ENGENHARIAS, TECNOLOGIA, GESTÃO E TURISMO
ENGINEERING, TECHNOLOGY, MANAGEMENT AND TOURISM
INGENIERÍA, TECNOLOGÍA, ADMINISTRACIÓN Y TURISMO

millenium 06

Millenium, 2(6), 89-97.

en

INDÚSTRIA 4.0: UM DESAFIO COMPETITIVO
INDUSTRY 4.0: A CHALLENGE OF COMPETITION
INDUSTRIA 4.0: UN DESAFÍO COMPETITIVO

Joaquim Gonçalves Antunes[1]
António Pinto[1]
Pedro Reis[1]
Carla Henriques[1, 2]

[1] *Instituto Politécnico de Viseu, Escola Superior de Tecnologia e Gestão, CI&DETS, Viseu, Portugal*
[2] *Centro de Matemática da Universidade de Coimbra, Coimbra, Portugal*

Joaquim Gonçalves Antunes - jantunes@estgv.ipv.pt | António Pinto – spinto@estgv.ipv.pt | Pedro Reis - pedroreis@estgv.ipv.pt | Carla Henriques - carlahenriq@estgv.ipv.pt

Corresponding Author
Joaquim Gonçalves Antunes
Escola Superior de Tecnologia e Gestão de Viseu
Campus Politécnico
3504-510 Viseu-Portugal
jantunes@estgv.ipv.pt

RECEIVED: 11th October, 2017
ACCEPTED: 08th January, 2018

Antunes, J. G., Pinto, A., Reis, P. & Henriques, C. (2018). Industry 4.0: A challenge of competition.
Millenium, 2(6), 89-97.
DOI: https://doi.org/10.29352/mill0206.08.00159

RESUMO

Introdução: A criação de valor na indústria dos países desenvolvidos, está a ser impulsionada pela quarta etapa de industrialização, denominada Indústria 4.0. A nova revolução industrial será impulsionada por tecnologias de informação de nova geração, como a Internet das Coisas (IoT), computação em nuvem, *Big Data* e análise de dados, robótica, computação móvel, simulação e modelação, identificação por radiofrequência ou RFID, sistemas ciber-físicos, entre outras. Abrir-se-ão novos horizontes para a indústria, sendo os desafios inúmeros, criando dificuldades para as empresas na adoção dessas tecnologias.
Objetivos: Efetuar uma revisão profunda da literatura procurando uma análise técnica dos requisitos da Indústria 4.0.
Métodos: Abordar-se-á os principais riscos e desafios associados à IoT e definiremos as medidas de atratividade regional como fatores de crescimento que devem ser implementadas para atrair empresas que perseguem o 4.0.
Resultados: A IoT (internet das coisas) une o mundo digital ao mundo físico (real), sendo considerada a rede da próxima geração ou da futura Internet. Permite dar capacidade de vida e comunicação, tanto a objetivos vivos e inanimados. A intervenção da IoT na indústria 4.0 é extrema, com uma interconexão contínua dos domínios digital e físico.
Conclusões: As perspetivas de crescimento de Portugal dependerão cada vez mais de políticas que permitam à economia competir com êxito e criar novas oportunidades de rendimento. No momento atual, existem estrangulamentos estruturais que continuam a travar o crescimento e a exacerbar as vulnerabilidades. Resolver alguns destes problemas criará as bases para um crescimento sólido nos próximos anos, mas isso apela a uma renovação do ímpeto de reformas estruturais. A indústria 4.0 pode contribuir significativamente para diminuir as referidas assimetrias regionais, contudo, será necessário melhorar as qualificações para fomentar o desenvolvimento e reduzir os elevados níveis daquelas desigualdades.

Palavras-chave: Indústria 4.0; IoT; Fatores de atractividade; Dão Lafões - Portugal

ABSTRACT

Introduction: The value creation in industry in developed countries is being driven by the fourth stage of industrialization, denominated by Industry 4.0. The new industrial revolution will be motivated by next-generation information technologies such as Internet of Things (IoT), cloud computing, Big Data and data analysis, robotics, mobile computing, simulation and modelling, cyber-physical systems, among others. This opens new horizons for industry, but the challenges are countless creating difficulties for companies in the adoption of these technologies.
Objectives: To make a powerful and deep literature revision pursuing a technical analysis of the Industry 4.0 requirements. Further.
Methods: We will address the main risks and challenges associated with IoT and define the regional attractiveness measures as growth drivers that leaders must put in place to appeal for companies chasing 4.0.
Results: IoT joins the digital world and the physical world being considered the next generation network or the future Internet. It allows to give life and communication capacity either to living beiings or to inanimate objects.
IoT's intervention in Industry 4.0 im extreme, with a continuous interconnection of the digital and physical domain.
Conclusions: Portugal's growth prospects will increasingly depend on policies that enable the economy to compete successfully and create new income opportunities. At the moment, there are structural bottlenecks that continue to curb growth and exacerbate vulnerabilities. Solving some of these problems will now lay the foundation for solid growth in the coming years, but this calls for a renewal of the impetus for structural reforms. Industry 4.0, can contribute significantly to reducing regional asymmetries. But in the longer term, skills will need to be improved to foster development and reduce the high levels of such inequalities.

Keywords: Industry 4.0; IoT; Factors of attractiveness; Dão-Lafões – Portugal

RESUMEN

Introducción: La creación de valor en la industria de los países desarrollados está siendo impulsada por la cuarta etapa de industrialización, denominada Industria 4.0. La nueva revolución industrial será impulsada por tecnologías de información de nueva generación, como Internet de las Cosas (IoT), computación en nube, Big Data y análisis de datos, robótica, computación móvil, simulación y modelado, identificación por radiofrecuencia o RFID, sistemas ciber-físicos, entre otras. Se abrirán nuevos horizontes para la industria, siendo los desafíos innumerables, creando dificultades para las empresas en la adopción de esas tecnologías.
Objetivos: Efectuar una revisión de la literatura buscando un análisis técnico de los requisitos de la industria 4.0.
Métodos: Se abordarán los principales riesgos y desafíos asociados a la IoT y definir las medidas de atracción regional como factores de crecimiento que deben implementarse para atraer a las empresas que persiguen el 4.0.

Resultados: IoT (internet de las cosas) se une al mundo digital y el mundo físico se considera la red de la próxima generación o el futuro de internet. Permite dar vida y capacidad de comunicación ya sea a seres vivientes o a objectos inanimados. La intervención de IoT en la industria 4.0 es extrema, con uma interconexión continua del dominio digital y físico.
Conclusiónes: Las perspectivas de crecimiento de Portugal dependerán cada vez más de políticas que permitan a la economía competir con éxito y crear nuevas oportunidades de ingresos. En el momento actual, existen estrangulamientos estructurales que continúan frenando el crecimiento y exacerbando las vulnerabilidades. Resolver algunos de estos problemas creará las bases para un crecimiento sólido en los próximos años, pero eso apela a una renovación del ímpetu de reformas estructurales. La industria 4.0 puede contribuir significativamente a disminuir dichas asimetrías regionales, sin embargo, será necesario mejorar las cualificaciones para fomentar el desarrollo y reducir los elevados niveles de esas desigualdades.

Palabras clave: Industria 4.0; IoT; Factores de atracción; Dão-Lafões – Portugal

INTRODUCTION

Industry is one of the pillars of the European economy - the manufacturing sector in the European Union represents 2 million enterprises, 33 million jobs and 60% of productivity growth (European Commission, 2017). On April 19th 2016, the European Commission launches the first financial support initiative with the aim of coordinating legislative policies to encourage investment in industry and create the conditions for a digital industrial revolution. The value creation in industry, in the more developed countries, is being driven by the fourth stage of industrialization, denominated by Industry 4.0. The term "industry 4.0" comprises a variety of new technologies for the digitization and automation of the production environment, as well as the creation of digital value chains (Oesterreich & Teuteberg, 2016).

The new industrial revolution will be driven by next-generation information technologies such as Internet of Things (IoT), cloud computing, Big Data and data analysis, robotics, mobile computing, simulation and modelling, radio frequency identification or RFID, cyber-physical systems, 3D printing, among others. This opens new horizons for industry to become more efficient, modernize processes and develop innovative products and services, increases quality and shortens the time to deliver products/services. However, the challenges are many, creating difficulties for companies in adopting these technologies. Huge investments, organizational and process changes, the need to reinforce skills/knowledge, are just a few challenges that companies face.

On the other hand, high technology sectors face strong competition from other regions of the globe, and small and medium-sized enterprises (SMEs), particularly in the traditional sectors, are experiencing a significant delay. In addition, there are strong regional disparities in industrial digitization (European Commission, 2017).

To implement the Digital Single Market, the European Community (2017) defined a strategy consisting of three areas of intervention: improve access to digital goods and services; create conditions to the development of digital networks and services and ensure that the opportunities for digitalisation are fully exploited by the economy, industry and employment.

The European Community has decided to encourage research into intelligent technologies. The “Horizonte 2020” Portuguese program, offers financial incentives for the development of projects such as smart cities and information communities to help develop their strategic role in terms of energy and mobility (European Commission, 2015a).

Europe can gain significant competitive advantages at the international level if it can generate a growing wave of digital innovation involving all industrial sectors. Around 60% of large industrial companies and more than 90% of SMEs feel that they are delayed in terms of digital innovation (European Commission, 2016).The creation of favourable conditions to the development of industry 4.0 encompasses many factors such as tax incentives, access to global markets, proximity to teaching and research centers, availability of capital, entrepreneurial culture, network integration, personal motivations of investors, technological infrastructures of information, business size, reluctance to change, the age of the company, financial resources and human resources (Azzoni, 1981; Schmenner, 1982; Balasingham, 2016). Certain regions, which have favourable conditions for the implementation of the industry or industrial sectors linked to innovation, have been working to stimulate the creation and development of a network of innovative enterprises, mainly small and medium-sized enterprises (SMEs), born from the entrepreneurial spirit of individuals.

Thus, the present work is an integral part of a scientific research approved by the Center for Studies in Education, Technologies and Health (CI & DETS, in Portuguese) of the Polytechnic Institute of Viseu. This project intends to make a survey of what The center region f Portugal has in terms of equipment, organization and human resources related to R & D; study the scale and nature of the technology-based business structure in the region; evaluate how the higher education institutions in the region can contribute to the capture / setting of 4th generation companies; to study which attractiveness factors are capable of

Antunes, J. G., Pinto, A., Reis, P. & Henriques, C. (2018). Industry 4.0: A challenge of competition.
Millenium, 2(6), 89-97.
DOI: https://doi.org/10.29352/mill0206.08.00159

appealing companies from the industry 4.0 and contribute to the development of integrated strategies that add value to the region of Viseu.
Thus, to respond to the objectives presented, a literature review was developed on Industry 4.0 and the main drivers such as equipment, resources, organizational structure, production technologies and products.

1. REVIEW OF LITERATURE

1.1 The Emergence of Industry 4.0

We are on the threshold of a new technological age, the fourth industrial revolution or Industry 4.0 (Magruk, 2016). According to this idea, the web network will boost the creation of intelligent processes in all phases of production, from creation, design to maintenance and recycling.
The first industrial revolution began in the 18th century with the increase of mechanical systems. The second stems from the introduction of mass production and assembly lines, at the beginning of the 20th century. The third brought computers and electronics in the early seventies. The fourth industrial revolution introduces cyber-physical systems, stemming from the fusion of the real and virtual world, where equipment, products and people are increasingly connected through the Internet (Huxtable & Schaefer, 2016). These systems interact to analyze data, predict failures, reconfigure and continuously adapt to customer needs.
The Industry 4.0 concept was first mentioned in Germany in 2011, at an event held in Hannover, as a proposal to develop a new industrial policy based on the state-of-the-art technology strategy (Mosconi, 2015). This includes cyber-physical systems, the Internet of Things (IoT) and the Internet of Services (IoS) (Ning & Liu, 2015), with on-going communication through internet that allows interaction and exchange of information, not only between humans (C2C-consumer to consumer) and between humans and machines (C2M-Consumer to machine), but also between machines (M2M-Machine to machine) (Roblek *et al.*, 2016). This communication interaction conditions Knowledge Management 4.0 (KM 4.0) (Dominici *et al*., 2016).
The transformation that is occurring in the industry 4.0 has three pillars, namely (Almada-Lobo, 2016.): *i*) production digitization (information systems for the management and production planning), *ii)* automation (data systems, production lines, machinery) and *iii)* automated data exchange (binding production sites allowing the overall management of the supply chain).
The ongoing revolution will unleash positive and negative impacts. The great challenge has to do with the destruction of a significant number of jobs, due to the change of job profiles (Kane *et al.*, 2015), which makes it necessary to change and adapt the educational offer in the field of education and the development of new professional profiles (Weber, 2015).
The transformation involves an effort of the companies/institutions. Indeed numerous challenges have been an obstacle for some companies, and sectors, to be at a more advanced phase of integration of the new technologies. Among the challenges is important to mention: high implementation costs, organizational and process changes, security and data protection, the need for qualified staff at all organizational levels able to handle with the increasing complexity of future production systems (Erol *et al*., 2016). On the other hand, the benefits in the adoption of new technologies are clearly identified: improvement of product quality, improvement of communications, time and costs saving, improvement in the relations with customers/consumers and more efficiency in development of customized products/services (Oesterreich and Teuteberg, 2016).
The latest Eurostat data available (end of 2014) showed the state of the European Union regarding the use of cloud computing by enterprises. The main findings indicate that: 19% of EU companies used cloud computing in 2014, mainly to house the e-mail systems and store files in electronic format; 46% of these companies used cloud advanced services relating to financial and accounting software applications, managing the relationship with customers or just using computers to develop daily business.
The European Cloud Initiative seeks to encourage the creation of an economy data and competitive knowledge in Europe, strengthening innovation oriented to data management, improve competitiveness and cohesion helping to create a Digital Single Market in Europe.
The European Commission created in June 2016 a specialized platform for intelligent industrial modernization. The actions to support the competence centers, such as I4MS, SAE, Fi-Ware, have led not only an increase in competitiveness of existing industries, especially SMEs, but also the creation of companies in new products and digitized services. It is the ambition of the Commission to allocate 500 million euros over the next five years on the “Horizonte 2020” incentives program budget for these actions.
In terms of human resources, workers will be increasingly specialized, will have to play short-term tasks, increasingly difficult to plan, and control increasingly autonomous equipment, integrated in decision-making decentralized procedures (Ganschar *et al*., 2013).
The increasing complexity of the industrial system cannot be managed from a centralized organizational structure. Thus, decision-making will be decentralized, based on available information, with workers or equipment using artificial intelligence as the main actors (Kletti & Zukunftskonzept, 2015). Network nodes, called intelligent factories, are linked to a longer value chain, taking into account market needs (Erol et al., 2016).

1.2 Conditions and requirements of Industry 4.0

There´s a growing number of initiatives to create technology parks and incubators, in an attempt to replicate the combination of elements such as the presence of strongly research-oriented teaching institutions, risk capital, skilled labor, social relations between agents and space, ease of transportation and communications, etc. (Barquette, 2002).

Among the new localization factors of modern industry are tax incentives, access to global markets, proximity to centers of education and research, availability of capital, entrepreneurial culture, network integration, personal motivations of investors, etc. (Schmenner, 1982; Azzoni, 1981).

The presence of educational and research institutions, capable of supporting innovative development, promotes the creation of a scientific potential necessary for the development of high technology companies (Dorfman, 1983). Despite the network development, face-to-face contacts, and therefore the physical proximity between innovative agents, continue to play a relevant role (Guedes and Hermes, 1997

The determinants of a country's innovative capacity are conditioned by the educational system, by the greater/less integration of the population into the global environment, by the transparency of the development and selection of innovative projects and by the degree of protection of intellectual property rights (Freeman, 1995). The analysis of the innovative environment of the countries reveals clear leadership from the USA, the countries of Northern Europe and Western Europe, Israel and Japan (Ushakov, 2012).

The innovative environment of any industrial enterprise is conditioned by macro environmental and micro environmental factors (Rolik, 2013). In the macro environment, four strategic areas are distinguished: social (social conflicts, transport and communication), technological (markets for technologies and scientific and technical information), economic (taxes, incentives, national/regional investment climate) and the company's environmental policy (regional plans and programs, legislative framework). It is constituted by the strategic areas of the environments, conditioning the objectives and the innovative strategies.

The macroeconomic environment includes many factors: investment in infrastructures, interest rates practiced by commercial banks, and inflows and outflows, whose relationship allows an estimate of domestic investment in the country.

In the internal (micro) it is possible to identify a set of constraints, namely: *i)* economic management capacity, market segment: level of competition, consumer relations and the establishment of partnerships; *ii)* the ability to make investments; *iii)* area of new technologies and scientific and technical information resources; *iv)* availability of fuels, energy and material and technical resources, *v)* specialized labor market, managers and workers, *vi)* prevalence of strategic impact groups (sectoral, city region, district) (Rolik, 2013).

Finally, the lack of human resources skills. Indubitably, technological transformation requires specific skills profiles of company employees. These competences can be acquired through an internal reconversion process and/or by hiring of new employees.

At the regional level, the common denominator of the different strategies should take into account the following aspects (IDA, 2012, CE, 2013):

- An "ecosystem" in which a variety of components, materials, production systems and subsystems and production services work together; a production system that prioritizes emerging technologies and new fields of research;
- Public-private partnerships should be developed in areas ranging from pre-competitive consortia to public procurement policy where support for the competitiveness of manufacturing should be encouraged;
- Creation of tools to cope with business challenges in terms of learning to identify and master the new needs of an increasingly urbanized population.

Industry 4.0 involves deep exchanges between different actors who work in electronics, computer engineering, mechanics and information technology. These networks must be particularly well-developed and supported by a well-established educational system, based on supplier-user partnerships, with market leadership in engineering and mechanical installations and with strong SME dynamics.

In regional development, the combination and creative interaction of existing actors is critical. The region must be endowed with a productive system and with a set of players with an industrial culture capable of generating dynamic processes of collective learning, which serve to reduce the uncertainty associated with innovative processes (Ratti *et al.*, 1997).

Obviously, this complex and ambitious result cannot occur without a concerted effort. The value chain follows from working together, coordinating public and private (subsidized) investments, adequate legal and financial incentives for investment, professional training of all workers that will be exposed to changes that occur at the level of organizations and the labor market.

In conclusion, regional approaches require adaptation of governance structures to enable the formulation and implementation of regional policies. In addition, the quality of government institutions has become a key factor in improving innovative

Antunes, J. G., Pinto, A., Reis, P. & Henriques, C. (2018). Industry 4.0: A challenge of competition.
Millenium, 2(6), 89-97.
DOI: https://doi.org/10.29352/mill0206.08.00159

performance on a regional scale. As such, the prevalence of good institutions has been a precondition for the development of regional innovative potential and to ensure that regional programs function properly.

1.3 Current and future applications of IoT

IoT joins the digital world and the physical world being considered the next generation network or the future Internet (Yan et al., 2008 and Castillejo et al., 2013). The IoT allows, by means of a sensor or an RFID tag (Radio Transmitter-responder) placed in a person, animal, equipment, packaging or product, among others, to give life and communication capacity either to living beings or to inanimate objects.

Although communication is not the ultimate goal of IoT, the communications network is an essential component of this system. The network provides users with a fast and inexpensive tool for sharing information, allows the possibility to connect users / objects that are geographically dispersed and offers associated service opportunities.

IoT breaks the barrier between the human world and the physical world making it possible to feel the physical world through digital means. According to Xiaopu et al. (2016) IoT is not a specific network format, but an idea, a systemic project that allows all devices and systems to work together, obtaining real-time context information, as well as getting feedback from other working systems and finally analyze the data collected. Xiaopu et al. (2016) anticipate a real revolution and business opportunity on a global scale within IoT. The data collected by the sensors must be stored and processed intelligently for the purpose of drawing conclusions. A mobile phone or a microwave oven can incorporate a sensor that provides data on its state of conservation. An "actuator" is an equipment that allows, for example, to change the temperature of an air conditioner. According to Palattella et al. (2016), the IoT paradigm revolutionizes the way we live and work with the emergence of an immense service based on the interaction between heterogeneous devices (machines, animals, people, objects, etc.).

Recently, several communication technologies have emerged that will enhance IoT's total performance. These heterogeneous, fragmented and complementary technologies, which characterize the landscape of the current connectivity, make possible connections and communication of elements unimaginable until today.

Palattella et al. (2016) divide the implications of IoT in terms of the impacts that originate in private and industrial consumption. The so-called Consumer IoT seeks to improve people's quality of life, saving time and money. It involves the interconnection of consumer electronic devices as well as of any object integrated into home environments, offices and cities. On the other hand, Industrial IoT concentrates on the integration between operational technology and information technology, as well as intelligent machines, network sensors and data analysis that can improve business-to-business (B2B) services in different sectors of activity. For example, monitoring processes in the production of chemicals, tracking the movement of vehicles, among others, or as part of a self-organized system, with distributed control without human intervention (autonomous factories).

IoT's intervention in Industry 4.0 is extreme, with a continuous interconnection of the digital and physical domain. Real-time information, the Big Data, the connection between people, objects and systems, will lead to the individualization of products and services on a large scale and thus to a change of control of the value chain.

The imagination has no limit, everything that can be sensed is capable of incorporating equipment that transmits, through a communications system, the collected data, depositing them in a cloud (virtual store of information), from which it can be develop analytical systems for information processing and thus manage, act, or allow for more accurate decision making. It is possible to provide a service or sell a product with higher added value, reducing flaws, defects, thus increasing the final quality.

According to Magesh et al. (2016), IoT products can be classified into five different categories: smart wearable, smart home, Smart City, smart environment and smart business. IoT products and solutions in each of these markets have different characteristics.

In industry, intelligent IoT systems enable the rapid production of new products, the dynamic response to demand and the real-time optimization of production networks and the supply chain, through the management of networked machines, using sensors and systems control.

Lindqvist and Neumann (2017) argue that IoT has the potential to encompass and implement a set of connected devices - including home appliances and utilities, wearables (glasses, watches, shoes, bracelets, shirts and so on). There are several examples of how mobile technology can be embedded in different accessories as a source of information, communication or entertainment for its users, both in homes and industrial buildings, as well as in industrial processes, medical devices, security devices, military equipment and other applications that today can only be imagined. Examples cited by the authors of IoT implementation are hospitals and health facilities, which tend to use devices that are remotely controlled. For example, things (objects): patient monitors, body scanners, pacemakers, defibrillators, infusion pumps, main and auxiliary power, lighting, air conditioning and many others. Also, critical infrastructure sectors, such as electric power, oil, natural gas, production and transportation, can use IoT devices such as sensors and actuators for automation and monitoring and remote control. Auto-driven and automated interconnected automobiles should be clearly regarded as things, especially on the future auto-roads.

Please see (Figure 1) the variety of applications only in the context of an intelligent private home and the ramifications it can induce to the level of a vast array of businesses. Activities may include security, irrigation, energy management (gas, electricity),

consumption (water), temperature and humidity management and precaution, ranging from air quality to smoke, gas, etc., health and more. The multiplicity of activities induced by IoT will be huge for 2020, with an estimated volume of sales and service delivery of up to 2 billion euros.

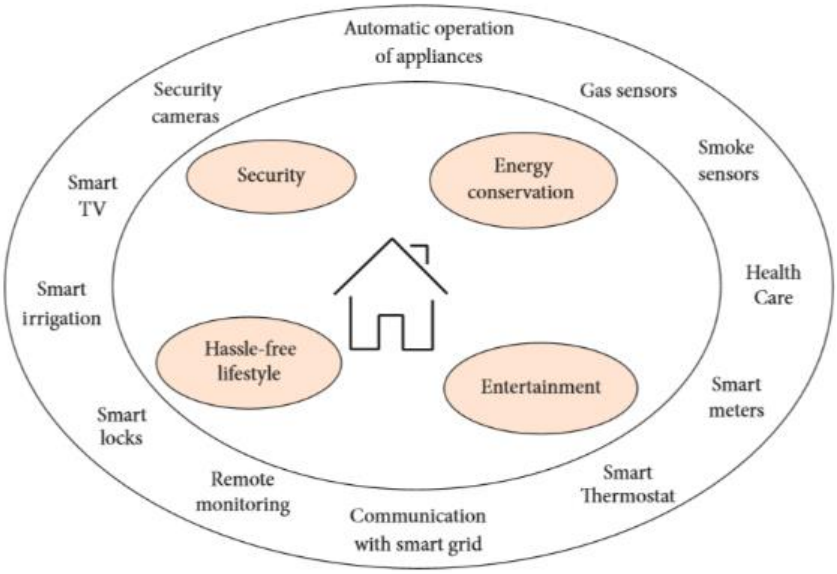

Figure 1: Example of a smart house with IoT.
Source: Sethi and Sarangi (2017), page17.

CONCLUSIONS

Portugal's growth prospects will increasingly depend on policies that enable the economy to compete successfully and create new income opportunities. At the moment, there are structural bottlenecks that continue to curb growth and exacerbate vulnerabilities. Solving some of these problems will now lay the foundation for solid growth in the coming years, but this calls for a renewal of the impetus for structural reforms. To do so, it is essential to reduce the inequalities of opportunities to make growth more inclusive in the long run. Portugal has the most unequal income distribution in Europe. Investing to boost prosperity and ensure competitiveness will be crucial (OECD, 2017).

We believe that the adoption of new technologies, such as industry 4.0, can contribute significantly to reducing such regional asymmetries. But in the longer term, skills will need to be improved to foster development and reduce the high levels of such inequalities.

The next steps of the investigation will be to conduct semi-structured interviews with entrepreneurs linked to industrial-based industry, in order to understand the factors of attractiveness and technological development, complemented by a survey of a broader sample.

ACKNOWLEDGEMENTS

We would like to thank Polytechnic Institute of Viseu, CI&DETS and Caixa Geral de Depósitos for the support of our work within the scope of the PROJ/CI&DETS/CGD/0013 project.

REFERENCES

Almada-Lobo, F. (2016). The Industry 4.0 revolution and the future of manufacturing execution systems (MES). Journal of Innovation Management, 3, 16-21.

Azzoni, C. R. (1981). Incentivos municipais e localização no Estado de São Paulo. São Paulo: FIPE/USP.

Balasingham, K. (2016). Industry 4.0: Securing the Future for German Manufacturing Companies (Master's thesis, University of Twente).

Antunes, J. G., Pinto, A., Reis, P. & Henriques, C. (2018). Industry 4.0: A challenge of competition.
Millenium, 2(6), 89-97.
DOI: https://doi.org/10.29352/mill0206.08.00159

Barquette, S. (2002). Fatores de localização de incubadoras e empreendimentos de alta tecnologia. Revista de Administração de Empresas,42(3), 1-13.

Bramanti A., Lazzeri G. (2016), "Smart Specialisation and Policy-Mix: Economic and Political Challenges Within the Italian Experience". RSA Annual Conference, Building Bridges: Cities and Regions in a Transnational World, 4-6 April, Graz.

Castillejo, P., J.-F. Martínez, L. López, and G. Rubio. 2013. "An Internet of Things Approach for Managing Smart Services Provided by Wearable Devices." International Journal of Distributed Sensor Networks 2013: 1–9. doi:10.1155/2013/ 190813.

Comunidade Europeia (2013), Relatório da Comissão ao Parlamento Europeu, ao Conselho, ao comité Económico e social e ao Comité das Regiões

Comissão Europeia, (2017), http://europa.eu/rapid/press-release_IP-15-4919_pt.htm

Dominici, G., Roblek, V., Abbate, T., Tani, M. (2016). "Click and drive": Consumer attitude to product development. Towards future transformations of driving experience. Business Process Management Journal, 22, 420-434. doi:10.1108/BPMJ-05- 2015-0076

Dorfman, N. S. (1983). Route 128: the development of a regional high technology economy. Research Policy, 12, p. 299-316.

Erol, S., Jäger, A., Hold, P., Ott, K., Sihn, W. (2016). Tangible Industry 4 . 0 : a scenario-based approach to learning for the future of production. Procedia CIRP, 54, 13–18. http://doi.org/10.1016/j.procir.2016.03.162

European Commission (2015a). Program smart cities. Retrieved from https://ec.europa.eu/energy/en/content/program-smart-cities

European Commission (2015b). The Factories of the Future.

European Commission (2016). Digitalização da Indústria Europeia - Usufruir de todos os benefícios do Mercado Único Digital. Retrieved from http://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:52016DC0180&from=EN

European Commission (2017). Digital single market. Retrieved from https://ec.europa.eu/digital-single-market/en/digitising-european-industry#Article

Eurostat (2014). Cloud computing. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Cloud_computing_-_statistics_on_the_use_by_enterprises

Freeman, C. (1995). The 'National System of Innovation'in historical perspective.Cambridge Journal of economics, 19(1), 5-24.

Ganschar, O., Gerlach, S., Hämmerle, M., Krause, T., Schlund, S. (2013).Produktionsarbeit der Zukunft-Industrie 4.0 (pp. 50-56). D. Spath (Ed.). Stuttgart: Fraunhofer Verlag.

Guedes, M., Hermes, M. H. (1997). Rio, uma cidade inteligente: parque tecnológico da Ilha do Fundão. In: Paladino, G., Medeiros, L. A. (Orgs.) Parques tecnológicos e meio urbano: artigos e debates. Curitiba.

Huxtable, J., Schaefer, D. (2016). On Servitization of the Manufacturing Industry in the UK. Procedia CIRP, 52, 46-51.

IDA - Intelligent Data Analysis (2012), The Eleventh International Symposium on Intelligent Data Analysis.

Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D. (2015). Is your business ready for a digital future? MIT Sloan Management Review, 56, 37.

Kletti, J.: Zukunftskonzept (2015). MES 4.0 Dezentrale Regelkreise synchronisieren. In: IT & Production, (4)

Lindqvist, Ulf e Neumann, Peter G. (2017). Insider risks. The Future of the Internet of Things, Communications of the ACM, 60 (2), 26-30.

Magesh, Kumar K; Vetripriya M, Brigetta A; Akila A, Keerthana D (2016). Analysis on Internet of Things and Its Application, International Journal of Scientific Research in Science, Engineering and Technology, 2(2), 1040-1047.

Magruk, A. (2016). Uncertainty in the Sphere of the Industry 4.0–Potential Areas to Research. Business, Management and Education, 14(2), 275-291.

Mosconi, F. (2015). The new European industrial policy: Global competitiveness and the manufacturing renaissance. London, England: Routledge.

Ning, H., Liu, H. (2015). Cyber-physical-social-thinking space based science and technology framework for the Internet of things. Science China Information Sciences, 58, 1-19. doi:10.1007/s11432-014-5209-2

OCDE (2017). Relatórios Económicos da OCDE. www.oecd.org/eco/surveys/economic-survey-portugal.htm. Fevereiro de 2017.

Oesterreich, T. D., Teuteberg, F. (2016). Understanding the implications of digitisation and automation in the context of Industry 4 . 0 : A triangulation approach and elements of a research agenda for the construction industry. Computers in Industry, 83, 121–139. http://doi.org/10.1016/j.compind.2016.09.006

Palattella, Maria Rita; Dohler, Mischa; Grieco, Alfredo; Rizzo, Gianluca; Torsner, Johan; Engel,Thomas e Ladid, Latif (2016). Internet of Things in the 5G Era: Enablers, Architecture and Business Models, IEEE Journal on Selected Areas in Communications, 34(3), 1-17.

Ratti, R., Bramanti, A., Gordon, R. (Eds.). (1997). The dynamics of innovative regions: the GREMI approach. Aldershot: Ashgate.

Roblek, V., Meško, M., Krapež, A. (2016). A Complex View of Industry 4.0.SAGE Open, 6(2),

Rolik, Y. A. (2013). A complex approach to evaluating the innovation strategy of a company to determine its investment attractiveness. Procedia-Social and Behavioral Sciences, 99, 562-571.

Rüßmann, M., Lozenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., Harnisch, M. (2015). Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries. The Boston Counsulting Group

Schmenner, R. W (1982). Making business location decisions. Englewood Cliffs : Prentice-Hall.

Ushakov, D. S. (2012). Innovative Capacity as a Modern Factor of Countries Investment Attractiveness Dynamic. International Journal of Organizational Innovation (Online), 4(4), 6.

Weber, E. (2015). Industrie 4.0—Wirkungen auf Wirtschaft und Arbeitsmarkt (Industry 4.0 Impact on the economy and labor market). Wirtschaftsdienst, 95, 722-723.

Xiaopu, Shang; Runtong, Zhang; Xiaomin, Zhu e Quan, Zhou (2016) Design theory, modelling and the application for the Internet of Things service, Enterprise Information Systems, 10:3, 249-267, DOI: 10.1080/17517575.2015.1075592

Yan, L., Y., Zhang, T. Yang, H. Ning. 2008. The Internet of Things: From RFID to the Next-Generation Pervasive Networked Systems. New York: Auerbach Publications.