships for two of the leading firms, based on the local concentration of expertise in cryogenics. Another theme emerging is that interactions are increasingly non-local and increasingly international. This is especially true of Sophos, whose links with the locality are weakening, except for a key relationship with Oxford University.

The models are information, labour market and policy dominated. These are not mutually exclusive but how they intersect diverges between the two locations. Moreover, the drivers of relationships between the anchor organizations and partners also differ. Public policy has had an impact on the role of anchor institutions and relationships within the locality. France is characterised by top down big spending, public sector-led development, taking advantage of government labs as 'anchor institutions'. Continuing cluster funding sustains these relationships as well as purposeful brokerage and networking.

Oxfordshire's inter-organisational relationships are coordinated more by public-private partnerships and privatisation of national assets, and particularly by that of labour markets (Lawton Smith and Waters 2011). This is alongside still dominant national research funding, thus knowledge and information resources continue to be shaped by previous local developments. This difference has increased over time.

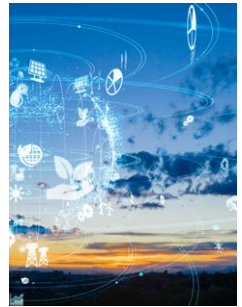
In Grenoble, the French state is of paramount importance. It is responsible for the coordination of relationships and influences the generation and flow of knowledge within and towards the cluster. The French government defines the cluster, hence the 'island of innovation' and the importance of place. Firms have to demonstrate that they are members of the cluster in order to bid for government funding, in this case under MINALOGIC.

In the UK, the state and public policy is important because of access to high level knowledge and information resources arising from government funding of research rather than systematic,



regionally organised initiatives. The dominant model is that related to mobility within local, national and international labour markets as well as sustained concentrations of skills in technologies such as cryogenics.

Finally, in both places 'branding' is important. Both are world leading 'islands of innovation'. This in itself is an anchor to firms in key emerging technologies.



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NOTES

1. <http://www.grenoble-inp.fr/grenoble-in-press-/grenoble-the-second-most-innovative-european-city-600825.kjsp>

2. The focus is on three major long established firms and their relationships with the science base. A series of studies on the Oxfordshire high-tech economy dating back to the mid 1980s, with follow up studies in the mid-1990s and mid-2010s forms the basis of the Oxfordshire evidence. In 1985, 182 local firms were identified as advanced technology firms and hence formed the population of the study. Of these, 164 firms agreed to be interviewed. In 2015, 170 companies were traced and data collected and 15 were interviewed.

3. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/380908/bis-14-1254-7th-survey-of-knowledge-transfer-activities.pdf (accessed May 26 2016)

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eInnovation: The importance of context

eInnovación: La importancia del contexto

I. INTRODUCTION

The origins of the word '*innovation*' are unclear; the exact meaning of the word is equally unclear. However, our understanding of the word, its meaning and the process of innovation (as we know it) have evolved over time. In the 1950s when there was a huge focus on re-building economies, post World War 2, the emphasis was on organisation theory and the development of industrial output through scientific management. During the 1950s and 1960s, the driver of economic growth was seen as innovation through scientific endeavour; that science, research and invention led to engineering and manufacturing and ultimately sales. The thinking at that time was that 'whatever was made was sold', that consumers would purchase goods regardless. The concept of marketing came to the fore in the 1970s, at that time it was seen that the demand for products and services was led by consumer needs. Therefore in the 1970s and 1980s it was considered that it was markets that drove economic development and the requirement for innovation to meet consumer demands.

It was not until the 1990s that convergent thinking about the concept and 'actuality' of innovation began to take place. It was then that researchers in domains such as economics, economic geography and social science began to consider, research and write about innovation as a more integrated and iterative process of creating economic wealth through meeting market demands. With the emergence of the world wide web (www) in the 1990s and particularly the exploitation of the www by technology entrepreneurs during the Dot-Com Boom of the late 1990s the concept of innovation became democratised, it was no longer the remit of large corporation and heavily funded research centres. Today in the 21st Century, innovation is 'in the hands of the masses'; because today



EXECUTIVE SUMMARY

Today, innovation is 'in the hands of the masses'; because it is driven by a combination of advances in technology, global communication, connectivity, consumerism, sustainability, societies and social conscience. To survive, in such economies, enterprises and other organisational entities need to consistently and continuously innovate. Innovation, however, is constructed from a set of tendencies and not a final condition in itself. These tendencies are geographically, organisationally and societally different and uneven. Different contextual settings lead to different innovations. This new era of innovation extends the impact of technologies and digitisation in dynamic unanticipated ways leading to paradigm shifts that force us, collectively and individually, to ensure benefits for the many, rather than the few. Therefore, innovation must be established as a 'way of thinking' a 'way of doing' no matter the context.

The key message to be extracted from this paper is that innovation is very much dependent on context. It is dependent of the context of the firm, government policy, absorptive capacity of citizens and on the processes in place to develop human capital.

RESUMEN DEL ARTÍCULO

Hoy en día, la innovación está "en manos de las masas"; porque está impulsada por una combinación de avances en tecnología, comunicación global, conectividad, consumismo, sostenibilidad, sociedades y conciencia social. Para sobrevivir, en esas economías, las empresas y otras entidades organizativas necesitan innovar de manera coherente y continua. La innovación, sin embargo, se construye a partir de un conjunto de tendencias y no de una condición final en sí misma. Estas tendencias son geográfica, organizativa y socialmente diferentes y desiguales. Diferentes entornos contextuales conducen a diferentes innovaciones. Esta nueva era de innovación extiende el impacto de las tecnologías y la digitalización de formas dinámicas imprevistas que conducen a cambios de paradigma que nos obligan, colectiva e individualmente, a garantizar beneficios para muchos, en lugar de para unos pocos. Por lo tanto, la innovación debe establecerse como una "forma de pensar" y una "forma de hacer" sin importar el contexto.

El mensaje clave que se debe extraer de este documento es que la innovación depende mucho del contexto. Depende del contexto de la empresa, de la política gubernamental, de la capacidad de absorción de los ciudadanos y de los procesos en vigor para desarrollar el capital humano.

innovation is driven by a combination of advances in technology, global communication, connectivity, consumerism, sustainability, societies and social conscience. To survive, in such economies, enterprises and other organisational entities need to consistently and continuously innovate. We must establish innovation as a 'way of thinking' a 'way of doing' no matter what your business or organisation is: be it a large, small or micro-enterprise; public or private sector entity; for profit, not-for-profit, or social enterprise.

2. THE CONTEXT OF INNOVATION

We must establish innovation as a 'way of thinking' a 'way of doing' no matter what your business or organisation is...

Innovation is not a singular concept nor is it geographically or organisationally bound. Rather innovation is fuzzy and evolutionary and is probably more dependent on societal constructs than merely on technology alone. No matter how advanced technology becomes, its use will be limited by the absorptive capacity and capability of the society in which the technology is being implemented. This may explain why there is such diversity in innovation across countries and across regions within countries (for more in depth and insightful views and experiences about this phenomenon of the contextualisation and diversity of innovation see Diversities of Innovation (Hilpert, 2019)).

Heretofore economic commentators and researchers attempted to define innovation as a set of characteristics or steps in a linear process that can be propagated at ease from one jurisdiction to another or from one company (or organisation) to another in the same jurisdiction. Therefore, for decades, policy makers and policy implementers have been attempting to find “best in class” innovation processes and trying to emulate these leading innovation regions, such as Silicon Valley, within their own regional domains. However, a single “best in class model” fitting all regions does not exist; and, by extension, a single ideal pathway for regions to design and implement a ‘best in class’ regional innovation system does not exist (Welter, Kolb, O’Gorman, Bugge, Hill, Peck, and Roncevic, 2008; Bugge, O’Gorman, Hill, and Welter, 2010). Rather innovation is constructed from a set of tendencies and not a final condition it itself. These tendencies are geographically, organisationally and societally different and uneven.

Different contextual settings lead to different innovations. Regions (and therefore countries) are on different technological, innovation and economic development trajectories ranging from the poorest underdeveloped regions in emerging economies to the well-endowed regions in mature economies. For example, from a “western civilisation” perspective, one could say that the first industrial revolution of the mid-18th Century was driven by entrepreneurs, capitalists and visionaries that saw the need of providing commodities to meet the needs of expanding societies that had the means to avail of these commodities. This necessitated new ways of thinking, new innovations. Innovations which led to the harnessing of steam to power large machines to create mass production and jobs, or the harnessing of steam to mobilise society at a faster pace using steam-engine trains and steam-ships, or the harnessing of water to generate electricity. The second industrial revolution, also known as the *technological revolution*, from the mid-19th to early 20th Centuries, built not alone on increasing outputs generated by the first industrial revolution, but also creating new products and services as well as new methods for generating and delivering these services to consumers. All this demanded new forms of innovation leading to increased levels of automation, greater degrees of mass production and a huge increase of uneducated, unskilled labour forces. The innovation system during the second industrial revolution could best be described as a ‘closed loop innovation system’. Because innovations were tightly coupled to industry sectors driven by advances in science and engineering. On the other hand, the third industrial revolution, a product of the late 20th Century incorporating the Information Age, was based on ‘manufacturing going digital’, the convergence of technologies, the almost total disappearance of manual labour, and the emergence and growth of the ‘highly educated, intelligent worker’, can best be categorised as the advent of ‘open innovation systems’. Of course none of this could happen without an evolutionary change in the conceptualisation and application of innovation.

Technological advances within the Information Age led to the democratisation of innovation. Also Open Access to knowledge and in the creation of that knowledge by citizen scientists and engineers has created what O’Gorman, Donnelly and Ritter (2019) refer to as ‘disruptive innovation ecosystems in regions’. However, no longer is disruptive innovation the prerogative of the ‘innovation-rich’ and

KEY WORDS

Innovation, Education, Absorptive Capacity, Societal Changes.

PALABRAS CLAVE

Innovación, Educación, Capacidad de Absorción, Cambios Sociales.



‘knowledge endowed’ regions. It is borderless and trans-regional and therefore it is also available to ‘innovation-poor’ and ‘knowledge unendowed’ region (O’Gorman, Donnelly and Ritter, 2019). Hence, emerging and underdeveloped economies can leapfrog into the *fourth industrial revolution* by being co-conspirators and collaborators in the co-creation and implementation of disruptive innovation. Thus, in the early decades of the 21st Century, as society and economies embark on the fourth industrial revolution, the conceptualisation and application of innovation has evolved to be something totally different than in the past.

Unlike the previous industrial revolutions, the fourth industrial revolution is embedded in intelligence rather than brute mechanical strength. Therefore it needs a paradigm shift in the innovation and commercialisation process. Heretofore, it was the preserve of the scientists, engineers and industrialists to design and develop new products and services. But all that changes because the relationship between producer and consumer becomes much more complex. In the first instance, the social and environmental impact of new products and services has led to a focus on responsible innovation and social innovation. The emergence of the ‘prosumer’ where the consumer becomes involved with designing or customising products for their own needs is changing the innovation process. Consequently, what was [once] innovative will not continue to be so, because becoming [innovation] mature is a permanent process associated with new technologies and innovation [as well as ever-changing societal demands] (Hilpert, 2019, p.3).

This is a very important point and begs the question how can local/regional societal needs be addressed without embracing the diversification of innovation and the need to include dimensions of innovation beyond boundaries (territorial, institutional and societal) of control? Also it must be considered that, in a globalised world where information is more freely available than ever before, societies evolve at different paces on different trajectories, and therefore what ‘has been’ innovation in one society can be perfectly adaptable and innovative in a different society. However, “technologies [and innovation] can contribute to socio-economic development only where they find appropriate contexts” (Hilpert, 2019, p.5).

3. THE MEANING OF INNOVATION

According to O’Gorman and Donnelly (2016), “it is not the innovation itself that is key, rather it is the process and location of innovation and the commercialisation and internationalisation of research outputs that matters” (p.264). They also contend that innovation is a process of co-creation, co-design, and co-implementation of solutions to meet societal needs whereby society (including the consumer) must be an integral dimension of the innovation process. In basic terms, innovation is the deliberate application of information, imagination and initiative to derive different values from different processes and/or resources. This is, in essence, the basis of the phenomenon of the diversification of innovation. From a technology perspective innovation is the generation and conversion of new ideas into new products and services. In a business sense, innovation is the application of new processes to increase productivity and profitability and satisfy customers’ increasing needs and expectations.

As regards the societal domain, innovation can be considered as the adoption, and adaptation, of technologies and processes to improve the wealth and well-being of citizens. For example, one innovation that was the application of information, imagination and initiative, which has totally transformed industry, business, economies, society, communications, and the way we live, think, behave, work and interact with each other, is the World Wide Web. What Tim Berners-Lee wrote in 2000 can be considered as a ‘modern day’ definition of innovation. He wrote:

“The vision I have for the Web [www] is about anything being potentially connected with anything. It is a vision that provides us with new freedom, and allows us to grow faster than we ever could when we were fettered by the hierarchical classification systems into which we bound ourselves.....it brings the workings of society closer to the workings of our minds” (Berners-Lee, 2000, p.1).

As stated earlier, it is the combination of tendencies and elements (concepts, materials, technologies, and so on) combined with location, societal need and the absorptive capacity of society that really makes innovation happen. Therefore, in the opinion of the authors of this paper, innovation is not constant. It is malleable, it is fluid. Innovation is contextual and situational dependent. These are reasons why there is such a diversification of innovation between countries and regions. But just as fluids can be “defined



unambiguously as a material that deforms continuously and permanently under the application of a *shearing stress*, no matter how small” (eFluids, 2016) so too can innovation. However, in the case of innovation, the shearing stress can be considered the tensions between scientists, inventors, innovators, investors, profiteers, industry, educationalists, governments and society.

4. INTERPLAY BETWEEN INNOVATION AND SOCIETAL CHANGE

Innovation plays a major role in the economic and social development of most countries; it is considered as the main source of economic growth, productivity improvement, foundation of competitiveness, welfare progress and therefore crucial for poverty alleviation (Ghazal and Zulkhibri, 2015). In general, economic geographers, regional studies scientists, economists and researchers of the impacts of innovation agree that innovation in regions is very much dependant on a region’s economy, industry mix, governance, human capital, levels of education, infrastructure, levels of investment in R&D and innovation, and the cohesiveness of collaborative arrangements between the region’s stakeholders (local/regional government, industry, Higher Education Institutions, and civil society organisations (CSOs)). According to Ghazal and Zulkhibri (2015), “the state of innovation and research and development (R&D) in selected developing countries can be characterised by large disparities among different geographic regions in terms of knowledge, information, research and scientific capacities” (p.237); and “.....[the] poor outcome in innovation and R&D [in regions] is partly attributed to the low quality of higher education and curricula, lack of infrastructure, dependency on natural resources, lack of comprehensive R&D policy, and brain drainage” (p.238). This also explains why there is such a diversity in innovation between countries and even between regions within countries, and/or between urban and rural areas within a given region or country.

However, the concepts of innovation that have been emphasised most by policy makers, researchers, economists and other commentators has been on the creation and diffusion of new technologies and knowledge mostly for the benefit of profit and economic gain via the commercialisation process with industry. Nevertheless, through such a process there are gains for society, for example through the creation of new jobs, and increases



in earning and spending power. Society also gains from the development and commercialisation of new technologies in that some of these technologies lead to advances in medicine, surgical procedures and healthcare in general. Equally, societies and the economies in which they learn, work, rest and play, gain from these technological advances in that citizens are more educated and information is more freely available at all levels of society. Advances in technologies related to logistics and transportation have enabled people to be more, physically and mentally, globally focused and have greater reach beyond where they were born, live and work. Consumerism is endemic which adds to a continuous evolutionary cycle of economic gain, re-investment in innovation and the generation of new knowledge and technologies. But with all these evolutionary, and revolutionary, gains chaos and complexity have also increased exponentially. Not alone does it appear to be the case that consumers play a passive role in economic development (Schumpeter, 2003), but it also seems that society at large plays a passive role in the evolution of innovation and technological advances.

Advanced technologies and the increased speed of access to and dissemination of information facilitates people in general to be more globally aware and more educated than ever before. As a result, the nature of work, the way we work and use our leisure time, as well as the processes of production and delivery of goods and services has changed completely. This scenario affects all organisations be they in manufacturing, education, tourism, public sector, social enterprises, or whatever. Because whereas once upon a time these organisation served local markets, consumers can now receive most products and services from almost any location outside of their local communities (be they local, regional or national). Therefore, in order to survive in today's economies, organisations/enterprises need to continually innovate. They need to clearly identify the drivers of those parts of the economy that enable the provision of appropriate goods and services to consumers. In the words of Peter Jelkeby, IKEA Country Manager for Ireland and the UK, 'innovation is not only about technology nor is sustainability only about environmental issues, rather the focus of IKEA is to be sustainable into the future by continuously innovating our offerings to our customers to address their ever changing needs'¹.



5. INDUSTRY IS NO LONGER WHAT IT USE TO BE

Since the 1990s, component miniaturisation, the advancement of computer technology and software development, the uptake of the world wide web (www), the focus on the 'knowledge economy' and 'knowledge workers', and the investment in innovation have all converged and changed the paradigm of work, research, education, leisure, and living irrevocably. The shape of industry has changed. For example, in developed economies in particular, many employees originally referred to as low-skilled blue-collar workers are now white-collar workers working in call centres, or as software developers, or code writers, and the like. The advancement in technology, speed of data transfer and the availability of data is such that the philosophy and thinking in relation to technology and work is that "today knowledge navigators are finding innovative ways to transfer information at dramatically lower prices" (Ogden, 1993, P.xvii). Because of this upheaval Handy (1995) introduced us to the career portfolio and 'empty raincoat' paradigm:

"....to me that empty raincoat is the symbol of our most pressing paradox. We are not destined to be empty raincoats, nameless numbers on a payroll, role occupants, the raw material of economics or sociology, statistics in some government report. If that is to be its price, then economic progress is an empty promise. There must be more to life than to be a cog in someone else's great machine." (pp.1,2)

As we zoom into the 4th Industry Revolution (Industry 4.0) where the focus is ever increasingly on new forms of technological innovation to increase the use, speed, manipulation and management of information (through the Internet of Things) for citizens in general these words are probably even more apt today than in 1995.

In advanced mature and developed economies, mostly because of the cost of labour, mundane, repetitive, low-skilled jobs are being automated. However, knowledge and the use of knowledge are key factors in today's working environment, regardless of the economy. Even trades such as plumbing, electrical work, and car mechanics depend on knowledge and hi-tech skills. Therefore, the role and delivery of education also needs to change in order to supply industry with the knowledge workers it needs. One may consider that these concepts are not applicable in low-cost and emerging economies and that such economies, because of their cheap labour base, are best suited to mundane, repetitive, low-skilled jobs. However, because of advances in communication technology nearly all citizens in nearly all countries have access to knowledge. Hence, as stated above emerging and underdeveloped economies can leapfrog into the *fourth industrial revolution* by



being co-conspirators and co-collaborators in the co-creation and implementation of disruptive innovation and new markets.

6. EXTENDING THE BOUNDARIES OF UNIVERSITY BEYOND THE CLASSROOM

Traditionally, Higher Education Institutions (HEIs) have been repositories and guardians of knowledge in society; this stance is reflected in their seemingly elitist and disengaged characteristics. However, the democratisation and massification of higher education across Europe has forced HEIs to review their role and reposition themselves. For example, because knowledge is more available and less controlled or controllable, HEIs must now co-ordinate and facilitate efforts to manipulate knowledge and create new knowledge (the basis of innovation), rather than merely guard existing knowledge.

Lester and Piore (2004) summarised four main areas in which universities contribute to industrial transformation: (a) education and training; (b) adding to the stock of codified knowledge through publications in technical journals, patents, software and hardware prototypes; (c) increasing local capacity for scientific and technological problem-solving; (d) providing space for open-ended conversations about industry development pathways and new technological and market opportunities. These actions can be more meaningful and appropriate to regional economic development if universities expand their reach beyond the classroom; if universities revert to being more proactive in the education roles as opposed to being reactive to immediate industry needs. In order to 'future proof' societies within regions, entrepreneurial universities need to be proactive in (i) facilitating the identification of future education needs of both industry and society in their region; (ii) blurring of the 'boundaries of learning' between academia, industry, government, and society. This will only be achieved if entrepreneurial universities take on the role and responsibility to work with an extended constellation of Quadruple Helix (QH) actors in co-designing, co-developing, and co-implementing learning and education solutions addressing societal needs.



7. KNOWLEDGE AND THE ABSORPTIVE CAPACITY OF SOCIETY IS SITUATIONAL

How regions progress and develop their innovation capacities and capabilities is very much dependent on a country's or region's enterprise and innovation policies, investment (from public



and private funds) and the absorptive capacity of its citizens and regional/national institutions. However, as pointed out by Oughton, Landabaso, and Morgan (2002), many regions/countries are incapable of absorbing or capitalising on the public funds they receive to enhance the innovation process and practices in their regions/countries. This ‘innovation paradox’ of societies not being able to absorb the investments (knowledge as well as monetary) they badly need to improve their innovation capacities and capabilities has been studied by many researchers and policy makers since 2002 (see for example De Bruijn and Lagendijk 2005). The conclusions from all this research are still mixed, complex, and paradoxical.

Innovation has become more global and dispersed than it used to be. As a result, the dynamics of innovation have changed dramatically over the last three decades. According to Dutta and Lanvin (2013), for real local and regional innovation progress to occur, critical region-specific dimensions need to be identified, explored and measured. Dimensions such as examining the strengths and weaknesses of local industries and knowledge institutions, access to finance and to markets within and outside national borders, and the knowledge pool and absorptive capacity of the region’s/country’s human capital. It is this milieu and interaction between different elements of the milieu that generates new opportunities for innovation and new markets. Remember, “firms, organisations and institutions, as well their interactions, differ substantially across regions and countries. This implies that policy responses to systemic imperfections will [always] be country specific” (OCDE, 2011, p.230). It is this richness of diversity between regions that yields an even broader breadth of *Diversities of Innovation* (see Hilpert, 2019) across sub-regions, regions and countries. As such, the co-creation and use of knowledge is situational, dependent on regional nuances and the absorptive capacity of society in any given region. Organisations (both public and private sector) that can respond to these changing region-specific characteristics will be sustainable, flourish and grow.

Education is an essential dimension in enhancing the absorptive capacity of regions (and countries) resulting in greater levels of innovation capacity and capabilities of regions and countries. According to Donnelly and Weber (2017) it will become increasingly necessary for education systems to evolve and equip individuals with the skills and flexibility required to be employed or create employment in the digital economy. However, the speed at which this can happen in any given region is both situational and contextual; it is very much dependent on the maturity of enterprise and educational policies

in that region, as well as on the maturity of industry itself and the levels of educational attainment of citizens in that region. Donnelly and Weber continue that it is not only machinery and labour that are important when investing in R&D; another significant, if not the most significant, factor of production [and innovation] is knowledge that was acquired in the past. For example, a researcher makes use of knowledge that he or she created previously and combines it with other researchers’ knowledge. This concept, if managed properly by policy makers, can enhance a region’s image as an innovation hub and/or regional innovation system (RIS). Because, as suggested by Bellini and Pasquinelli (2016), “in place branding the reference to innovation is, indeed, crucial: places are branded as ‘the’ location where innovative activities can flourish, either because of previous performance or because of emerging favourable conditions” (p.79). Bellini and Pasquinelli also suggested that “in the absence of [place] branding innovation policies may result in socially and politically weaker policies, since they are unable to strategically promote the engagement of the regional community in the process of change” (p.87). This certainly appears to have been the case in Ireland after the death of the Celtic Tiger in 2008 and the emerging economic recovery post 2011. Between 2008 and 2011 Ireland’s economy seemed to be on a never-ending downward spiral. A change in government in February 2011 yielded a new Programme for Government, the prime focus of which was on innovation and job creation. Through a series of government instigated “good news stories” about new jobs, new enterprises and new markets the economy began to recover. With the results that in 2019 there are more people in employment than ever before in the history of the state and the level of unemployment, down to 4.9%, is nearly as low as it was during the height of the Celtic Tiger.

Donnelly and Weber (2017) stated that different types of knowledge play different roles in the production and innovation process. For example, the more theory-driven knowledge from universities is traditionally generated with the specific purpose of making it freely available; and on the other hand the more application-driven knowledge generated in a corporate [enterprise/industry] R&D department is often kept secret or commercially protected. The first of these knowledge domains takes the form of a quasi-public good whereas the knowledge generated by an enterprise can be more readily appropriated to generate new products or processes.



8. RELEVANCE OF THE CONTEXT OF INNOVATION TO BUSINESS

A critical point to note from this paper is that innovation is a response to meeting a market need. Innovation is *a way of doing business*; it is not external to an organisation; it is not a group of people working in one part of an organisation in isolation of all other members of that organisation. Innovation is the role of everybody working in a given organisation. But innovation, and the embedding of a culture of innovation in an organisation, needs to be led. In the case of micro-enterprises and SME (together these organisation make up more than 95% of the industry stock in most economies, and generally employ up to 65% of the working population in that economy), the innovation process needs to be led by the owner/manager and the executive team.

The first realisation of owner/managers and their executive teams is that they need to understand the context of their business environment. This context includes understanding their market, the needs of their market, the community they serve, as well as understanding (and resourcing for) the technology and human capital they need to supply their markets and service their communities. The owner/manager and the executive team need to acquire the ability to see the connection between innovation and the value drivers of the business at hand, rather than viewing innovation as an activity to be undertaken for its own sake.

The second realisation is that owner/managers and the executive teams need to appreciate that the results of digitalisation and continuing emergence of disruptive technologies means that their business models need to change. The traditional tried and test business models are no longer fit for use in today's flexible, digitised, knowledge intensive local/global markets.

The third realisation is for owner/managers and their executive teams (and indeed policy makers) to embrace the fact that the migration of the economic value of innovation from product platforms to more complex innovative consumer led services developed on open source platforms has provided greater opportunities for enterprises in less developed regions to transform themselves into innovation leaders. A key factor in delivering such an environment is the optimisation of the quadruple helix (QH) model based on open innovative government structures and citizen entrepreneurship. Industry needs to accept an active role in this QH engagement process.

The fourth realisation for owner/managers and executive teams of micro-enterprises and SMEs is that they need to be comfortable with the fact that their contribution to the education process and



increasing the human capital of the region within which they operate is essential. Their contribution to the learning process in a region is as important as large enterprises, multinational national enterprises (MNEs), government and HEIs. Traditional concepts of education are rapidly changing to reflect this with greater emphasis on life-long learning experience. There is a move away from skills development to providing citizens with the tools to access, understand and apply knowledge for the economic and social benefit of society. Supporting the free flow of people and knowledge across traditional national boundaries the creation of regions of innovation. Micro-enterprises and SMEs have a significant role to play in the continuous co-creation co-dissemination of knowledge and skills.

In summary, in the words of Hilpert (2019), “skills and education are related with societal dynamics and social change creating particular situations” (p.6). As regards innovation, “industrial societies are more than just a description of a societal context or social structure” (p.6). In other words innovation is contextual and situational. Therefore focusing on the broader aspects of innovation within public and private sector organisations, will lead to the continuous socio-economic development of regions.



9. CONCLUSION

The key message to be extracted from this paper is that innovation is very much dependent on context. It is dependent of the context of the firm, government policy, absorptive capacity of citizens and on processes in place to develop human capital. Enterprises and organisations be they for profit, not-for-profit, social enterprises or public or private sector entities need to be fully aware of the drivers of innovation pertinent to their organisations. Understanding and addressing these drivers of innovation is what makes organisations relevant to the consumers of their products and services. Without relevance, there is no guarantee of sustained commerce. But relevance, just like innovation, is buoyant and ever-changing – it is contextual and situational. Hence the importance of understand the *Diversities of Innovation* (Hilpert, 2019a).

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NOTES

1. Paraphrased from an interview with Peter Jelkeby on the Morning Ireland radio show on 20th November 2019





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The Italian experience in implementing Industry 4.0

La experiencia italiana en la puesta en marcha de la Industria 4.0



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I. THE SITUATION OF THE ITALIAN MANUFACTURING INDUSTRY

The Italian Industry 4.0 plan was born following the German one. It depends on the deep integration of a large part of the industrial system of northern Italy with the German one.

SMEs are an important element of national and regional strategies; but in the case of Italy, for the main industrial sectors, the risk is that these companies are increasingly dependent on OEMs of the different value chains. The OEMs are often located in other countries. This is particularly true for companies located in the North West and the North East of Italy.

There are some idiosyncratic aspects of the Italian industrial structure, also stressed by the government, which make it particularly subject to being affected by Industry 4.0. Especially in the sectors producing machines for industrial automation and components (mechanics and mechatronics), SMEs are clustered in industrial districts which would become more and more integrated with a reduction of the distance, within the value chains, between suppliers and subcontractors.

Besides, SMEs has different challenges to cope with, depending on the sector. The widespread idea in the business community is that what should be appropriate for many SMEs is a retrofitting strategy. This is not suitable for SMEs that depends on global or EU value chain in which the OEMs are still on the edge of the process.

The Government's plan includes five intervention areas. The first one is intended to provide for investment in innovation and legal incentives (laws for machinery modernisation, patent box,



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EXECUTIVE SUMMARY

This article analyzes the implementation of Industry 4.0 technologies in Italy. The article provides, in the first part, the essential information on the government plan on Industry 4.0 and the reactions of entrepreneurs and unions to this plan. In the second part, the research summarizes the results of a field research conducted by the "Claudio Sabattini" Foundation on behalf of the Italian unions. In this research, we interviewed both company managers and individual workers in thirty companies. We identified two different paths of innovation based on Industry 4.0: the smart factory and the smart products. According to the employees' interviews, the main problems of the adoption of Industries 4.0 technologies are the intensification of work pace and the intensification of workloads made possible by the new technologies.

RESUMEN DEL ARTÍCULO

Este artículo analiza la implantación de la Industria 4.0 en Italia. En la primera parte, la información esencial sobre el plan Industria 4.0 del gobierno italiano y las reacciones de los empresarios y sindicatos a dicho plan. En la segunda parte, resume los resultados del estudio de campo llevado a cabo por la Fundación "Claudio Sabattini" en nombre de los sindicatos italianos. En esta investigación, entrevistamos tanto a los gerentes de la empresa como a los trabajadores en treinta compañías. Los resultados muestran dos caminos diferentes de innovación basados en la Industria 4.0: la fábrica inteligente y los productos inteligentes. Según las entrevistas de los empleados, los principales problemas de esta transformación a la industria 4.0 son la intensificación del ritmo de trabajo y la intensificación de las cargas de trabajo que hacen posible las nuevas tecnologías 4.0.

tax credits on R&D, etc.). The second area concerns investments in technologies (connectivity infrastructure, reduction of SMEs' digital divide, improvement of STEM skills). The third area concerns interoperability and communication standards to foster production processes and business models based on IoT. The fourth aims at developing corporate finance to support companies' investments for Industry 4.0.

Finally, what is worrying for the labour organisations, the Minister endorsed the need for making industrial relations more flexible by decentralising bargaining activities to the level of the single firms. Besides, He stressed the necessity of closely linking salary adjustments and corporate productivity following a model which, in recent years, has been strongly supported by the latest governments and CONFINDUSTRIA (the General Confederation of Italian Industry).

This relationship between wage developments and productivity developments has proved to be very detrimental to workers: first of all, because the term "productivity" has only meant higher business profitability. Besides, "productivity" bargaining was based on indicators over which workers and trade unions could not exercise any control. From this point of view, the regional differences concern only the spread of second-tier bargaining, which is concentrated for about 80% of the contracts stipulated in Northern Italy (about 39% for both the North West and the North East).

The effects on the labour conditions of this push for different industrial relations and of the restructuring of the work places to fit the industry 4.0 requirements can be checked in the second part of this chapter.

2. THE GOVERNMENT PLANS

2.1. The design of the government program

The Italian Government in 2015 gave its opinion, in the person of the Minister of Economic Development, Carlo Calenda, during a parliamentary hearing at the Chamber of Deputies. According to the Minister, digitalisation improves the competitiveness of the Italian manufacturing sector, starting from those production chains mainly based on SMEs.

*The widespread
idea in the business
community is that what
should be appropriate
for many SMEs is a
retrofitting strategy.*

The government's plan opened a phase of the progressive introduction of manufacturing digitization processes and a growing interest and discussion on the consequences of this choice. The discussion involved both the research world and the business organizations and the trade unions.

The Minister ruled out the possibility that Italian industrial policies can foster the development of vertical chains, giving priority instead to a horizontal approach based on innovation, internationalisation and recourse to the capital market.

The concept is supporting the industrial structure in its existing configuration, without any explicit objective of reducing the territorial and the dimensional imbalances of this structure. Besides, the Minister didn't make available the analytical data on the utilisation of the funds, so we can say for sure that there was not a convergence process, but we cannot produce any analytical data set beyond the ones here listed.

The Government presented the plan in September 2016 (National Plan Industry 4.0, later renamed Impresa [firm] 4.0).

The Government's Plan to stimulate the spread of Industry 4.0 was so important that in the face of the new possibility of remodelling incentives for investment, the business world said it would slow down the planned investments. This confirmed our concern about the fact that the only interest of Italian companies was to benefit from generous tax incentives and economic contributions.

The Government's plan has many critical elements

First of all, the entirety of the plan's objectives concerns only the firm-level.

The main objectives are:

Greater flexibility, which would allow taking advantage of economies of scale even when producing small batches; shortening the time necessary for prototypes to be switched-over to series production; decreasing set-up time, mistakes and machines stops, which would enhance productivity; the introduction of sensors monitoring production in real-time, which would increase quality. All these objectives should be consistent with the imperative of competitiveness, to be achieved thanks to the advantages offered by the internet. Social and labour issues are not considered, but as to the functional ones as skills.

KEY WORDS

Industry 4.0, Labour, Competitiveness, Digital Technologies.

PALABRAS CLAVE

Industria 4.0, Trabajo, Competitividad, Tecnologías Digitales.

2.2. The weaknesses of the Plan

First, the infrastructure provision plan is already showing the first criticality: the realisation of ultra-broadband is hugely behind schedule. Secondly, public commitment should stimulate private investments in goods and technologies connected to Industry 4.0. However, it is not clear whether such investments would generate production and employment in Italy or abroad. In other words, are sensors, devices, robots, hardware, software, and so on going to be produced in Italy or imported? If the latter is the case, besides a worsening of the Italian trade balance, the Government's Plan is going to generate employment abroad rather than in Italy.

The list of investment goods that can benefit from tax advantages is extensive: in this way for companies, it was enough to buy a capital good connected with some form of ICT technology.

In the absence of any prospect of intervention in the Italian industrial structure, the advantages benefited the most structured companies, with the risk that this could increase social and regional inequalities. Moreover, the Plan hardly mentions a chronic weakness of the Italian industrial system, i.e. the absolute predominance of small enterprises, usually part of more complex production chains whose head is located abroad, often in Germany. The risk is, therefore, that of digitalising a set of production chains led by German companies, whose leadership on the whole supply-chain would be even reinforced.

This means that even the most industrialised and modernised regions risk further deepening their dependence on the foreign industry.

Finally, the Plan, by its admission, adopts a horizontal approach to industrial policies, with the explicitly stated aim of avoiding the vertical approach.

The Plan lacks any reference to labour, but in terms of training and skills development.

One example suffices: Industry 4.0 generate new jobs (new sectors, products, services) and, at the same time, destroy jobs (due to automation, robots, etc.). Estimating job balance at the single firm or sector level appears to be feasible. Moreover, it would be worth trying to understand how Industry 4.0 change workers' status (new and more flexible forms of employment; the dichotomy between employment and self-employment, etc.) and working conditions (working time, safety at work, etc.).

How will companies and territories comply with the new paradigm? Which new skills become necessary? How will working tasks and



processes change? How will working performance take place, and be monitored by each firm? All these are questions which the Government's plan does not even mention. This list of questions should be made explicit as there has been no prior assessment of how the work would have changed, especially for work organisation and production. As usual, the only point of view adopted is the enterprises' one.

2.3. Firms benefitting from Industry 4.0

First of all, it is necessary to underline the absolute lack of transparency of the Italian Government, which has never provided a clear and detailed report¹ on the use of the resources made available and the number and type of companies that have had access to the various forms of incentive. Consequently, the only "data" available refers to surveys conducted on samples of companies.

A survey conducted by ISTAT on the "Climate of Confidence for Manufacturing Enterprises" in November 2017 produced the following results.

For investments in digital technologies, most of the companies surveyed stated that they made them in software, IoT and Cloud, followed by Cybersecurity and Robotics. Compared to the size of the companies that made these investments, most of them are large companies, followed by mediums and ultimately small ones.

The type of incentives considered most useful for companies sees in the first place the tax advantages of super depreciation and hyper depreciation, followed by the tax credit in R&D and the new Sabatini (partial coverage of interest for loans for investment expenses).

Companies benefited differently depending on their size:

the mediums benefited most from super depreciation, the large and mediums from hyper depreciation as well as the tax credit on R&D, while the small ones are in the lead in the use of the New Sabatini.

For the geographical distribution North-West, North-East and Centre have made greater use of the incentives of super-depreciation and hyper-depreciation with the South left behind. The gap between the South and the rest of Italy, in the utilisation of the incentives, is less relevant in the case of the use of tax credit on R&D and the Nuova Sabatini's incentives.

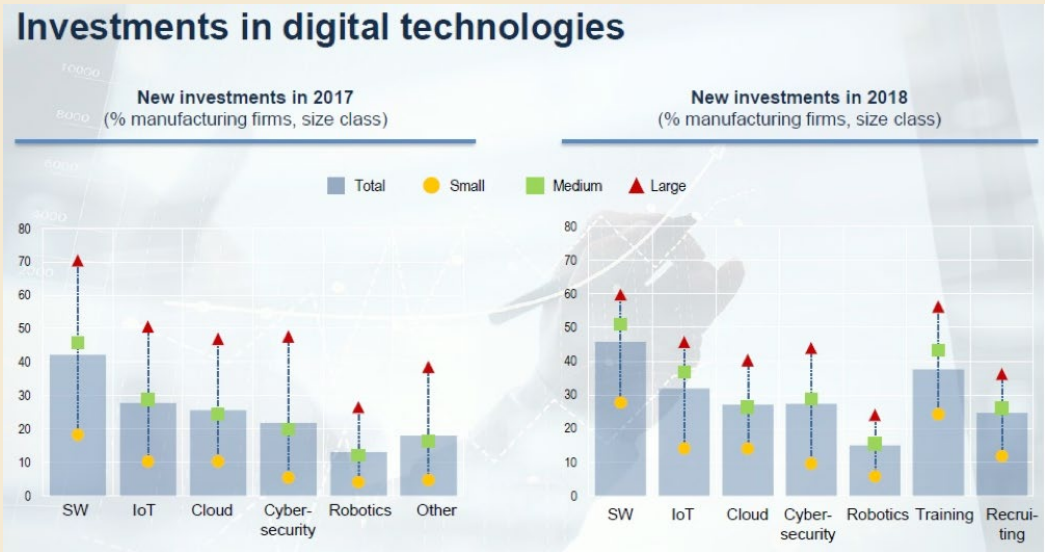
As we can see from the graphs below, in 2017 about 80% of large companies used the incentives of the government plan, while among small companies this percentage was only 20%. The



following year (2018) the distance in the use of incentives between large and medium enterprises was reduced; small companies also grew, but with percentages still far from large ones. Most of the incentives financed the purchase of technologies such as software and the IoT, i.e. technologies directly linked to connected capital goods. A significant spread of these technologies has been found in engineering industries (automotive, white domestic appliances, steel and iron production, industrial machinery, transport equipment etc.), chemical, telecommunications and logistics companies.

As we stress in the second part the introduction of Industry 4.0 required a change in the management of the firms: the main precondition was and still is the introduction of the Lean management scheme and of some kind of Manufacturing Execution System and data analysis

Figure 1. Investment in digital technologies in Italian firms



Source: Istat (2017) and Istat (2018). Climate of Confidence for Manufacturing Enterprises

3. ON THE EFFECTIVENESS OF THE PLAN

3.1. A companies' assessment

The results of a qualitative survey conducted by ISTAT in 2017 on a representative sample of manufacturing companies provided some indications of the perception of the business world regarding the effectiveness of some of the measures contained in the Plan “Impresa 4.0”. Among the main measures, super depreciation played a “very” or “fairly” significant role in the decision to invest for 62.1 per cent of manufacturing enterprises, with values ranging from 57.3 per cent of small to 66.9 per cent of medium-sized enterprises. Hyper-depreciation was considered relevant for investment decisions by 53.0 per cent of medium-sized enterprises; by 57.6 per cent of large enterprises and by 34.2 per cent of enterprises with less than 50 employees. The tax credit for R&D expenditure was considered favourable by more than 40 per cent of manufacturing companies, a percentage that is close to 50 per cent in larger companies.

The financial benefits provided by the “Nuova Sabatini”, an instrument introduced to encourage investment in the capital goods of smaller companies, were considered necessary by 35.2 per cent of small and 28.9 per cent of medium-sized companies.

From a sectoral point of view, super depreciation was considered positive in at least half of the companies in all sectors, except for clothing and other transport equipment. Hyper depreciation, instead, was relatively more important for companies operating in the electrical equipment (58.9 per cent), rubber and plastic (57.7 per cent), metallurgy (55.8 per cent), electronics and machinery (53.6 per cent in both cases) sectors.

The R&D tax credit was considered useful mainly by companies in the automotive (69.8 per cent) and other transport equipment (60.0 per cent) sectors.

For investment plans for 2018, almost 46 per cent of enterprises states that it expects to invest in software, almost a third (31.9 per cent) in technologies machine-to-machine or Internet of things. Only 27 per cent to invest in connection with the Internet, high speed (cloud, mobile, big data, etc.) and computer security, to the extent that the directly proportional to the size of the business.



3.2. The MET's report

A report published by the Ministry of Economic Development in July 2018 highlighted the main results of the Industry Plan 4.0. The MET Study Centre produced this report through a survey involving about 23.700 companies considering their use (or planned investments) of the following technologies: advanced manufacturing solutions, additive manufacturing, augmented reality, simulation, smart technology/materials, industrial Internet of things, horizontal integration, vertical integration, big data/ analytics, cybersecurity.

Of the total manufacturing, 8.4% of companies use at least one of the above technologies. A further 4.7% of companies are planning specific investments in the next three years. The “traditional” enterprises (which do not use 4.0 technologies nor have future interventions planned) are 86.9%. The propensity towards these technologies increases significantly with the growth of the company's size: above ten employees, 4.0 companies reach 18.4% of the total; between 50 and 249 employees they reach 35.5%; over 250 employees they reach 47.1%.

The diffusion of 4.0 technologies is more significant in the Centre-North (9.2%) than in the South (6.1%).

These data seem to be consistent with the Italian industrial matrix, characterised by a high regional imbalance. In this sense, the Government's plan does not seem to have triggered convergence trajectories, but rather to deepen regional disparities.

A little less than half of the 4.0 enterprises use only the data management technologies acquired along the production chain, 36% use both the technologies that concern the production process and those of data management, while those that use only the production technologies are 16.0%. The ones using only the data technologies prevail in the micro and the enterprises with less than fifty employees, while beyond that threshold prevails the concurrent use of both, with percentages equal to 50% in the case of medium enterprises and 69.2% in large enterprises.

In the majority of cases, the involvement in 4.0 technologies appears limited to the use of a minimal number of applications. 62.4% of 4.0 companies use one or at most two technologies; above 50 employees the number of technologies expands, but it is only in large companies that the use of more technologies becomes a widespread model: over 60% of them, in fact, use at



least four of 14.0 technologies.

Among the companies that employ at most two technologies, the use of techniques of data acquisition and management prevails. Starting from three technological applications, the probability of observing uses that are more strictly related to the production instead of information management increases. The case of companies using only production technologies is rare.

For future investments, 10.0% of all companies (including those that do not currently use 4.0 technologies) expect at least one intervention in the next future; this percentage increases significantly in companies with 10-49 employees (22.5%), reaching about one-third of medium and large size companies. Southern companies show a negative gap also as to future commitment (8.1% vs 10.6%).

The probability that traditional companies implement 4.0 interventions in the next three years is very low; on the contrary, companies that currently use 4.0 technologies have a high probability of expanding the set of 4.0 technologies they employ soon.

Among the goals that companies aim to achieve with 4.0 technologies are: improving product quality and minimising errors (63.4%); increasing productivity (46.3%); increasing production flexibility (25.3%); the possibility of entering new markets (21.9%); improving safety from 20.9%; and reducing personnel (6.3%). From a dimensional point of view, there are few significant differences.

This survey also confirms the widespread use by companies of the incentives made available by the Government. 56.9% of 4.0 companies state that they have used at least one public support measure compared to 22.7% of companies that do not use 4.0 technologies: 4.0 companies have mostly used Super-amortisation and hyper-amortisation (36.8%), the tax credit for R&D expenditure (17.0%), Nuova Sabatini (19.8%) and guarantee funds (11.3%).

There is a high propensity to cumulate incentives: 57.5% of the 4.0 companies involved in the plan had access to at least two incentives; in 27.9% of cases to at least three measures.



4. THE SITUATION AS AT THE SECOND HALF OF 2019

Since March 2017, France, Germany and Italy have initiated trilateral cooperation to promote the digitisation of the manufacturing sector and to support the European Union's efforts in this area.

From 1 June 2018 to 5 September 2019, the Lega and Five Stars alliance run the Italian government. The new government renamed the Industry 4.0 plan in Enterprise 4.0 and reduced the scope of the project with a series of modifications to the approved economic and financial planning document at the end of 2018. There was a reduction in the entire part of the economic incentive with a downsizing of the section relating to investments, with a system more favourable to SMEs. Besides, the weight of training has been redefined. In May 2019 there was a rethinking with the launch of the growth decree, then transformed into law (28 June 2019, n. 58), with a new allocation for the digitization of businesses. The new Conte government in the programmatic declarations put at the centre the project of an extensive digitalization of companies with particular attention to SMEs.



4.1. The patterns of change and the consequences for the employees

We started a field research on the introduction of industry 4.0 in the metalworker's sector.

Our sample, available in a report available in English, is made of 30 companies – 3 in Piemonte, 6 in Lombardia, 15 in Veneto, 6 in Emilia – Romagna - ranging from metal casting companies to an automaker, and a sample of different producers of machine tools. This is a work in progress, and we have more case studies in some reports, available only in Italian².

These companies represent different sectors according to the NACE codes. As it is easy to check this sample is very coherent with the actual distribution of companies involved in the Industry 4.0 project funded by the Italian state. We carried out the research interviewing both the managers of the companies and a sample of workers and their delegates.

4.2. Managers

According to the managers' interviews, there are two different paths of innovation based on Industry 4.0: the smart factory, the

smart products. There are also companies affording both, but frequently even in these cases, a path is the prevailing one. The way toward producing smart products is based on achieving a new business model based on the integration of manufacturing and services in smart products. In some sectors, the smart component of the product is more relevant, regarding the value and competitive edge, than the manufactured part. Besides, smart products usually include a basket of services for the client – as, for instance, the possibility of predictive maintenance – allow the collection of data – an enormous amount of data – by customers and clients to feed AI-based innovation shortly.

Summarising our main findings, what does mean and imply looking for a smart factory?

4.3. The smart factory

I. It requires a reorganisation along the lines of the lean production, of the tense flow scheme and production flexibility. In conclusion, **this eliminates all non-value-added activities** and introduces **feedback mechanisms** to align production with demand. These objectives were first pursued mainly with organisational measures. Now Industry 4.0 technologies allow this to be accomplished primarily by technology but presuppose previous organisational changes.

II. In all, there have been critical structural changes - new plant layouts - both in IT and in smart tools. The adoption of the new MES (Manufacturing Execution Systems) management systems, i.e. systems that unlike the old MRP (Material Requirement Planning), support in an integrated way the production both in the management of production operations and in those supporting production.

The companies best prepared to accept the technologies of Industry 4.0 seem to be those that had already implemented organisational innovations in the direction of lean production.

Besides, companies owned by multinationals, mainly concentrated in Northern Italy, or with close ties to German industry (also in this case located in Northern Italy) have shown a higher propensity to Industry 4.0.

There is, therefore, no standard formula for the application of Industry 4.0. The forms depend on the nature of the strategic problem of the product/market relationship that every company





must solve. However, there are in all **some common elements (which are explained in detail in a subsequent chapter):**

- a. Elimination of non-value-added activities more effectively and pervasively than before. Achieving this goal through technical devices changes the relationship between the hierarchy and the forms of the work command. Everything becomes less mediated by the social contact and more by the apparent objectivity of a relationship mediated by technology.
- b. There is a previously unthinkable **control** not only of performance as a result but also of its execution moment by moment and in real-time.
- c. A shift - with the ideal model of the tense flow - towards a flexible and continuous alignment between market and production through the use of cyber-physical systems able in different measures to self-settle concerning market demand. The ideal model is batch production one.

The previous points involve a significant intensification of the work that must be evaluated case by case in its effects, also as to the psychological factors.

Future employment consequences must also be assessed. In our research, although concerns have been expressed, there does not seem to be significant consequences at the moment.

III. The supply network is integrated directly - at least at the first level - in production management. There are currently two integration profiles:

- a. An operational integration mainly through the adoption of the parent company's standards by the suppliers;
- b. In addition to operational integration, real co-design relationships develop.

IV. On the other hand, there are different elements regarding personnel management. If we take as reference the **International High-Performance Work Practices (HPWP)** - considered in the managerial theories, the more advanced - only in some cases, this model starts to be applied. It can be deduced by analysing the following aspects:

- i. *Criteria and methods* of entry of personnel: very stringent selection procedures up to personality tests.
- ii. *Training and career*: a substantial investment in the first six months, continuous training; process transparency for career and incentives.

- iii. *More or less deep forms of operational decentralisation:* such as team self-management, problem-solving practices, etc.
- iv. Dissemination of teamwork forms and job rotation practices.

4.4 Smart products: hybrid manufacturing, product-cum-services

There are more and more obvious paths of innovation that arise from the possibility of diversification/specialisation towards more complex products that, for example, include services whose exclusivity creates value (Bryson, 2009).

There is, in short, an interdependence between manufacturing and services which may affect the so-called mature industries significantly.



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5. THE SOCIAL SIDE

5.1. Employees' participation

Participation with changes in progress requires a multi-level assessment. On the first level, the participation of workers must be evaluated and only in some cases, there are practices of involvement of individuals, but of a functional nature. Functional participation is achieved through both initial and ongoing training on ongoing changes. On the second level, that of the company and the provincial unions. In all the cases analysed, the union and the Trade unions' delegates (RSU) are at least informed. There are significant cases of proactive practices of the RSU. Even when they do not realise real framework agreements can intervene promptly to protect workers and workers involved. At the third level, there is the negotiated participation with the presence of real joint commissions. It happened only in a few cases.

5.2. The employees' interviews

The main consequences for employees are at least three:

1) Times reduction

Industry 4.0 allows a reduction of working times in a way adverse to workers, with an intensification of the pace of work and a decrease in times for each operation.



This modification was not due to the mere introduction of new technologies, but rather to the implementation of new business models, strictly determined by market conditions.

Technologies supported these new business models, making a different organisation of labour possible by reducing operation times.

Order fulfilment times became stricter, strongly influencing working times and schedules.

For this reason, a series of software tools acquired greater relevance.

In the vast majority of cases, Companies unilaterally define work schedules and working times. This is often the pre-condition to implement labour organisation models such as Lean Production, Just in Time; Just in Sequence, WCM etc.

These labour organisation models – supported by Industry 4.0 technologies - enable:

- compliance of supplies deliveries to planning defined by the company at the head of a production chain (OEMs);
- the synchronisation of production stages (internal and external);
- the management of the high degree of variability of workloads and product mix.

Work orders have a barcode that embeds cycle times, often based on machine times.

In this way, working times are presented by Companies as “objective”, and as such, not subject to bargaining.

Finally, all data are immediately uploaded, collected and analysed by ERP/MES.

2) Control of workers performance

The intensification of workloads was made possible by technologies that can track the start and end of every single operation. Data concerning operation times are recorded, collected and monitored thanks to computer-based systems. Moreover, Companies introduced devices for remote control of plants and equipment and, therefore, of the corresponding workers' performance. This control can be realised by matching barcodes associated with workers (ID badge), the machines they operate, the batch which is being produced, and the specific components under process. Machines also generate data about production volumes and

downtimes (breakdowns, set up, controls, lack of materials, etc.). This monitoring system often involves suppliers and customers as well.

In this way, Companies can achieve new goals:

- computing production costs;
- calculate the cost of each worker;
- decide whether to externalise or not some specific production stage.

Companies, via these control systems, can compare internal costs with costs charged by potential external suppliers. They create competition between internal and external workers and put much pressure on their employees.

3) Human-machine relation

Despite the rhetoric of Industry 4.0 about the upskilling of workers, we found that companies exclude workers more and more. This exclusion concerns all aspects related to production process information. The elaboration of software and scripts is of competence of planning and engineering departments. In some cases, this service is not even provided internally, but by the companies which supplied equipment, which is in charge of software updates, maintenance, etc. Programming requires computer science skills. It is also true that workers could well be involved in the discussion concerning software goals (machines' performance, modes of operation, times, etc.).

After being programmed, scripts are not uploaded by the worker operating the machine, but directly by programmers. In some cases, this is done by programming/engineering departments which remotely upload scripts through intranet or internet networks.

Once uploaded, workers do not always launch scripts. In some cases, choosing scripts to be started is the competence of the head of the department or the production responsible. In other cases, scripts are automatically launched by optical readers thanks to barcodes associated with the production batch, which in its turn is associated with a specific script.

The fact that workers are not aware of the working of the machine is a potential additional source of alienation: information, data, scripts by which the system works are entirely unknown.

The utilisation of more advanced tools and machines (connected



devices, smart devices, etc.), therefore, does *not imply higher-level skills for workers. On the contrary*, tasks might even result simpler and poorer.

6. CONCLUSIONS

In the last ten years *Italy lost quite 1/4 of its industrial production*, still not fully recovered, and quite the 8% of the GDP/person. In the Southern regions, it leads to a creeping process of deindustrialisation and degradation of the productive matrix, besides the GDP/person losses are with two digits. The integration of Italy in the EU industrial structure is very different for the northern regions and the rest of Italy. The Italian northern industrial structure is fully integrated into the leading European value chains. The drive to Industry 4.0, without specific policies to overcome these disequilibria, will confirm this divide. This is the more critical issue also in the political arena. Digitalising Italian SMEs is now a key political issue as well as the upgrading of skills for the employed and the continuous training of the new entrants.

Trade Unions and Employer associations are delivering training material and training packets for their associates and officials. For instance, the Association of the Engineering sector' employers sponsored a book to explain what digitalising manufacturing is about and delivering suggestions for SMEs. In this book, they suggest to small firms to avoid a full implementation of all technologies at once; it is better to start with small steps. There are already some new good cases of company's agreements to afford the chief complaints of the employees and to smooth the way to the digitalisation.



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NOTES

1. There is a report but it is not available, at least at the moment of writing this article.
2. [1] <http://www.fondazioneSabattini.it/ricerche-1/ricerca-europea-industria-4-0>





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High skilled workers mobility in Spain and Europe: motivations and implications

Movilidad de trabajadores altamente cualificados en España y Europa: motivaciones e implicaciones



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I. INTRODUCTION

Most economies are experiencing a productive paradigm shift, since several industries are facing new challenges related to innovation races to create new goods and services and the amount of knowledge required to create these innovations. Since one of the main sources of knowledge for the firms are high-skilled workers, the global demand for these workers has also rapidly increased in such a way that they have become a scarce and desired. Nowadays, compared to low-skilled workers, high-skilled workers may change more easily their residence to locations where their needs are best met. According to OECD data, between 2001 and 2006 the stock of tertiary educated migrants increased by 108% in OECD countries.

The increasing mobility of high-skilled workers create significant threats to the innovative capacity of those companies and regions that cannot create incentives to retain these workers. Regions exporting talent face the risk of entering a vicious cycle where the scarcity of high-skilled workers limits the abilities of their local companies to innovate, but in turn these low rates of innovation do not create enough satisfying professional opportunities to high-skilled workers, who are forced to leave the region in search of better opportunities elsewhere. As long as high-skilled workers leave a region, the economy of the region does not only loose valuable workforce but also highly purchasing-wielding consumers. Therefore, the economy suffers also from negative spillovers from high-skilled worker



EXECUTIVE SUMMARY

Competing today through innovation requires attracting and retaining a high-skilled workforce. Compared to less skilled workers, high-skilled workers have a higher mobility. In order to help businesses and governments to create strategies that leverage or counter this high mobility of workers, this research explores the motivations and implications of regional concentration for high-skilled workers. The study analyses how the characteristics of the labor market and the dynamics of agglomeration of knowledge create incentives for the local concentration of engineers and scientists. The concentration of high-skilled workers is studied in Spain and Europe. At the empirical level the research shows how strong are the flows of workers moving from less-innovative regions to Madrid and Catalonia, since in some of these less-innovative regions more than 40 per cent of science and engineering engineers migrate. In Europe, the results show two coexistent phenomena: islands of innovation in some countries that attract most of the high-skilled workforce from that country and valleys of innovations formed by interconnected innovative regions. These regional concentrations of engineers and scientists are explained by unemployment rates of skills-exporting regions and greater concentrations of innovative activities. In this sense, the results suggest that the prospects for a future professional career rather than wage disparity is the most influencing factor in the regional concentration of high-skilled workers.

RESUMEN DEL ARTÍCULO

Competir hoy en día a través de la innovación requiere atraer y retener una fuerza de trabajo altamente calificada. En comparación con los trabajadores menos cualificados, los trabajadores altamente cualificados tienen una mayor movilidad. Con el fin de ayudar a las empresas y a los gobiernos a crear estrategias que aprovechen o modulen esta alta movilidad de trabajadores, esta investigación explora las motivaciones e implicaciones de la concentración regional de los trabajadores altamente cualificados. El estudio analiza cómo las características del mercado laboral y la dinámica de la aglomeración del conocimiento crean incentivos para la concentración local de ingenieros y científicos. La concentración de trabajadores altamente cualificados se estudia en España y Europa. A nivel empírico, la investigación muestra lo fuertes que son los flujos de trabajadores que se trasladan de regiones menos innovadoras hacia Madrid y Cataluña, ya que en algunas de estas regiones menos innovadoras más del 40% de los ingenieros científicos e ingenieros emigran hacia regiones más innovadoras. En Europa, los resultados muestran dos fenómenos coexistentes: "islas de innovación" en algunos países que atraen a la mayoría de la mano de obra altamente cualificada de ese país y "valles de innovación" formados por regiones innovadoras interconectadas. Los resultados indican que las concentraciones regionales de ingenieros y científicos en Europa se explican por las tasas de desempleo de las regiones exportadoras de trabajadores cualificados y las mayores concentraciones de actividades innovadoras en las regiones con mayor capacidad de atracción. En este sentido, los resultados sugieren que las perspectivas de una futura carrera profesional en lugar de disparidad salarial es el factor más importante en la concentración regional de trabajadores altamente cualificados.

consumption to labor markets for low-skilled workers (Mazzolari & Ragusa, 2013).

As a result of high-skilled workers mobility, economic differences between innovative regions, skills importers, and non-innovative regions, skills exporters, are increasing (Lee & Rodriguez Pose, 2013). Besides, once the vicious cycle of innovation-high skilled workers mobility starts, there is a serious risk of no turning back since former evidence shows that migration of high-skilled workers is a process rather than an event and that migration is spanning over a sequence rather than being exhausted by the responses of members of a single "cohort" (Stark & Wang, 2002). This process view implies

the perpetuation of the differences between regions and the irreversibility of these differences, posing serious managerial, political, economic and social challenges. For instance, existing literature shows that this process has an important effect on the location and concentration of multinationals, and on the capability or incapability of firms in innovative or not innovative regions to generate innovative business models based (Salt, 1992).

The main goal of this research is to confirm whether the pool of high-skilled workers is increasingly concentrated in few regions in Europe, to dig deep into the roots of this phenomenon and finally discussing the implications at the firm, regional and national level. At the empirical level, the research will first drive its attention towards the regional concentration of high-skilled workers, and more precisely scientists and engineers, in Spain and then to the regional concentration of scientists and engineers in Europe.

2. THEORETICAL DRIVERS OF THE REGIONAL CONCENTRATION OF HIGH-SKILLED WORKERS

The location and mobility of high-skilled workers has been a subject of research for several years. Two theoretical arguments stand out about others when it comes to explaining the regional concentration of high-skilled workers: the regional differences in terms of wage returns to educational attainment and the regional differences in terms of agglomeration economies.

In China, for instance, regional wage disparity is the main explanation to the local concentration of high-skilled workers which on the other hand is less influenced by the friction of distance, the regional

... one of the main sources of knowledge for the firms are high-skilled workers...

unemployment rate, and the concentration of foreign investment (Liu & Shen, 2017). Shen & Liu (2016) confirm that in China the low average wage level explains why high-skilled workers leave some regions, but also show that regions with small population, an excessive supply of university graduates, a small non-agricultural sector are also more likely to lose skills (Shen & Liu, 2016). Factors such as high unemployment rate or small amount of foreign investment better explain the interregional migration of low-skilled workers. The relevant role of wage disparity in the local concentration of high-skilled workers is confirmed also in Italy by Nifo & Vecchione, (2014) and Ermini et al., (2018). However, these works also show that in this country the better quality of governmental institutions is positively correlated to the regional concentration of high-skilled workers. This argument is not surprising, since previous research had also confirmed the role of some dimensions of the institutional quality of governments to explain the international migration of high-skilled workers to the US (Bang & Mitra, 2011).

Beyond wage disparity and institutions, the literature shows that the patterns of regional concentration of high-skilled workers are quite consistent with agglomeration economies (Kerr et al., 2017). Agglomeration economies are directly related to the number of job opportunities for high-skilled workers. For instance, interregional concentration of high-skilled workers in Finland is explained by the density of firms in the high tech industry and the fewer firms in other industries (Simonen et al., 2018). Similarly, Sanchez-Moral et al., (2018) found that skilled workers in Spain tend to migrate to regions with more job opportunities. This work also shows that in Spain, beyond the classic idea that agglomeration economies benefit all residents, big cities, and the capital Madrid in particular, had become 'escalator regions', propelling the careers of young creative workers that had been attracted to them. In fact, these urban areas have thick regional labor networks that are the main channel to flow the knowledge needed to promote innovation in the local firms (Almeida & Kogut, 1999) which in turn will create new job opportunities to these workers. Besides, network thickness will favor professional development of skilled workers not only through these professional opportunities, but also through long-life learning and reskilling opportunities. In fact, in innovative regional economies firms are embedded in an ecology rich in informal and labor market transmission mechanisms and in a web of contractual linkages among physically proximate organizations

KEY WORDS

High-Skills, Education, Innovation.

PALABRAS CLAVE

Alta Cualificación, Educación, Innovación.

which represent relatively transparent channels for information transfer that will favor knowledge transmission and therefore long-life learning and reskilling (Owen-Smith & Powell, 2014). Nevertheless, wage disparity, knowledge agglomerations and institutional quality cannot fully explain the reality, since the impact of these factors on the mobility of high-skilled workers and the economic competitiveness of regions and firms is very heterogeneous and differ from place to place (Iammarino et al., 2019). Therefore, the next sections will analyze more deeply the specific impacts of these variables in Spain and Europe as a whole.

3. MOBILITY OF GRADUATE STUDENTS IN SCIENCE AND ENGINEERING IN SPAIN

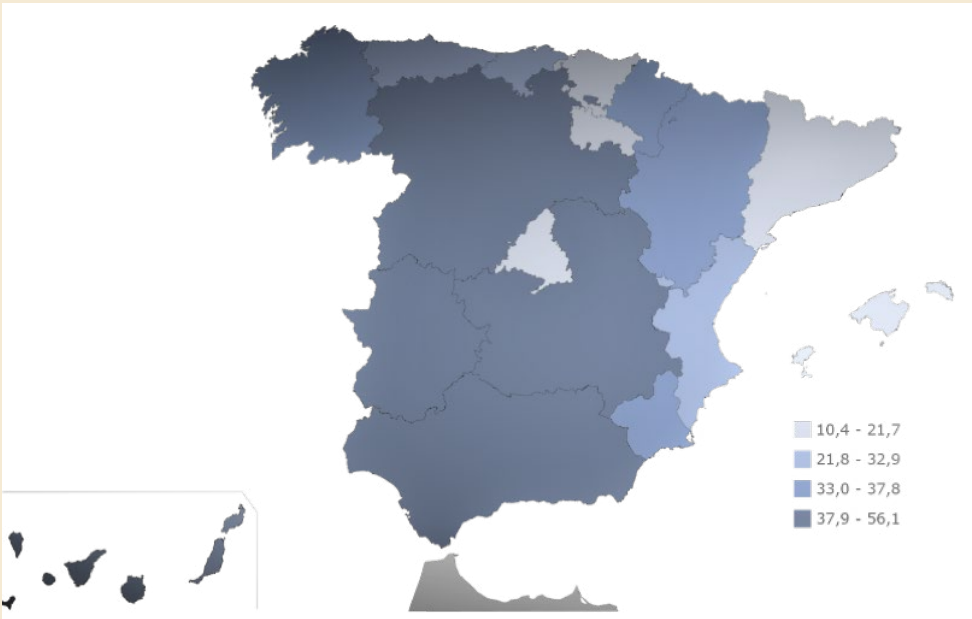
Spain is a good example of a country where the uneven regional distribution of talent shapes disparities in terms of economic development between regions (Kerimoglu, E., & Karahasan, 2012). Understanding the inter-regional mobility of skills in Spain, will help to understand the nature and reasons of the inter-regional and international mobility of high-skilled workers in similar regions. Spain has an intense interregional mobility of human capital in science and engineering. According to data from the Spanish National Statistical Institute (INE 2017), there are Spanish regions such as Castilla-La Mancha, Extremadura and Castilla y León where more than 40 percent of engineering (**Figure 1**) and science students (**Figure 2**) leave the region where they studied after graduation. These students typically move to the regions absorbing the majority of students graduated in science or engineering, which are also those with stronger economic development: Madrid and Catalonia. In Figure 1 and Figure 2, the regions with a darker color represent the regions with more than 42.2 per cent of graduate students in engineering and science migrating to other regions, three years after the graduation. Both for engineering and science studies, the regions with higher rates of brain drain are typically rural and less populated regions such as Castilla-Leon, Aragon, Galicia, Extremadura and Castilla-La Mancha. On the other hand, the regions receiving these skilled workers are Catalonia, Madrid and The Basque Country.



Figure 1. **Proportion of graduate students in engineering migrating to a work in a different region where they studied, by region.**



Figure 2. **Proportion of graduate students in science migrating to a work in a different region where they studied, by region.**



To check the factors that affect the mobility of science and engineering graduates, a regression model has been carried out for the 17 NUTS2 regions in Spain for 2011, which is the only year available related to the migration of graduate students. Previous studies for Italy (Dotti et al., 2013) or China (He et al., 2016) show that the main determinant of the mobility of graduate students is not wage disparity but the employability in the region where they have studied. That means, that in the early stages of professional development of scientists and engineers, wages are not as determinant as job opportunities for inter-regional mobility.

Therefore, our empirical model, rather than on inter-regional wage disparity, will focus more on a set of variables linked to the likelihood of finding a job in R&D-intensive sectors, such as the *Stock of R&D workers* in the region where students have completed their degree and the *unemployment levels* for science or engineering graduates in the region where students have completed their degree. In addition, variables linked to the quality of university institutions have been included in the model. The literature (i.e. Ciriaci, 2014) suggests that the quality of universities may also influence the mobility of graduate students, to the extent that students from better universities will have a better chance of finding a job in a different region. Within this second set of variables, the model measures the average quality of the universities in the region and their international exposure. More precisely, to measure the quality of universities in the region the model will consider the *Average Research Score of the region universities* in the Times Higher Education world university ranking, while to measure the international exposure of these universities we will use the *Average Internationalization Score of the region universities* in the Times Higher Education world university ranking, and the *Average Proportion of University Students* in the region that have completed international mobility stays.

The results of the robust estimation of the model shown in **Table 1** suggest that employability conditions have a significant impact on mobility, to the extent that regions with lower proportions of R&D workers or with higher rates of unemployment have a higher proportion of graduate students in science and engineering who migrate to other regions once they finish their studies. This explains the remarkable migration of graduates in science and engineering to regions with greater economic development such as Madrid and Barcelona, and to a lesser extent the Basque Country and the Valencian Community.



We have found that there are different factors explaining interregional and international migration of graduates in science and engineering. While, R&D intensity of the region, unemployment rates among science and engineering graduates and the mobility orientation of the skilled workers seem to explain interregional migration, for international migrations the main factor is the previous mobility experience of graduated students in science and engineering. This result is in line with former research suggesting that international experiences increase employability of students, since the international experience is linked to the forging of networks, opportunities for experiential learning, language acquisition and the development of soft skills related to cultural understandings, personal characteristics and ways of thinking (Crossman & Clarke, 2010).

Table 1. **Factors explaining the mobility of graduated students in science and engineering in 2011, three years after the graduation.**

	INTERREGIONAL MOBILITY OF SCIENTISTS	INTERREGIONAL MOBILITY OF ENGI- NEERS	INTERNATIONAL MOBILITY OF SCIENTISTS	INTERNATIONAL MOBILITY OF ENGI- NEERS
High-Skilled Workers Unemployment Rate	0.07***	0.28**	0.06**	0.57
R&D Workers Stock	-0.23***	-0.13*	0.17	0.18
University Students Mobility	1.63***	1.10***	1.15*	1.14
Regions University Internationalization	2.02	0.76	2.74	1.17
Regions University Research Ranking	-2.05	-0.75	-2.80	-0.16
Constant	8.94***	7.05***	5.25**	4.81
R ²	0.77	0.79	0.58	0.76

The results for Spain confirm that workers who are more qualified to be employed in innovative activities and companies tend to leave less innovative regions since these regions offer less job opportunities that match their skills. The loss of these skills means that firms and research organizations in these regions will find more difficult to recruit appropriate talent to support their innovative activities. Aggravating the gap between skilled workers' stocks can perpetuate interregional differences in terms of innovative capacity and economic development. On the other hand, at least for interregional

mobility, the quality of the tertiary education seems not to be relevant in fostering mobility of high-skilled workers. One of the reason is that on average more economically developed regions have better universities in Spain. In Spain, there are only nine universities among the 600 best universities in the world according to the Times Higher Education ranking. Seven out of these top universities are located in Madrid or Barcelona, and the remaining two are located in Navarra and Valencia, which are regions with lower levels of mobility. None of the regions exporting skills have universities with good reputation.

4. IS THE CONCENTRATION OF HIGH-SKILLED WORKERS IN EUROPE INCREASING?

In addition to inter-regional mobility of high-skilled workers one of the main goals of the research is to understand international mobility of these workers. It is well known that high-skilled workers tend to concentrate in certain regions such as Silicon Valley, Boston, Singapore, London, Paris or Bayern which attract skilled professionals not only from other regions in their countries but also from regions abroad. We want to look at this phenomenon in Europe. In fact, the question we resolve in this section is to examine whether the concentration of high skills in a few European regions is a growing phenomenon or not. The answer to this question will confirm if the different wealth redistribution policies undertaken by European governments and the European Commission for years have been able to reverse the inter-regional differences that provoke inter-regional mobility of high-skilled workers. To answer this question, we analyzed the evolution of the stocks of scientists and engineers from the European regions (at NUT2 level) of the European Union and Norway from 2007 to 2017.

A first indicator that can give us information on what has happened is the measurement of the stock of scientists and engineers in the regions that are European poles of attraction of skills. We will consider for the sake of this research as a pole of attraction of skills those regions grouped in the 95th percentile in terms of stock of engineers and scientists in 2007. The regions within the 95th percentile in terms of stock of engineers and scientists in 2007 were Ile de France and Rhone-Alpes in France, Bayern, Dusseldorf, Stuttgart and Koln in Germany, Madrid and Catalonia in Spain, Mazowieckie in Poland, Outer London in the United Kingdom, Southern Eastern Ireland in

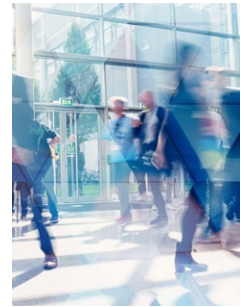


Ireland and Lombardy in Italy. In 2007, these regions concentrated a total of 2,669,000 engineers and scientists, which represents the 23 per cent of the total 11,592,000 scientists and engineers in our sample of countries.

Ten years later, in 2017, the stock of scientists and engineers grew significantly in Europe up to 18,448,000 individuals. During this decade, the regions in the 95th percentile have undergone some changes. First, new regions have joined the group of regions in the 95th percentile, such as Inner London in the UK or Berlin in Germany, while some other regions such as Dusseldorf left the group. The total number of scientists and engineers in these poles of attraction has grown to 4,009,000 scientists and engineers in 2017. Despite this growth, it can be said that in general terms the concentration of the stock of scientists and engineers has diminished in Europe, as the proportion of scientists and engineers in the 95th percentile went down to 20 per cent of the total stock in our sample. That is, although in absolute terms there has been an increase of more than 1.3 million scientists and engineers in three years in these leading regions, in relative terms there has been a reduction of three percentage points. Therefore, it seems that European policies to promote a more homogeneous development of the stocks of scientists and engineers have been successful. However, a more detailed analysis of reality reveals certain important nuances that should be included in this commentary, as the reality of European regions is much more heterogeneous than global statistics might suggest. **Figure 3** shows the contribution of each region to the increase in the stock of scientists and engineers in Europe between 2007 and 2017.

The regions represented with a red colour are those regions that are in the 95th percentile in terms of contribution to the increase of the European stock of engineers and scientists between 2007-2017. Brown regions are between 50 and 95 in terms of this variable, the darker the brown colour the closer the region is to the 95th percentile. Blue regions are below the 50th percentile, and the darker the blue colour the lower the percentile of the region.

Graph 3 shows how some of the regions that already had a high concentration of engineers and scientists in 2007 such as Outer London, Madrid, Catalonia, Oberbayern, Stuttgart, Lombardy or Rhone Alps have also registered a strong growth in the stock of scientists and engineers in the last decade. As shown in previous section for Spain, in some other countries there is also a “capital



effect” where some of the regions that host the capitals of their countries have also played a major role in the strong growth in the stock of scientists and engineers. Specifically, this “capital effect” can be seen in the regions of Lisbon in Portugal, Berlin in Germany, Stockholm in Sweden, Madrid in Spain, London in the UK or Vienna in Austria.

At the country level, the UK has experienced the strongest growth in the stock of engineers and scientists over the last ten years. There has been a strong growth in the stock of engineers and scientists in the regions of Inner London, Surrey, Sussex, Berkshire, Buckinghamshire, Oxfordshire, Gloucestershire, Wiltshire, Bristol/Bath, East Anglia, Derbyshire, Nottinghamshire, Greater Manchester, West Yorkshire and Eastern Scotland. This reflects the growing concentration of scientists and engineers in the South East of England, Manchester area, Edinburgh area and London.

Among the regions with the highest concentration of engineers and scientists in 2007, the French region of Ile de France is an anomaly, as in the last decade it has experienced a reduction in the stock of engineers and scientists by 27,000 individuals, 5 percent of those recorded in 2007.

In order to study in greater detail the motivations, we constructed a model that explains the factors that influence the greater or lesser growth of the stock of scientists and engineers in these European regions (**Table 2**). Within the different factors considered in the model, a first group of variables were linked to the regional labor market, such as the unemployment rate, the wage disparity and the quality of the regional institutions. The model expects that regions with lower unemployment rates (Eggert et al., 2010), higher average wages (Liu & Shen, 2017) and higher quality institutions (Charron, & Rothstein, 2016) will be more able than other regions to both retain and attract high-skilled workers. Therefore, we would expect that high scores on these variables are associated with higher relative growth in the stock of engineers and scientists compared to other regions in Europe. A second group of variables in the model measures the effects of knowledge agglomerations. These variables simply reflect the broad literature that explains how agglomeration economies and knowledge spillovers tend to favor the local concentration of high-skilled workers. The variables that reflect this effect in the model are the initial stock of scientists and engineers, the intensity in workers with tertiary education (Carrington, 1999), the intensity in medium-skilled workers



as a necessary complement to the productivity of high-skilled workers in high-tech industries (Christopherson & Clark, 2007) and the improvement in a region's innovative capabilities measured by the score in the Regional Innovation Scoreboard (Zaetel, 2006). GDP per capita of the region has been introduced as a control variable.

Graphic 3. **Contribution to growth.**

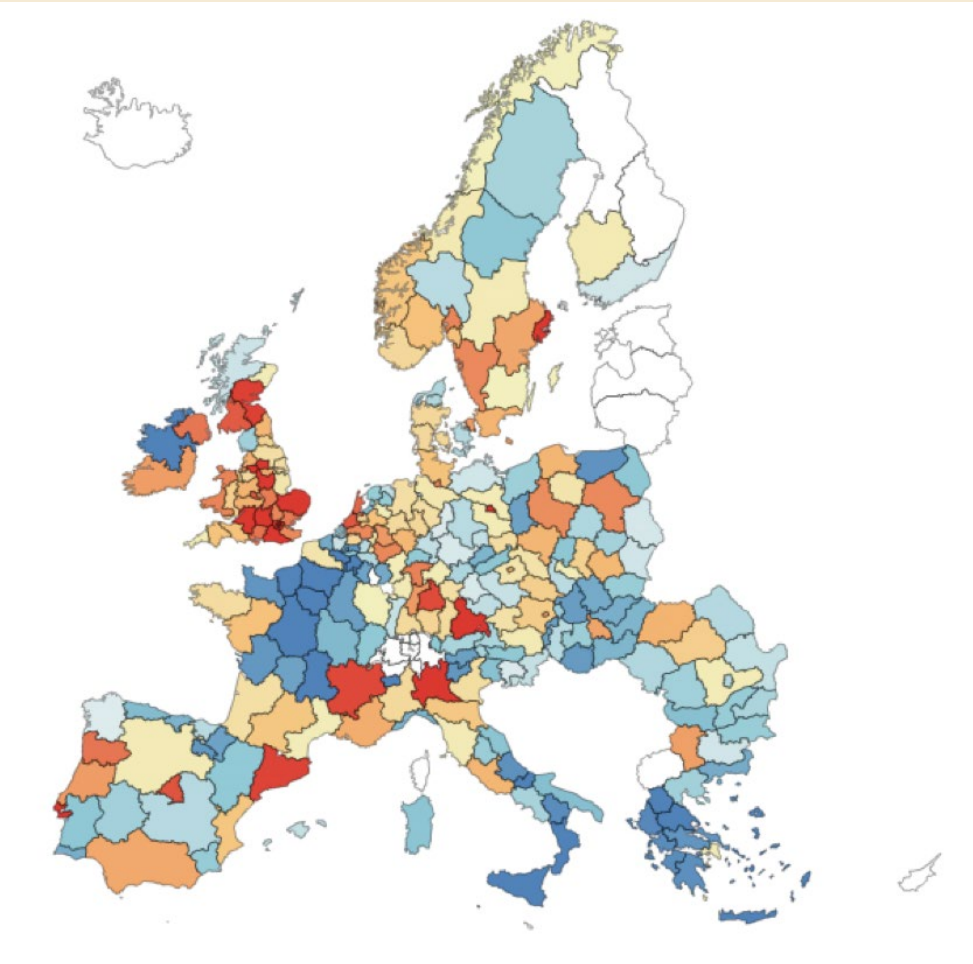


Table 2. **Variables for the estimation of the factors that explain the growth of the stock of scientists and engineers in European regions.**

Relative Increase in the Stock of Scientists and Engineers	(Moving Average Stock of Scientists and Engineers region i year 2017-Moving Average Stock of Scientists and Engineers region i year 2007)/(Moving Average Stock of Scientists and Engineers Europe year 2017-Moving Average Stock of Scientists and Engineers Europe year 2007)	Eurostat (2019)	Jacobsson & Os-karsson (1995)
Unemployment rate	Unemployment rate of region i in year 2007	Eurostat (2019)	Eggert et al., (2010)
Wage Disparity	Average Wage Region i year 2007/ Maximum Regional Average Wage for Country j year 2007	Eurostat (2019)	Liu & Shen (2017)
European Quality of Government Index (EQI)	Aggregated index built from three components: quality, impartiality and corruption	Quality of Govern-ment Institute of Gothenburg University (2017)	Charron, & Roths-teïn. (2016)
Initial Stock of Scientists and Engineers	Number of scientists and engineers in region i in 2007/ Number of scientists and engineers in Europe in 2007	Eurostat (2019)	
High Skilled Workers	Proportion of the population with tertiary education in 2007	Eurostat (2019)	Carrington (1999)
Medium Skilled Workers	Proportion of the population with upper secondary education in high tech industries in 2007	Eurostat (2019)	Christopherson & Clark (2007)
Variation in Regional Innovation Capabilities	Innovation Scoreboard 2017 – Innova-tion Scoreboard 2009	European Commis-sion (2019)	Zaletel (2006)
GDP per capita	GDP / Total Population in 2007	Eurostat (2019)	

The robust results of the estimation of the censored regression model confirms only partially the hypotheses. Regarding the relationship between labor market characteristics and skills concentration, only the variable measuring the *Unemployment Rate* of the region has a statistically significant relationship. In this sense, the stock of scientists and engineers will grow more in those regions with lower unemployment rates, confirming the results already observed for Spain. *Wage disparity* does not provide any statistically significant result, similarly to the variable *Quality of Regional Institutions*. The lack of statistically significant results can be explained by two theoretical arguments. In first place, workers face strong information asymmetries related to the average wages and the quality of

regional institutions specially in more distant regions. Together with social and language barriers, these asymmetries explain why inter-regional mobility is more frequent than international mobility. In fact, with some exceptions such as London or Bayern, the “capital effect” discussed above refers more to national patterns of skills mobility than to international flows towards capital cities. For instance, the concentration of engineers and scientists in Mazowieckie, Madrid, Berlin, Stockholm or Vienna reflects more the attraction force of these regions for scientists and engineers from nearby regions in their country. In that sense, these capital cities create unconnected islands of innovation in their countries. Contrasting to these islands of innovation, the analysis shows the existence of valleys of innovation formed by interconnected innovative regions with more distant knowledge exchanges. We can see one of these “innovation valleys” running from the Rhone-Alps and Lombardia, running through Switzerland and, Baden-Wuttenberg, Stuggart, Bayern up to Noord and Zuid Holland in the Netherlands. There is another “innovation valley” in terms of agglomeration of scientists and engineers connecting the South-East of England with Manchester through London and the Midlands.

Related to the knowledge agglomeration hypothesis, we can see in the results that this hypothesis is confirmed by both variables related to the innovation performance of the region and the proportion of workers with tertiary education. The results confirm previous research on the existence of a complementarity between engineers and scientists and other workers with tertiary education. However, the complementarity between the stock of engineers and scientists with the stock of workers with upper secondary studies is not confirmed. Probably, this complementarity, observed previously in the literature, is more specific of a few industries and regions, since the set of skills of workers with upper secondary studies is quite heterogeneous throughout Europe due to the lack of a standard European curriculum. The remaining variables do not provide statistically significant values (**Table 3**).

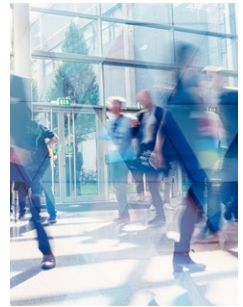


Table 3. Results of the estimation of the factors that explain the growth of the stock of scientists and engineers in European regions.

RELATIVE INCREASE IN THE STOCK OF SCIENTISTS AND ENGINEERS	COEFFICIENT
Unemployment rate	-0.00073**
Wage Disparity	0.00201
Quality of Regional Institutions	-0.0003
Tertiary Education	0.00323***
Initial Stock of Scientists and Engineers	0.00050
Upper Secondary in High Tech Industries	0.00069
Variation in Regional Innovation Capabilities	0.00203***
GDP per capita	-0.00076
Constant	0.29047***
Log Likelihood	1267.54
N	222
LR chi2	136.16
Prob>chi2	0.00000

5. CONCLUSION

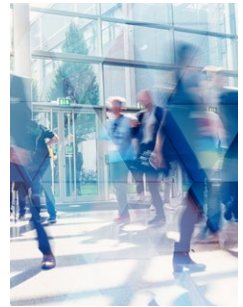
This research has analysed the phenomenon of geographical concentration of high skilled workers. The study has been carried out from two levels of analysis: the inter-regional mobility in Spain, and the international mobility in Europe.

For both levels of analysis a common conclusion is reached: the geographical concentration of scientists and engineers depends on the unemployment rate of the region in which they are located. The explanation for this fact is to be found in the greater mobility of scientists and engineers with respect to other categories of workers with fewer skills. In the analysis that has been carried out on the mobility of undergraduate students in Spain, it is shown that in several Spanish regions, the migration rate of graduate students in science or engineering is over 40 percent. Therefore, in the face of unfavorable labor markets, scientists and engineers are favored by a growing demand from those regions with an economic structure appropriate to their skills. The importance of the appropriate economic structure has been confirmed by the study that shows how economic models based more on high skilled workers and the development of robust regional innovative capabilities are the main factors in the development and

retention of high stocks of skilled workers. In this sense, the results of the study seem to indicate that a distinction must be made between economic structure and wealth. The non-significant results for the variables of wages or GDP per capita suggest, at least for the data analyzed, that the attraction of scientists and engineers cannot be based solely on high wages, but needs an adequate environment. This conclusion has important implications, since it means that regions wishing to increase the stock of scientists and engineers can not only rely on economic incentives, such as the tax-bonuses offered by several European countries to high-skilled workers, but must first seek to develop a business and industrial structure that will serve as a long-term basis for the career development of skilled workers. This argument is in line with recent research that shows how skilled workers respond better to incentives linked to their long-term professional development and life-long learning compared to short-term incentives based on salaries.

However, the departure of their scientists and engineers plunges regions into a vicious circle when it comes to developing an appropriate industrial structure. Regional governments in non-innovative regions face a chicken-egg challenge because of the endogenous relationship between skills and economic growth. Apparently, there are some common patterns in those regions in Taiwan, Rwanda, Chile or India that suggest that regions should start by a combination of policies aiming at both creating a large stock of high-skilled workers with low wages and policies to attract investment of foreign multinationals, which are the foundation of new innovation ecosystems in those regions.

The implications for firms' managers in non-innovative regions are similar. First, firms in these regions should offer jobs with tasks that match the skills of high-skilled workers, otherwise workers risk falling into the overqualification trap. This overqualification trap has some serious implications for firm performance. On one hand, former research shows that relying on an overqualified workforce may further damage the company's innovative capacity (Sandulli & Fernandez, 2019). Therefore, hiring high-skilled workers for jobs designed for lower skills may have the opposite effect as expected by reducing firm innovative performance. Second, in the middle and long term underemployment will limit firms' ability to retain high-skilled talent in the company. The results of this research point in the direction that high-skill workers make decisions about where



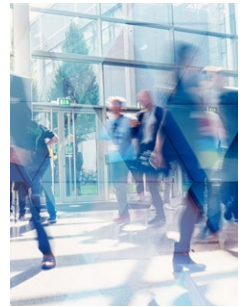


to work based more on long-term incentives such as professional career development than on short-term incentives based on wage premiums. In fact, recent research shows that expected wage gains of high-skilled workers are simply the long-term result of knowledge spillovers produced in knowledge agglomeration areas which lead to workers increasing capabilities over time (Lehmer & Ludsteck, 2011). High-skilled workers in non-innovative regions will expect lower wage gains in the long-term because of weaker knowledge spillovers which limits the development of their own capabilities. Therefore, firms in non-innovative regions willing to attract high-skilled workers should compensate for the lack of knowledge spillovers by creating programs aimed at reinforcing existing workers capabilities or building new capabilities. Therefore, training programs or intrafirm job mobility programs can play a more relevant role in attracting and retaining talent in those firms located in non-innovative regions compared to firms in knowledge agglomeration areas.

Finally, from the point of view of policy-making the research confirms that the challenge of regional integration has two level of analysis: islands and valleys of innovation. At the national level, we have shown in several countries the presence of islands of innovation, mostly in capital-city regions, that attract large proportions of high-skilled workers from neighboring regions. This is the most common form of high-skilled workers mobility in Europe, where high-skilled workers flows between more distant regions is less frequent than in the US or China. From a policy level, the existence of these islands have some relevant implications. On one hand, these regions create asymmetric knowledge agglomerations that favor their competitiveness and economic growth, but create demographic and economic imbalances in the whole country. In countries with islands of innovation such as Spain, Poland or Sweden the success of policies to fight regional inequalities depends on the capacity of governments to attract a minimum scale of firms and industries needed to break the vicious circle whereby the greater the agglomeration in the islands of innovation, the greater the difficulty of non-innovative regions to retain skills and talent needed to reorienting their productive structure towards higher value-added industries.

We have also described in this research the existence of valleys of innovation formed by regions linked by interconnected flows of knowledge and workers. There is one valley of innovation from ranging from Lombardia and Rhone Alps, crossing the center of

Europe through Switzerland, Baden-Wuttenberg and Bayern up to Nord and Zuid Holland, while there is another valley of innovation that covers from South-East of England to Manchester, through London. One of the natural solutions to these challenges would be the knowledge spillovers from innovative regions to less-innovative regions through the return of high-skilled workers to their home regions (Klagge & Kleinn-Hitpab, 2010). However, compared to the other parts of the world such as the US, more restrictive labor regulations and lower migration in Europe curtails these returning knowledge spillovers (Lee & Rodriguez-Pose, 2013). These institutional restrictions to knowledge flows also limit the capability of the valley of innovation from north Italy to the Netherlands to become a real central and integrated hub of innovation for Europe similar to Silicon Valley in the US. On the other hand, before the Brexit the valley of innovation in England benefited from lower institutional constraints to skills mobility that helped to build a solid economic growth based on high-value industries. However, more restrictive immigration regulations in the aftermath of Brexit deal may pose a serious risk also to the capabilities of the British valley of innovation.



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