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SKILLS TO BOOST INNOVATION - IN THE CONTEXT OF PUBLIC POLICIES

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ABSTRACT

Innovation public policy has a vital role in influencing the competitive capacity of companies and is strongly associated with their ability to innovate and the way they are organized. As important as the technological and the organization of work is the social dimension, namely, involvement, participation, and commitment of the workforce, as these are, par excellence, factors that contribute to creating added value and differentiation for companies. In this sense, the concept of innovation depends on an integrated vision between the human dimension and the other multiple dimensions that innovation can assume. Public policies besides the goal of creating a more modern and competitive business and industrial context, also are focused on the development of the workforce, not only in digital skills but also in workplace skills. This type of skills contributes to creating a more innovative context and a culture of innovation. This article goal is to make a global overview of the innovation concept and innovation skills. Also, explicitly, the research aimed to identify the critical skills and disruptive digital skills in the sphere of innovative public policies. To this end, a literature review was conducted, and an online survey explored the main critical skills for the future and the disruptive digital skills contributing to the definition and implementation of public innovation policies.

Keywords: Dynamic Skills, Innovation Skills, Digital Skills, Innovation, Public Policies

INTRODUCTION

The technological modernization of the industry, promoted by the various innovation support programs, has been a strategic choice of organizational change in the last decade for governments and public policies. The political, economic and social context that has been experienced in recent years led, to a commitment to innovation in a concerted and integrated way - not only technologically but also, and in particular at an organizational level. In this context, Public Policies can play an important role by promoting programs that contribute to improving the way companies invest in their capacity for innovation, mainly by developing workforce skills.

This article identifies the critical skills in the sphere of innovation public policies, presenting a literature survey based on the keywords "innovation skills" and "public policies" and a breve literature review about innovation and skills and identifying

three dimensions of skills which can boost innovation and help to develop strategic scenarios regarding innovation public policies in order to achieve economic growth.

LITERATURE SURVEY

The methods for this systematic review follow several phases, including the background of the research, the primary goals, the data sources and the eligibility criteria, the methods, the results, and the discussion of the results of the literature survey.

Eligibility criteria and methods

A systematic search of online scientific databases using b-on, a scientific information research tool, was conducted at the end of April 2019. The search was made using several queries, containing the terms "Innovation Skills", and "public policies".

The criteria for this studies selection were the following: a) studies which involved mapping innovation skills and public policies; b) studies involving other dimensions than public policies were also excluded; c) there were also restrictions on language (only English). Moreover, be eligible for this study, the papers had to: d) have the full-text available and e) to be published after 2015.

Results of the paper's search

The number of papers found with these queries is presented in ***Table 1***. It is interesting to note that, after introducing the time criteria: last five years (since 2015), the number of papers reduced to half of the total papers retrieved (from 409,594 to 122,103).

Table 1. *Number of Articles Found Per Query*

Keywords: Innovation Skills + Public Policies
122,103 Scientific papers in journals since 2015, last five years (2015-2020)

The next criteria are related to another query "with no expansors", and the number of retrieved papers is significantly lower (1,207); only in academic journals and in English (***Table 2***).

Table 2. *Number Of Articles – Excluding Criteria*

1,207 No expansors *786 Academic journals* *47 Subjects:* *innovation* *skills* *technological innovations* *policy* *economic development*

The number of papers are 47 according to the criteria applied for the current research.

Data Survey and Discussion

All the 47 papers were analyzed with Mendeley (Elsevier); namely, the papers titles and the abstracts were screened and the final number of papers were 29 (n=29). These papers helped to identify dimensions of analysis, expressions, and methodologies (***Table 3***) for this research and to develop the literature review.

From the literature survey three skills dimensions have emerged and will be used in the research as vectors of definition and analysis of the skills identified by the DELPHI method. In this context it is important to define these three concepts which represents the above mentioned dimensions:

Dynamic skills are those skills that are important in the workplace and for the relationships among employees and managers.

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Table 3. Innovation Skills for Public Policies

Dimension of Analysis	Expressions		Authors
Innovation skills	Corporate culture; Industrial revolution; Organizational performance; Technological innovations; bureaucratic culture; industrial revolution; innovative culture; managerial approaches; organizational culture; Industry 4.0	[1]	Mohelska, Hana Sokolova, Marcela
	Behavioural aspects; Business enterprises; Business models; Decision making; Industry 4.0; Quality culture; Quality management; Technological innovations; Technology; Total quality management	[2]	Gunasekaran, Angappa Subramanian, Nachiappan Ngai, Wai Ting Eric
	Analytical Hierarchy Process; Disruptive Technology; Disruptive technologies; Industry 4.0; Quality Function Deployment; Smart Factories; Leadership	[3]	Kasapoğlu, Özlem Akçay
	Clustering; PLM job offers; Recursive M-Means; TF-IDF; PLM Competencies	[4]	Messaadia, Mourad Ouchani, Samir Louis, Anne
	Business planning; Digitalisation; Europe; ICT; Industrial policy; Innovation; Investment; Labor incentives; Organizational change; R&D; Economic development	[5]	Gruber, Harald
	Economics Knowledge; Entrepreneur; Finance; Innovation; Innovations In Business; Innovative Entrepreneurship; Policy; Entrepreneurship -- Economic Aspects	[6]	Niculescu, George
	Business people; Economic development; Exploratory factor analysis; India; Innovation; Rural development -- India; innovation network; rural entrepreneurship; Entrepreneurship	[7]	Hukampal, Singh Sonal Bhowmick, Bhaskar
	Radio Telescopes; Science & Society; Science & State; Ska Telescope; Technological Innovations; Economic Development; Innovation; Large-Scale Science Facilities; Science Engagement; Big Science	[8]	Gastrow, Michael Oppelt, Thelma
	Employee Motivation; Market Surveys; Open Data Protocol; Open Data; Technological Innovations; Adoption; Driving Factors; Innovation; Open Data Adoption; Open Government Data; Open Innovation; Entrepreneurship	[9]	Susha, Iryna Grönlund, Åke Janssen, Marijn

Dimension of Analysis	Expressions		Authors
Digital Skills	Future skill demand; Industry 4.0; Intelligent manufacturing; Performance management; Learning Factory	[10]	Schallock, Burkhard Rybski, Christoffer Jochem, Roland Kohl, Holger
	Gig Economy; Industry 4.0; Skilled Labor; Technological Innovations; Unskilled Labor; Higher-Value Jobs; Industry 4.0 Technologies; Reskilling; Skilled And Unskilled Jobs; Structural Transformation; Gig Economy	[11]	Mehta, Balwant Singh Awasthi, Ishwar Chandra
	Business Enterprises; Ecosystem Dynamics; Skilled Labor; Technological Innovations; Industry 4.0	[12]	Tunnicliffe, Helen
	Data analysis; Digitization; Educational System; Industrial revolution; Industry 4.0; Labour Market; Manufacturing processes; Smart Enterprises; Sustainable development; Technological innovations	[13]	Habanik, Jozef Grencikova, Adriana Krajco, Karol
	Economic systems; Fourth industrial revolution; Industrial policy; Industry 4.0; Manufacturing industries; Policy implications; Social systems; Stakeholders; Technological innovations	[14]	Sung, Tae Kyung
	Digitalisation; Employment; Employment; INDUSTRY 4.0; Industry 4.0; Manufactures; Manufacturing; Skills; Technological innovations; Technological change; Digitization	[15]	Freddi, Daniela
	.Net; Artificial Intelligence; C#; Digital technology; Educational Programs; Engineering students; Fortran; Object-oriented; Programming; UML; Chemical engineering education	[16]	dos Santos, Moisés Vianna Jr., Ardson S Le Roux, Galo A C
	Career development; Corporate narratives; Crowdworking; Digital economy; Digital innovation; Digital work; Industrial revolution; Internet of things; Smart factory; Warehousing & storage; Technological innovations	[17]	Caruso, Loris
	Cyber-physical systems; Industry 4.0; Teaching Factories; Education 4.0	[18]	Mourtzis, D Vlachou, E Dimitrakopoulos, G Zogopoulos, V
	Industry 4.0; Ontology; Training; Skill; Evaluation	[19]	Arena, Damiano; Perini, Stefano; Taisch, Marco Kiritsis, Dimitris

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Dimension of Analysis	Expressions		Authors
	Digitalization; Energy Efficiency; Industry 4.0; Training	[20]	Büth, Lennart; Blume, Stefan Posselt, Gerrit; Herrmann, Christoph
	Industry 4.0; Learning Factories; Trace; Track; RFID	[21]	Louw, Louis; Walker, Mark
	3D printing; Business models; DELPHI method; Education -- Spain; Employment -- Spain; Industry 4.0; additive manufacturing; DELPHI prospection; education; employment; Three-dimensional printing	[22]	Pérez-Pérez, M Puerto Gómez, Emilio Sebastián, Miguel A
Dynamic Skills	Intuitive decision-making; Knowledge creation; Organizational performance; Rational decision-making; Knowledge management	[23]	Abubakar, Mohammed Elrehail, Hamzah Alatailat, Maher Ahmad Elçi, Alev
	Communication; Cooperative Research; Cooperativeness; Economics; Focus Groups; Group Formation; Information Sharing; Intellect; Interprofessional Relations; Innovation; Knowledge Exchange; Life Sciences; Medical Policy; Mapping Sectoral; Methods; Policy; Research Funding; Wales. National Health Service; Wales; Life Sciences	[24]	Lee Perkins, Brian Garlick, Rob Wren, Jodie Smart, Jon Kennedy, Julie Stephens, Phil
	Cultural Studies; Disruptive Technologies; Education Policy; Innovation; Labor Market; Stem Crisis; School Reform; Technological Innovations; Stem Education	[25]	Ellison, Scott Allen, Ben
	D21; Decision Making; Dynamic Model; Employee Fringe Benefits; Environmental Impact Analysis; Environmental Externality; H41; Impure Public Good; Innovation; Investments; O33; Public Goods; Q53; Technological Innovations; Investments	[26]	Corradini, Massimiliano Costantini, Valeria Mancinelli, Susanna Mazzanti, Massimiliano
	Economic development; Embeddedness (Socioeconomic theory); Emigration & immigration; Industrial productivity; Labor market; employment; innovation; labour; markets; resilience; work; Regional economics	[27]	Clark, Jennifer Bailey, David
	Cardiovascular disease; Economic development; Evolutionary theory; Innovation; Networks; Small group behavior	[28]	Brenner, M Harvey

Dimension of Analysis	Expressions		Authors
	Change; Decision making; Government policy; Latvia; innovation; innovation barriers; innovation system functions; innovative company; national innovation system; Technological innovations	[29]	Resele, Liene

Innovation skills are the ones related to the conception, management and promotion of the innovation.

Digital skills include the technological skills that are emerging and in constant change as artificial intelligence, robotics, augmented reality and others that are important in the context of industry 4.0 and innovation.

LITERATURE REVIEW ON INNOVATION AND SKILLS

The concept of innovation can be translated as "the successful production, assimilation, and exploitation of novelty," according to the Green Paper on Innovation from the European Commission [30]. The concept is structured around three pillars: the renovation and enlargement of the range of products and services and the associated markets; the creation methods of production, supply and distribution; and the introduction of changes in management, work organization and skills of the workforce - organizational innovation.

According [31], organizational innovation means applying new principles to the production of goods and services, new structures and processes, new kind of relationship between people and role models (values, attitudes, and mindsets). Researchers such as [31]; [32]; and [33], consider that it integrates concepts such as restructuring of work, extension of tasks, enrichment of tasks, semi-autonomous groups, teamwork, quality of life at work, organizational development, progress and work groups, quality circles, In a more macro view, organizational innovation does not refer only to "new" management models, "new" forms of work organization (e.g., e-work), to "new" organizational forms (e.g. network structures), but also to the development of skills as well as knowledge creation and transfer processes.

Concerning organizational innovation, [31], states that the main objectives of its implementation in companies are increasing effectiveness and efficiency of work, increased cooperation and coordination within the company, the company's ability to adapt to changes.

On the other hand, there are some factors [31] which can be more favourable to innovations: training and development of employees, the organization of work, an involvement of people in the innovation process and how the company learns and shares knowledge.

Although systems theory, other as complexity theory [34] has contributed to open new dimensions for innovation as the concept can be viewed from different perspectives, making difficult a existence of a single definition, however, there is a consensus on the fact that innovation refers to something new. Another central idea is that innovation should be something useful [35], [36], [37] this assumption differs innovations of inventions not have a

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practical application [38], [39]. Innovation is, however, a concept that is still under construction and delimitation and new concepts are emerging, as collaborative innovation, open innovation, green innovation and others that brings even more complexity, but also more possibilities of creating a culture of innovation not only for companies but also for a country itself.

Open innovation and collaborative innovation [40] refers to companies' active search for new technologies and ideas outside of the company's boundaries, but also through cooperation with suppliers and competitors, in order to create customer value. The research phase is considered as the moment of creation of all types of ideas and research projects with the support of a diversity of actors (workers, suppliers, clients, competitors, and others), and the development phase represents the moment where the ideas and projects become to be a reality but not all of them are developed within the company.

The main benefits of this type of innovation are that when companies collaborate in innovation, they share the risks, but also the successes (profits) or the failures (losses). The resources available in these processes are almost unlimited, the knowledge and the skills are diverse and also the time to market is much faster, and the investment and the cost of all process are shared by all the participants.

Other emergent concept is green innovation, and can be defined as "hardware or software innovation in technology that is related to green products or process, consists of the innovation in technology like energy-saving, waste recycling, green product designs or corporate environmental management. From the various definition of green innovation existing in the previous literature, this paper then concludes it as a new environmental approach, idea, product, and process or services that concern on minimizing negative environmental impact and also creates differentiation of developed product among competitors. Green innovation is categorized into four types of innovations including (i) product innovation, (ii) process innovation, (iii) managerial innovation, and (iv) marketing innovation" [41].

In resume, it is possible to say that in a complex environment as economies face currently it is challenging to establish a boundary among the concepts, and it is also difficult to define a very rigid profile of innovation for organizations. Depending on the situations and on the characteristics of the market [34] and also on the openness of the management [42] and the workforce skills [43], companies approach to innovation reveals a mix of types, and innovation is becoming a strategy to increase their competitive capacity.

The implementation of innovation implies that the surplus value that may come from it is perceived by all so that potential resistances can be eliminated. In this context, it is important only to contribute to improving working conditions, the development of workers and the competitive capacity of companies. These issues gravitate in the sphere of the workforce, companies and, in a more macro register, public policies.

METHODS AND TECHNIQUES

Delphi Technique

The Delphi survey methodology was chosen in order to get information from experts and academicians about possible future scenarios for Skills in the sphere of Innovation Public Policies. The Delphi expert's panel was chosen in order to cover

a maximum of differentiation of innovation contexts in order to capture different views.

This technique allows structuring individuals' contributions to achieving consensus among a group of experts. It is characterized by the anonymity that reduces certain biases as it "eliminates committee activity among the experts altogether and replaces it with a carefully designed program of sequential individual interrogations (usually best conducted by questionnaires) interspersed with information and opinion feedback." [44, p. 8].

This technique is the most adequate in this research because its goal is to forecast future events. The first step consists in identifying a panel of experts [44]. For the current study, it was identified by 53 experts and academicians from the field of innovation to who was administered a questionnaire using an online survey.

After identification, participants need to be briefed on the topic and on the Delphi technique itself. Subsequently, experts are invited to participate in two or more rounds of the survey. Between two rounds, the researcher analyses the responses and set up feedback in terms of an anonymized summary of the experts' answers from the previous round. Usually, experts are then encouraged to revise their answers, comparing them to the answers given by the other panel experts to reach consensus among the group. After consensus or at least a majority-consensus has been reached, the second round can be initiated, focusing on a different aspect of the topic that builds on the consensus from the first round.

In the case of this research, experts in the first round were asked to rate the likelihood of Skills in the sphere of Innovation Public Policies. Between the first and the second round, we then calculated likelihood means for each of the skills in analysis, also taking into consideration the comments of respondents on the skills that were accounted for in terms of statement modifications for the second round. In the second round, respondents were then presented with the adjusted options.

After the ultimate round, the data was then be analyzed calculating mean and standard deviations scores to shed some light on how the future in a particular field might look like according to the field's experts.

Finally, it is important to note that the approach used was designed to map the skills of the workforce and the future skills that will be important in the sphere of innovation public policies.

Survey Design

The survey design has a first section about the characterization of the experts: their professional as well as national backgrounds and their fields of interest; the second section is an overview on the themes and questions about skills in the sphere of innovation public policies.

Expert Panel Design

The sample was composed of 53 experts. Table 4 gives a short overview of the distribution between practitioners and academicians.

Table 4: *Distribution of expert participants according to their professional field*

Position	Practitioners	Academicians
Experts	11	6
Researchers	10	5
Institutional representative	7	3
Policymaker	6	5

Note: N=53

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The decision about the experts was based on their positions in order to capture the plurality of opinions on the topics surrounding the trends of skills in the sphere of Innovation Public Policies.

The experts that participated in round 1 and round 2, represents eight different countries (Belgium, France, Germany, Italy, Netherlands, Portugal, Spain, and the United Kingdom).

The process consisted of two rounds; the second round administered four weeks after the first. Both rounds were mainly focusing on asking experts to rating importance (round I and II) of potential innovation skills. The Round I and II of the Delphi Survey had 21-items about relevant skills in the sphere of innovation public policies.

The questionnaire contained both closed and open-ended questions, which allowed generating a quantitative analysis, and also gathering respondents' comments and suggestions for reformulations. After the data collection, the qualitative answers and comments were analysed in order to re-formulate statements and items on innovation skills. The second questionnaire was not a mere replication of the first questionnaire but presented validated and refined statements.

FINDINGS

The Skills identified during the research process as the most relevant in the sphere of innovation public policies were distributed in three dimensions: a) dynamic skills; b) innovation skills; c) digital skills, as showed in table 5, ***table 6*** and ***table 7***.

The first skills dimension "Dynamic Skills" suggests Problem-solving, Teamwork and Communication, the most important skills in the sphere of innovation public policies. As indicated by ***table 5***, the experts' opinion was largely overall in agreement with this position a) Problem-solving: M = 4.58, SD = 0.58, (strongly agree = 39.5%, agree = 42.2%); b) Teamwork: M = 4.55, SD = 0.65, (strongly agree = 36.5%, agree = 40.2%); c) Communication: M = 4.17, SD = 0.77, (strongly agree = 35.0%, agree = 33.8%). The majority of experts perceived this skill to be or to become increasingly important for innovation public policies.

The second skills dimension "Innovation Skills " suggests Define an innovation strategy, Define goals to implement the innovation and Elaborate scenarios about potential future developments, the most important skills in the sphere of innovation public policies. As indicated by ***table 6***, the experts' opinion was largely overall in agreement with this position a) Define an innovation strategy: M = 4.77, SD = 0.81, (strongly agree = 39.7%, agree = 48.1%); b) Define goals to implement the innovation: M = 4.68, SD = 0.77, (strongly agree = 37.1%, agree = 40.6%); c) Elaborate scenarios about potential future developments: M = 4.15, SD = 0.83, (strongly agree = 29.0%, agree = 39.7%). The majority of experts perceived this skill to be or to become increasingly important for innovation public policies.

The third skills dimension "Digital Skills" suggests Digital literacy, Artificial Intelligence and Cybersecurity the most important skills in the sphere of innovation public policies. As indicated by ***table 7***, the experts' opinion was largely overall in agreement with this position a) Digital literacy: M = 4.91, SD = 0.67, (strongly agree = 37.7%, agree = 51.3%); b) Artificial Intelligence: M = 4.73, SD = 0.61, (strongly agree = 51.0%, agree = 37.2%); c) Cybersecurity: M = 4.67, SD = 0.86, (strongly agree = 40.7%, agree = 43.3%). The majority of experts perceived this skill to be or to become increasingly important for innovation public policies.

Table 5: *Dynamic Skills*

Ability to be creative	M = 4.11, SD = 0.81 Strongly agree = 37.0%; Agree = 32.2%
Problem-solving	M = 4.58, SD = 0.58 Strongly agree = 39.5%; Agree = 42.2%
Communication	M = 4.17, SD = 0.77 Strongly agree = 35.0%; Agree = 33.8%
Teamwork	M = 4.55, SD = 0.65 Strongly agree = 36.5%; Agree = 40.2%
Ability to take initiative	M = 3.12, SD = 1.23 Strongly agree = 21.0%; Agree = 27.2%
Cooperation	M =3.16, SD = 1.17 Strongly agree = 20.2%; Agree = 29.5%

Source: Sousa, 2019

Table 6: *Innovation Skills*

Knowledge about methodologies to facilitate the implementation of organizational innovations.	M = 3.78, SD = 0.83 Strongly agree = 25.1%; Agree = 30.2%
Elaborate scenarios about potential future developments.	M = 4.15, SD = 0.83 Strongly agree = 29.0%; Agree = 39.7%
Flexibility to work with a diversity of equipment and materials.	M = 3.89, SD = 0.71 Strongly agree = 26.1%; Agree = 32.6%
Identify and evaluate future improvements	M = 4.01, SD = 0.79 Strongly agree = 29.1%; Agree = 47.0%
Define goals to implement the innovation	M = 4.68, SD = 0.77 Strongly agree = 37.1%; Agree = 40.6%
Define an innovation strategy	M = 4.77, SD = 0.81 Strongly agree = 39.7%; Agree = 48.1%
Project management	M = 3.99, SD = 1.03 Strongly agree = 20.2%; Agree = 32.7%
Context analysis	M = 3.87, SD = 0.91 Strongly agree = 22.4%; Agree = 33.1%

Source: Sousa, 2019

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Table 7: *Digital Skills*

Digital literacy	M = 4.91, SD = 0.67 Strongly agree = 37.7%; Agree = 51.3%
Artificial Intelligence	M = 4.73, SD = 0.61 Strongly agree = 51.0%; Agree = 37.2%
Robotics	M = 3.97, SD =1.02 Strongly agree = 37.1%; Agree = 32.5%
Augmented Reality	M = 4.01, SD = 1.21 Strongly agree = 34.2% Agree = 32.7%
Blockchain Technology	M = 3.17, SD = 1.34 Strongly agree = 32.1%; Agree = 31.7%
Cloud Computing	M = 3.18, SD = 0.73 Strongly agree = 36.6% Agree = 32.1%
Cybersecurity	M = 4.67, SD = 0.86 Strongly agree = 40.7%; Agree = 43.5%

CONCLUSIONS

A primary focal point for this research was to increase interactions between innovation public policies and skills, and the main goal was to identify different skills dimensions that can drive the definition and implementation of public policies.

From a critical point of view, two aspects are worth mentioning regarding this research: the link between innovation and skills was essential to consider from a multidisciplinary approach; and, to draw valid conclusions applicable in practice, namely the skills identified and distributed in three dimensions: Dynamic Skills, Innovation Skills, and Digital Skills.

The role of public policies is, first of all, a driver to create a culture of innovation for economies and this research can help through the identification of the most relevant skills for innovation to define measures that can promote the enhancement of workers qualifications, which is a strategic factor for economic growth.

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