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# Aging and IoT: Developing innovative solutions in a Quadruple Helix approach

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### Abstract

The paper investigates, through the use of a case study, how local firms can promote technological advancements in a very specific field, such as the one of ICT and IoT applied to the care of elderly people, benefiting from relationships with institutions, enterprises, universities and users in a Quadruple Helix Model. The firm selected, which is launching innovative solutions and systems of connected care and wellness, provides evidence on how technological improvement can flourish if a collaborative approach is followed.

**JEL Classification:** *O14; O35; O38*

**Keywords:** *Aging; Innovation; Quadruple Helix*

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# 1 Introduction

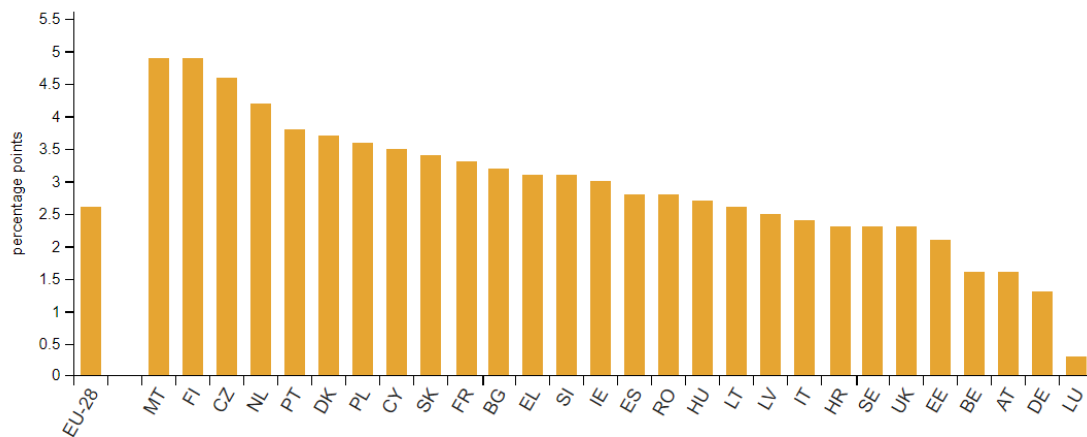
Due to the decline in fertility and improvement in survival, the percentage of elderly is increasing throughout the world. As the average age of populations continues rising, governments are called to implement policies to support the needs and interests of older persons (United Nations, Department of Economic and Social Affairs, Population Division, 2017). A great range of solutions can be provided by new technologies aimed at improving elders' everyday life and home care (Iwasaki, 2013). Indeed, innovation strategies supporting elderly are part of the European Smart Specialization Strategies (S3) with the priority of Active and Healthy Aging. However, the complexity behind the definition of innovation strategies and technological advancements requires the participation of different stakeholders (Foray *et al.*, 2012). Their involvement can take place in the form of triple helix (TH), which is a model involving government, industry and academia (Etzkowitz *et al.*, 2007) expandable to a quadruple helix (QH) including civil society (Carayannis and Campbell, 2009).

Among European regions, the Marche region in Italy has focused on the S3 priority of Ambient Assisted Living and health industry. The priority is aimed at increasing the provision of smart and high-quality personal care products/services with a focus on solutions and models for active longevity. To gain a better comprehension on how a QH approach can promote technological development for supporting elderly in the Region, we consider the case of a firm, ADiTech S.r.l. Our aim is to understand how the QH methodology can foster innovation and help developing ad hoc solutions in the market for the elderly. The firm chosen is based in the Marche Region and it was selected for its high involvement in national and international projects, which ensure the involvement of different stakeholders as the QH approach implies; these projects are recognized by the firm as a source for introducing innovative solutions and systems of Telemedicine, Home Care and Wellness. The article is structured as follows. After describing the aging challenge in Europe, the role of new technologies for the elderly is presented, focusing on the need for collaborative approaches. Secondly, the methodology and case study are discussed. Lastly, conclusion and future research suggestions are drawn.

## 2 An overview of aging in Europe

By 2050, it is expected that there will be 2.1 billion people over the age of 60, compared with 901 million in 2015 (United Nations, 2015). Looking at Europe, as presented in the figure below, the share of the population aged 65 or over between 2008 and 2018 has increased among all countries, registering an average growth of 2.6%. The greatest increase was recorded in Malta (4.9%), followed by Finland (4.9%), Czechia (4.6%) and the Netherlands (4.2%), while the lowest increase was recorded in Luxemburg (0.3%). Italy's rate was slightly below the EU-28 average (2.4%).

Moreover, the total European population is expected to increase from 511 million in 2016 to 520 million in 2070, while the working-age population (people aged between 15 and 64) will decrease significantly from 333 million in 2016 to 292 million in 2070. The old-age dependency ratio (people aged 65 and above relative to those aged 15 to 64) in the EU is projected to increase by 21.6 percentage points, from 29.6% in 2016 to 51.2% in 2070 (European Commission, 2018). Over the next two decades, the ongoing demographic shift could put a significant strain on the European economy, society and on the sustainability of public finances. Therefore, policies towards the "Silver Economy", defined as the economic opportunities arising from the

**Figure 1:** Share of the population aged 65 or over between 2008 - 2018

public and consumer expenditure related to population aging and the specific needs of the population over 50 (European Commission, 2015), are increasing. The Innovation Partnership on Active and Healthy Aging of the European Commission, under the Innovation Union, is one of the major steps forward in this field.<sup>1</sup> The development of new skills and entrepreneurship meeting the needs of an aging population is supported not only by the new Knowledge and Innovation Community on Healthy Living and Active Aging under the European Institute of Technology but also by European Regional funding. As a matter of fact, 110 European regions have identified Active and Healthy Aging as a priority in their Smart Specialization Strategies (S3), which are place-based approaches embracing a broad view of innovation including - even if not limited - to technology-driven approaches. These findings are complemented by national and sectoral initiatives that provide examples for public policy actions, including voluntary norms and quality labels for Silver Economy goods and service providers, which could contribute to competition and cross-border market exploitation at a European scale.<sup>2</sup>

### 3 Innovation in aging: Towards collaborative approaches

Many countries strive to deal with the increasing number of service requirements for the elderly. This is why improving elders' lifestyle quality on one hand and decreasing the costs of healthcare and services, on the other hand, are crucial challenges faced by governments. The United States have the most expensive healthcare system in the world, and the costs for elderly care are continuing increasing (Rahtz and Sirgy, 2000). In the EU, the total cost of aging, including public spending on pensions, health care, long-term care, education and unemployment benefits, is expected to increase by 1.7% to 26.7% of GDP between 2016 and 2070 (European Commission, 2018).

Rooting technological innovation into elders' everyday life and home care is an answer to prevent elders' dependence and support their independence (Iwasaki, 2013). Palumo *et al.* (2014) proved that home-assisting technologies are entering the market and that such technologies are

<sup>1</sup> [http://ec.europa.eu/research/innovation-union/index\\_en.cfm?section=active-healthy-aging](http://ec.europa.eu/research/innovation-union/index_en.cfm?section=active-healthy-aging)

<sup>2</sup> <http://ec.europa.eu/research/innovation-union/pdf/active-healthy-aging/silvereco.pdf>

moving from the research and development stage to mass production. Furthermore, [Kohlbacher and Hang \(2011\)](#) expressed that the market of elderly is an excellent field for disruptive innovation application since the elders' demand for new, easy to use, and affordable products and services is continuing to grow. In this scenario, as underlined by [Melkas \(2013\)](#) the adoption of technology is a multi-disciplinary and complex process and its success will depend on technology application, costs and marketing.

Gerontechnologies and social innovations can be considered as essential components of the Silver Economy. Gerontechnologies are related to the study of technology, products and services dedicated to older people, designed to assist them in most of the aspects of life starting from health and self-esteem, housing and daily living, mobility and transport, communication and governance to work and leisure ([Burdick, 2007](#)). This area involves designing electronic aids for daily living such as telework solutions, detectors, alarms, sensors, equipment to overcome impairments in hearing and sense of smell and bathroom systems. On the other hand, social innovation refers to new strategies, concepts, products, services and organisational forms aimed at satisfying the needs that arise, especially on the edges of various sectors of the social system ([O'Sullivan et al., 2010](#)).

The complexity of these technologies requires the participation of different stakeholders, starting with the design of innovation strategies ([Foray et al., 2012](#)). The interaction by different stakeholders becomes relevant in innovation processes in the form of triple helix (TH), which is a model involving government, industry and academia ([Etzkowitz et al., 2007](#)).

Taking into account S3, regions seems to be highly challenging with the adoption of new approaches ([Iacobucci, 2014](#)). Indeed, the involvement of various stakeholders is a central argument emphasized by the S3 Guide ([Foray et al., 2012](#)), which addresses governance as a sophisticated form of shared process management, between actors all striving towards a shared future outcome. Moreover, the TH model has been extended towards a quadruple helix (QH) by maintaining the interaction of the spheres of the TH, formalising the role of civil society ([Yawson, 2009](#)) and extending the range of actors towards a fourth category identified as innovation users ([Arnkil et al., 2010](#)). According to this model, citizens would not only be involved in the actual development work, but they would also have the power to propose new types of innovations, which connect users to stakeholders across industry, academia, or government ([Arnkil et al., 2010](#)).

## 4 Methodology

The methodology adopted in this work falls within the qualitative research methods. Qualitative research can be employed to study the less concrete aspects such as “the meanings, concepts, definitions, characteristics, metaphors, symbols and possibly the description of things” ([Berg, 2007](#), p.3). Accordingly, the use of a qualitative research method for this research is deemed more suitable for examining experiences of firms and their involvement in the active aging field, in order to gain a deeper understanding. Among the different qualitative methods, the paper adopts a case study approach,<sup>3</sup> according to the definition provided in [Thomas \(2011, p. 513\)](#).

Case studies are analyses of persons, events, decisions, projects [...] or other systems that are studied holistically by one or more methods. The case that is the subject of the inquiry

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<sup>3</sup> Case study research is widely used in the social sciences. A study by [Bennet et al. \(2003\)](#) shows that, by analysing 14 journals focusing on 2 areas of research in social science, the proportion of articles employing case study analysis was around 20% in the period 1975-2000.

will be an instance of a class of phenomena that provides an analytical frame - an object - within which the study is conducted and which the case illuminates and explicates.

This paper is based on one case study selected as revelatory for understanding how a QH approach can promote technological solutions for addressing the aging challenge in the Marche Region. This research adopted a constructivist and interpretivist approach to understand the phenomenon from an individual's perspective and examine the interactions between individuals, whilst taking into consideration the historical and cultural contexts (Creswell, 2009; Scotland, 2012). Accordingly, the approach chosen for this research needed to provide flexibility to the participants to enable them to have a voice to share their respective experiences. For this reason, the method adopted consists in semi-structured interviews through questionnaire,<sup>4</sup> which allows to examine the reflections of the managers' experiences when facing businesses related to active aging and to gain an in-depth perspective of their thoughts.<sup>5</sup> The methodology here described has been applied by developing an interview protocol available in Appendix A. The interview was delivered as a face-to-face interview of 2 hours addressed to the President of ADiTech. The interview is composed by 8 open-ended questions which can be grouped in two areas: the first four questions concerning the connection between the aging challenges and the products or services that the company offers in order to face these challenges; the other questions, instead, want to explore the level of awareness and participation of the company interviewed within national and regional smart specialization strategies related to Active and Healthy Aging.

#### 4.1 The Research setting: *Addressing the aging challenge in the Marche Region*

Italy is experiencing a relative and absolute growth in its elderly population. In January 2019 the over 65 years old were 13,8 million (representing 22,8% of the total population), while the aged till 14 years old were about 8 million (13,2%).<sup>6</sup> Considering the aging index (ratio of the number of elderly persons of an age when they are generally economically inactive—aged 65 and over—to the number of young persons, aged between 0 and 14), the Marche region is placed above the Italian average (191 vs. 169).

This priority is strongly supported by the other three priorities, which are:

- smart homes for smart communities - Create an integrated home automation system, including Ambient Assisted Living (AAL) for higher comfort, safety, and energy efficiency;
- new advanced industrial automation solutions for mechatronics - Robotic, automation systems and haptic interfaces for higher performance and minimize the environmental

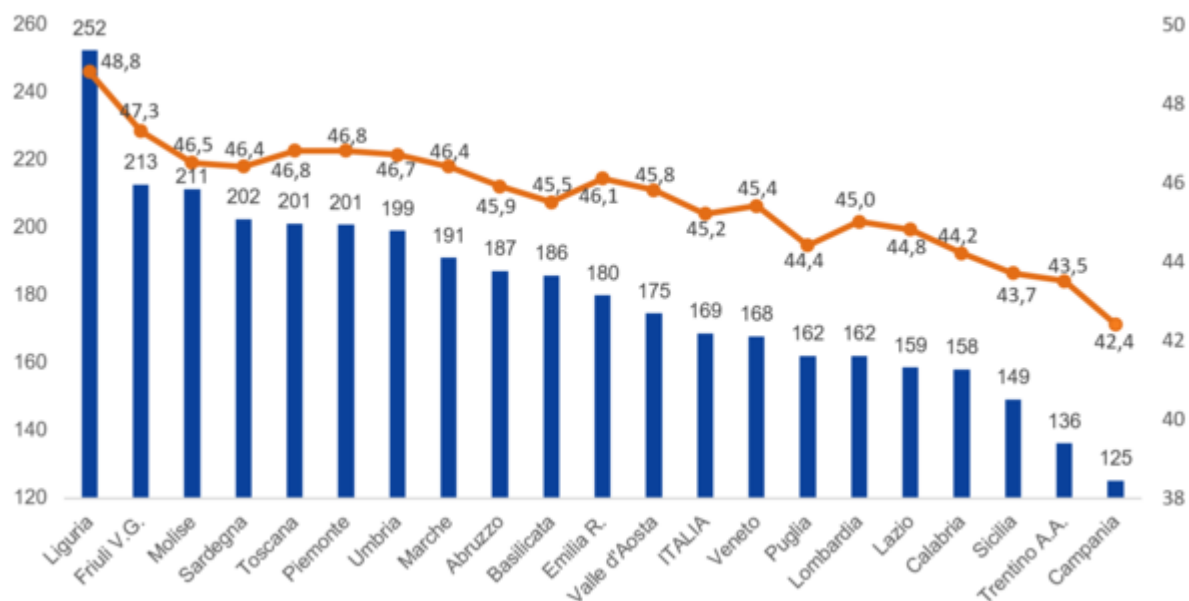
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<sup>4</sup> There are three main interview types: the standardized (formal or structured), the non-standardized (informal or nondirective), and the semi-standardised (guided semi-structured or focused) interview (Fontana and Frey, 2000; Rubin and Babbie, 2012; Nieswiadomy, 2002; Berg, 2007). The difference between these interview structures is in their degree of formality, in terms of how rigid or structured the interviews are.

<sup>5</sup> A researcher employing a semi-standardized interview technique generally develops a list of predetermined questions and prompts or identifies topics upon which to ask questions. In this format, the interviewees ask the interviewees predetermined questions in an organised, consistent, and sequential manner. However, the interviewees have the flexibility to deviate; therefore, the interviewees are allowed to “probe” further into the answers offered by the interviewees to their predetermined questions (Seidman, 2006). It is argued that the necessary and suitable questions will come up as a result of interactions during the interview (Schwartz and Jacobs, 1979).

<sup>6</sup> <https://www.istat.it/it/files/2019/02/Report-Stime-indicatori-demografici.pdf>

**Figure 2:** *Aging Index and Average Age*



Fonte.: ISTAT (2019), demographic trends

impact of different sectors, from micromechanics to biomedical. Advanced mechanical and electronic technologies applied to biomedical sciences;

- integrated and sustainable manufacturing - Application of energy-efficient and low environmental impact technologies to productive processes in the manufacturing industries by combining innovation and labour safety procedures.

Moreover, aware of the need to involve different stakeholders in the definition and implementation of its priorities, the Marche region has focused on ensuring a collaborative governance represented by the four clusters, among which the e-living cluster, Ambient Intelligence Innovation Cluster, is included. ADiTech, the firm under analysis, is involved in this e-living cluster.

## 5 Case study—ADiTech

ADiTech S.r.l - Advanced Digital Technologies was founded in 2006 in the Marche Region for the implementation and integration of innovative solutions and systems of Telemedicine, Home Care and Wellness. The company benefits from the several years of experience of its two founders and bases its competitive advantage on its internal know-how and ability to create applications related to the rapid development of new technologies. Its strategy is to follow the needs of the telemedicine and prevention market by requiring different solutions in terms of price, performance and technology. The company is based in Italy, in the Marche region, with its headquarters in Ancona but operates also outside the local territory and abroad, where the “culture” of Telemedicine and Connected Health is more developed.



## 5.1 Problems addressed by ADiTech Technologies

ADiTech technologies try to face three main issues and related market needs: (i) prevention, (ii) chronicity and care, (iii) active aging, all by respecting the quality of life. To face these needs, the company is engaging in diversified projects and products through alliances and partnerships with leader companies in ICT. ADiTech is a leader company in the Italian and in the European market for telemedicine, wellness and homecare: its competitive advantage is based on its ability to develop new technology fast through know-how resulting from the participation to national and international projects and through an active presence in the major telemedicine organizations at national and European level. The leading product of ADiTech for addressing aging needs is the platform ADiLife. It is a platform of “connected health” with the aim to be “all-inclusive” by offering functions and services suitable for every age step and care need. A longer-lived population means an older population. Age advancing not only implicates deterioration of the physical conditions; it also brings out symptoms typical of chronic diseases. The platform can be applied to several different scenarios ranging from simple self-measurement of aerobic parameters, prevention and lifestyle, applicable to any type of user to remote care of active elderly and in long-term care patients. One of the strengths of ADiLife is to combine real-time monitoring and communication technology via chat, video communication, social networking, SMS and virtual assistant. About prevention, through the use of a series of IoT devices combined with the ADiLife App, the user is able to monitor the potentially critical parameters that affect health such as lifestyle, diets and physical activity. In this case, the user will be able to choose the IoT equipment that best suits his/her needs (food/calorie scale, non-invasive bracelet or belt that measures activity, heart rate, calorie consumption, sleep quality, stress, HRV or glucose meter, touch ECG or pressure bracelet). The data collected will be recorded in Cloud to be supervised by a health service provider, who can provide advice, guidelines or request a checkup. IoT medical devices combined with the use of the platform can also help control heart rate, single track ECG, blood pressure, blood sugar, SpO2, weight, cholesterol, hemoglobin, etc., which are critical parameters in case of chronic conditions, such as tachycardia, hypertension, diabetes. Each user will have a personal page, accessible by the operators of the service provider and with whom it will be possible to communicate via audio, video or simply chat and email. This type of service is offered to associations, nursing homes, retirement homes, or directly to users with chronic diseases and over 65 in need of additional care. The ADiLife platform can also be used in combination with activometers (movement intensity measurement devices) and sensors installed at home to monitor in a completely passive way the activity of an elderly person. These give indications on the presence or not in the house, on possible falls or sudden illness, they control for gas and smoke. Passive sensors can also be located under the mattress and measure parameters such as heart rate, breathing, sleep quality, night agitation and stress level. The user can even be equipped with a small wearable device, with rescue buttons in case of fall and GPS tracking to ensure safety at all times even when outdoors. Ultimately, the platform allows an active elderly person to live in complete freedom and safety by combining: activity, movement, vital parameters and safety.

## 5.2 The collaborative perspective

ADiTech is currently involved in initiatives linked to the implementation of the S3 strategy of the Region Marche with reference to the priority of Active and Healthy Aging. The company is

part of the E-Living (Ambient Intelligence Innovation Cluster) regional cluster. As part of the cluster, ADiTech has taken part in different awareness events, as the Smart Regions Conference in 2016 in Bruxelles to promote initiatives supported by the Region in its S3 priorities. At this conference regions, institutions, enterprises, research centers have met to discuss innovation and S3. Moreover, the company has taken part at the Expo meeting of Innov-aging, held in June 2018. The meeting organized by the Fondazione Marche<sup>7</sup> promoted a discussion on the opportunities of the Silver Economy with different stakeholders, including policy makers, researchers, scientists, representatives of the private and public sector, professional associations. The event was aimed at planning Silver Economy initiative in the Marche region, favouring the diffusion of new technologies as those of ADiTech as well as the development of a district of local enterprises on the Silver Age.

However, according to the manager: *“more initiatives should be promoted to create awareness, especially on the benefits and feasibility of new technologies for prevention. Indeed, first of all a culture on aging technologies must be developed”*.

In particular, taking into account other relationships in the region, the manager recognizes the potentiality of the emerging system of Digital Innovation Hubs in fostering strategic collaborations in the aging domain especially in the area of Big Data creating linkages with local start-ups.

Moreover, since *“Different needs of the market require a variety of products”* ADiTech has formed alliances and partnerships with leading companies in ICT innovation, with which it develops and implements solutions dedicated to home care, assisted living, teleconsultation, prevention, sport and psychophysical well-being. Some monitoring platforms have been tested in Italian hospitals. The company has linkages also with local companies for developing and testing new technologies. Further national and international collaborations and commercial relationships include Padua, Milan, Florence the Rome area, Ostia in Italy, Germany, UK, Austria, US, Canada, Brazil, Korea, China etc. As underlined in the interview the company's ultimate mission is to share the experience and know-how acquired through participation in national and international projects, with the active and proactive presence in major national and European telemedicine organizations. Due to its innovation-oriented profile, the company holds strong collaborations with universities in the region. as with the Università Politecnica delle Marche and the University of Camerino, and with universities outside the region. These partnerships concern the development of research projects in the area IoT. Moreover, training is provided to researchers and professionals at university and first research institutions to create awareness on the topic.

Lastly, as for users, these represent the starting point of all ADiTech technologies. The ADILife is a concrete example of the central role of the user, starting from the selection of the IoT equipment, collection of data and the management of a personalized page. Their role is expected to become even more relevant in shaping future technologies of the company.

## 6 Conclusions

By the adoption of a qualitative type of methodology, this paper presents a case study analysis for the company ADiTech S.r.l. active in the provision of innovative solutions and systems of

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<sup>7</sup> Fondazione Marche was formed on 26 January 2009 as part of a compensation settlement between, on one side, Francesco Merloni, Gennaro Pieralisi, Mario Pesaresi, Massimo Virgili, Walter Darini and Paolo Tanoni, and on the other side, Banca Popolare di Ancona and BPU: <http://fondazionemarche.it/en/the-foundation>



Telemedicine, Home Care and Wellness. This work has been developed using a QH approach, ie trying to understand the role of academia, civil society, industry and government in the development of the company and its growth strategy. The company analysed has been selected as a best practice case for a better understanding of the aging challenge which Europe is facing. We conducted a face-to-face semi-structured interview to the President of the company, aimed at exploring the firm's offer of products and services for answering to the aging challenge and understanding the level of awareness and participation with other stakeholders within the Active and Healthy Aging S3. The interview showed that ADiTech is fully involved in the activities promoted by the local government. ADiTech together with other companies in the field is participating in the definition of new programs for supporting the elderly through technological innovation in the e-living cluster. This collaboration is further confirmed by research and training programs in regional universities and partnerships with local companies. Moreover, the role of DIHs in the Region is considered crucial also to promote startups. However, the interview revealed that there is still a lack of awareness on the impact of the elderly for the future economy of the region and on the opportunities offered by technological development. More in general, as the manager interviewed mentioned, there is a lack of a "culture" of the role of connected health and telemedicine, which instead is far more developed outside the regional territory and abroad. For this reason, awareness events opened to citizens should be organized while defining new ways to involve them. Even if the results are based on one unique case study and results cannot be generalized, the interview points out the need to define programs to enhance user involvement and reinforce a QH approach in the aging field. Future research should provide evidence from similar companies and consider also perspectives from other stakeholders on the critical aspects and opportunities perceived in the aging industry. Quantitative methodologies could be applied to collect data from different European regions that have considered the S3 priority of Active and Healthy Aging to see in which way this priority is supported from a collaborative perspective.

## Appendix A

This Section displays the questionnaire scheme proposed to the firm object of this analysis.

1. Could you give a brief overview of your business? Is it related to the themes of Health and Active Aging? How?
2. What are the problems that your products/solutions wish to solve?
3. Describe one or more products responding to these issues. What challenges (if any) have you met in implementing your product/solution? How did you overcome them?
4. Does your product/solution is exported to Europe or has a potential to be adopted all over Europe?
5. 1. Intelligent Specialisation Strategies in your region: Considering the smart priority health and wellness, has your company participated in initiatives and events related to the definition/implementation of the S3 in the region where you are active?
6. Is the company aware of the Digital Innovation Hub context in your region/country? Has the company participated in initiatives related to its DIH partners? Which ones?
7. Positioning of the company in the regional ecosystem: What are the company's links with the various stakeholders in the region: universities (are there projects, programmes underway?) and with other companies in the area (collaboration, support?)
8. How important is user involvement? and how does the company involve the final user?

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# Invecchiamento e IoT: Sviluppare soluzioni innovative con un approccio di quadrupla elica

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## Sommario

Attraverso un caso studio, l'articolo analizza come le aziende locali possono promuovere i progressi tecnologici in un campo molto specifico, come quello dell'ICT e dell'IoT applicati all'assistenza agli anziani, beneficiando di rapporti con istituzioni, imprese, università e utenti in un modello a quadrupla elica. L'azienda selezionata, che sta varando soluzioni innovative e sistemi di assistenza e benessere connessi, fornisce la prova di come il miglioramento tecnologico possa fiorire se si segue un approccio collaborativo.

**Classificazione JEL:** *R10, O30, O34*

**Parole Chiave:** *Invecchiamento, Innovazione, Quadrupla elica*