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THE EVOLUTION OF SMART WORKING AND SUSTAINABILITY IN SOCIO-TECHNICAL PERSPECTIVE: A SCIENTOMETRICS TECHNOLOGY ANALYSIS

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Abstract

Smart working is used to describe evolutionary changes that occur in a number of dimensions in the world of work. These changes occur in approaches to work, work culture, ways of working, workplaces, decision-making processes, communication, and collaboration. To understand smart working is to highlight the "multiplicative relationships" framework and the interaction of subsystems that include management values, performance systems, technology and work environment, Socio-technical approach is needed. This article tries to link with vocational education as an institution that prepares the workforce, especially in the era of industry 4.0, as part of sustainability. This article consolidates intellectual production and the evolution of the field of smart working and sustainability research with a socio-technical approach, using the analysis of scientometrics technology. The results are discussed from the perspective of the author using the relevance of the journal, the keywords, and the relevance of the article and its citations. We provide a comprehensive view and review of smart working and sustainability studies using a socio-technical approach. At the end of the article, there is a discussion about the implications and limitations of research.

Keywords: Industry 4.0, Scientometrics technology analysis, Smart working, Socio-technical, Sustainability, Vocational education.

1. Introduction

The term of 'smart working' has been used to describe evolutionary changes that occur in a number of dimensions in the world of work [1]. These changes occur in approaches about work, work culture, ways of working, workplaces, decision making processes, communication, and collaboration [2]. Smart working practices have the main feature of flexibility [3, 4]. Another more complex definition, that smart working is to work smart, agile, dynamic, and superior [5]. To understand smart working is to highlight the framework of "multiplicative relationships" and interaction of sub-systems which also include the values of management, system performance, technology and work environment [6]. A Socio-technical approach is needed to explore this "multiplicative relationship". Socio-technical is the view that a work process cannot be seen as two separate things consisting of technical systems and social systems [7]. Both must be seen as unity. Thus, Socio-technical theory is a way of looking at organizations that emphasize the interrelationships of the technical and social dimensions [8]. Socio-technical theory defines that the system doesn't only consist of related elements, but also is open. Open understanding here relates to the organizational environment.

This article tries to relate it to vocational education as an institution that prepares workforce. With a broad meaning, that vocational education is not only at the secondary level (Vocational School) but at every level. Vocational education emphasizes the practical skills needed to jump right into the world of work [9]. The rapid development of technology, especially information technology, has influenced the era of industry 4.0 which includes four main characteristics namely cyberphysical systems, internet, cloud and cognitive computing. These four characteristics cause very basic changes in work patterns in the industry. The World Economic Forum predicts that until 2020 there will be some skills lost because jobs do not need them anymore [10]. At the same time, skills will emerge for new types of work that are different from what is currently available. Experts predict that changes in work patterns will occur more quickly [11]. This progress and development demand vocational education as an institution that prepares a well-prepared workforce to fulfill it.

One of the various challenges faced by vocational education so far is the huge number of graduates who are not immersed in the world of work, thus they become unemployed [12, 13]. One of the causes of this problem is the mismatch between vocational education with industry and the business world [14-17]. So, we need a study that can be used to solve it. In this research, we tried to evaluate the development (evolution) of the study of smart working and sustainability by using a socio-technical approach.

2. Methods and Data

Scientometric is a development of meta-analysis research method [18]. Scientometric analysis is also known as bibliometrics analysis. Scientometrics technology is combining scientometrics research with information technology (IT), that is by utilizing technology in analyzing big data [19]. In general, the process of scientometric research is shown in Fig. 1, consisting of data collection, analysis and report [18, 20-22].

Fig. 1. Scientometrics process.

In this research, the process of data collection is done by using some softwares, such as PoP 'Publish or Perish'. This software makes it easy to collect databases from Google Scholar, Scopus, and Crossref [23, 24]. Other software used is Zotero [25] and Mendeley [26] by utilizing plugins in the browser. This application can help for getting and evaluating data [27].

To sample relevant articles, the author uses a database from Google Scholar, Scopus, and Crossref. All three are a comprehensive database of peer-reviewed journals in the world. Scopus is currently considered a top rank database for academic and scientific information from various studies [18]. These three databases provide detailed bibliographic information from a large number of prestigious peer-reviewed journals from all over the world, also have citation indices that serve to develop various indicators of scientometrics.

The research was conducted by searching online in October 2019 with the words "smart working", "sustainability" and "Socio-technical" in titles, keywords and abstracts (topic areas). We have used all the years available in the Google Scholar, Scopus, and Crossref databases and obtained a range of 1960 - 2019, obtained in about 1855 samples. This sample is used to see the development (evolution) of research. Samples generated through PoP software by searching the Google Scholar, Scopus, and Crossref databases, are then screened specifically for articles in the form of scientific work and checked for relevance and are limited in the range of 2004 - 2019. The samples used are also only indexed by Scopus. A sample of 400 article titles (dataset) was used in the next data analysis.

The sample is then exported in *ris format using Zotero software and in *.txt format to use in the Histcite software. Zotero is a free and easy software that is used to help collect, organize, quote, and share research [28]. The software used to carry out further analysis are called Histcite and VOSviewer. Histcite is used to produce a bibliographic chronological map produced from the subject, author, institution or search journal source [29]. Meanwhile, Vosviewer is used to visualize and analyze trends in the form of bibliometric maps [30]. Citation analysis, co-word analysis and co-citation analysis are the three basics used as analysis.

This method allows us to analyze specific data, which comes from 400 articles consisting of 277 journals, 995 authors and 15503 cited references. Citation analysis determines the relationship of items to the number of times the items cite each other, which offers insights about people, ideas, journals and organizations which are the given fields [31]. Co-word analysis is used to look at the frequency of co-occurrence in keywords to identify potential groups of very frequent keywords. Co-citation is used to determine the relationship between times based on

the frequency of joint citations [32]. Co-Authorship analysis makes it possible to analyse the relevance of articles based on the number of written together articles. The closer the point is between writers; the more writers write together.

3. Descriptive Results

The dataset in this study was divided into 2 parts, namely the initial dataset and the validation dataset. In order to see developments (evolution), the data used in this dataset uses preliminary data, namely 1855 articles. Based on Fig. 2, we can see the evolution of studies on smart working and sustainability with a socio-technical approach, which can be divided into 2 categories, namely the incubation period (until 2006) and an increase in the period after 2006 as shown in the curve with a cumulative number of 1855.

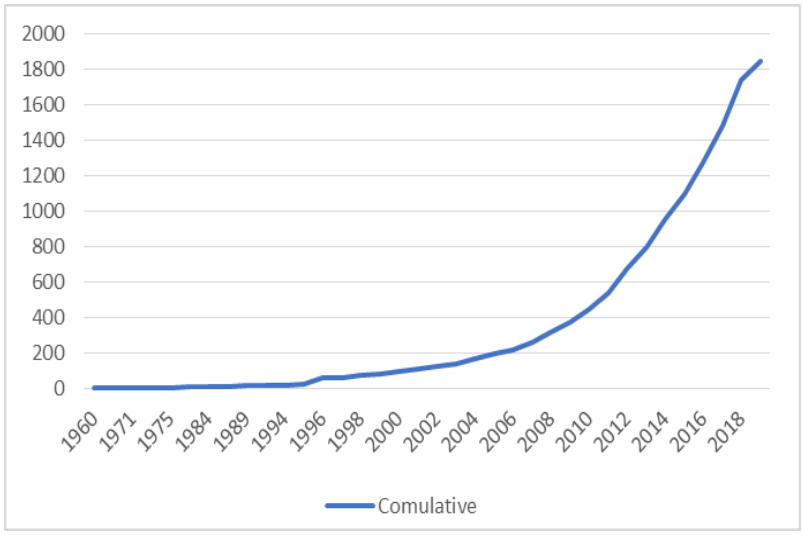

Fig. 2. Annual publication counts from 1969 to 2019 in collection data.

3.1. Author

The most relevant authors based on the number of TGC citations and the number of articles can be seen in Table 1. Some of the authors appear to be working in the same sub-fields as shown in Fig. 3. Table 1 also shows the strong correlations between the most productive writers (in terms of number of articles) and the most quoted.

Each group in Fig. 3 was formed by a set of writers who more often cite their respective works, integrating each other, as if they are coming from a single institution where members share similar intellectual ideas. One example is Geels FW (red cluster) which is a researcher who often discusses sustainability. Smith A (green cluster) is a sustainability policy researcher. They look like they are connected to many other clusters. In other clusters, it is seen some writers forming groups who quote each other.

Other important information regarding the author is the degree of co-citation. Co-citation analysis is used to measure the number of specific groups of authors cited together in an article [19, 33]. In other words, clusters in the co-citation network can

show the main references of researchers and who contributed to the development of a study. The co-citation network of this research is shown in Fig. 4.

Table 1. The most relevant authors according to the number of TGCS citations (a) and the most relevant authors according to the number of articles (b).

Rank (a)	Author	Citation score TGCS	Rank (b)	Author	Article count
1	Geels FW	4364	**1**	Geels FW	7
2	Schot J	2883	**2**	Kern F	7
3	Watson M	1349	**3**	Rohracher H	7
4	Smith A	1244	**4**	Pitt J	5
5	Hoogma R	1215	**5**	Schot J	5
6	Kemp R	1215	**6**	Wells P	5
7	Pantzar M	1184	**7**	Bolton R	4
8	Shove E	1184	**8**	Brown RR	4
9	Warde A	1180	**9**	Kivimaa P	4
10	Voß J-P	635	**10**	Lee J	4
11	Grin J	615	**11**	Nykvist B	4
12	Coenen L	522	**12**	Ober J	4
13	Kern F	514	**13**	Smith A	4
14	Truffer B	452	**14**	Turnheim B	4
15	Stirling A	411	**15**	Abdelnour-Nocera J	3
16	Benneworth P	405	**16**	Bucchiarone A	3
17	Kivimaa P	274	**17**	Diaconescu A	3
18	Martin CJ	264	**18**	Hyysalo S	3
19	McMeekin A	255	**19**	Iliffe S	3
20	Rohracher H	215	**20**	Kouloura TC	3
21	Verbong GPJ	170	**21**	Markard J	3
22	Berkhout F	166	**22**	McMeekin A	3
23	Nykvist B	162	**23**	Nikolic I	3
24	Bolton R	156	**24**	Pan W	3
25	Turnheim B	152	**25**	Shin Y	3
26	Woods DD	149	**26**	Sovacool B	3
27	Boxall P	144	**27**	Sovacool BK	3
28	MacKy K	144	**28**	Truffer B	3
29	Geels F	123	**29**	Welch C	3
30	Hof A	123	**30**	Alkemade F	2

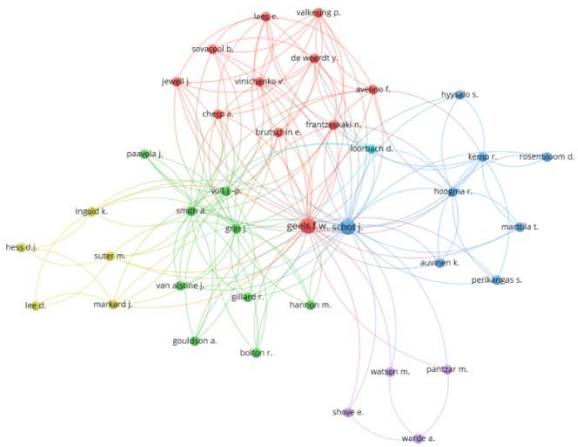

Fig. 3. Author citation network with the VOSviewer visualization.

In Fig. 4, there are seen several clusters. Blue, red, yellow and green clusters are researchers in the main fields, which contribute to research related to smart working and sustainability using a socio-technical approach. Like Geel FW, Kemp R, Loorbach D, and Bednard PM.

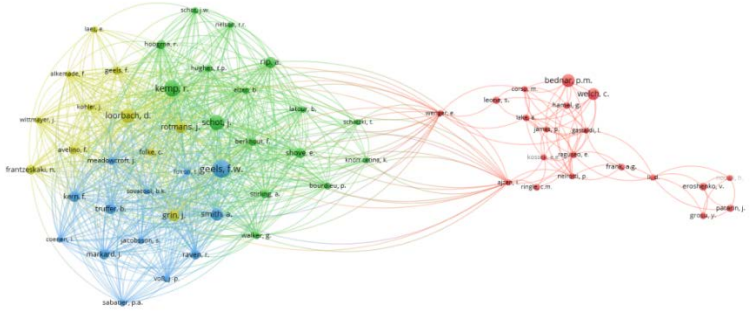

Fig. 4. Author co-citation network with the VOSviewer visualization.

3.2. Journal

In the 400 articles published in 277 journals, the top 15 journals publish as much as 30% of all articles. Journal of Cleaner Production 6%, Technological Forecasting and Social Change 5%, Research Policy 4%, Energy Policy 3%, Environmental Innovation and Societal Transitions 2%, Sustainability (Switzerland) 2%, Energy Research and Social Science 2%, and others 1% down (can be seen in Table 2). An analysis based on the relevance of the journal was also carried out, using the number of citations in each. The results obtained in the top 15 journals, the most citation found in 7 journals. This result shows that articles with subjects related to smart work and sustainability using a social-technical approach are scattered in certain journals, even though they are also in other journals.

In general, journals can be divided into 6 clusters, as shown in Fig. 5: journals relating to the sustainability literature in economics (Research policy, technology analysis and strategy), journals relating to environmental and social sustainability literature (Environmental Innovation and Societal Transitions), journals related to

sustainability informatics literature, journals related to smart working (The dynamics of social practice: everyday life and how it changes).

Table 2. The most relevant journals according to the number of articles (a) and the most relevant journals according to the number of TGCS (b).

Rank (a)	Journal	Rec	Rank (b)	Journal	TGCS
1	Journal of Cleaner Production	21	**1**	Research Policy	5619
2	Technological Forecasting and Social Change	20	**2**	Technology Analysis and Strategic Management	1321
3	Research Policy	17	**3**	The Dynamics of Social Practice: Everyday Life and How It Changes	1184
4	Energy Policy	10	**4**	Journal of Consumer Culture	1180
5	Environmental Innovation and Societal Transitions	8	**5**	Technological Forecasting and Social Change	697
6	Sustainability (Switzerland)	8	**6**	Journal of Cleaner Production	406
7	Energy Research and Social Science	6	**7**	Ecology and Society	317
8	Building Research and Information	4	**8**	Energy Policy	309
9	Design Studies	3	**9**	Ecological Economics	264
10	Global Environmental Change	3	**10**	Journal of Transport Geography	211
11	Journal of Environmental Policy and Planning	3	**11**	Global Environmental Change	207
12	Renewable and Sustainable Energy Reviews	3	**12**	Environmental Innovation and Societal Transitions	192
13	Sustainability	3	**13**	Reliability Engineering and System Safety	149
14	Systems Research and Behavioural Science	3	**14**	Asia Pacific Journal of Human Resources	144
15	11Th International Conference on Engineering and Product Design Educate	2	**15**	Journal of Environmental Policy and Planning	135
16	12Th Pacific Asia Conference on Information Systems: Leveraging Ict Fo	2	**16**	Energy and Buildings	40
17	16Th Ifip Tc13 International Conference on Human-Computer Interaction,	2	**17**	Social Science Research	37
18	17Th International Conference on Autonomous Agents and Multiagent Syst	2	**18**	Annual Conference on Systems engineering Research, CSER 2014	35
19	Acm Transactions on Autonomous and Adaptive Systems	2	**19**	BMC Veterinary Research	35
20	Applied Energy	2	**20**	Education and Training	33

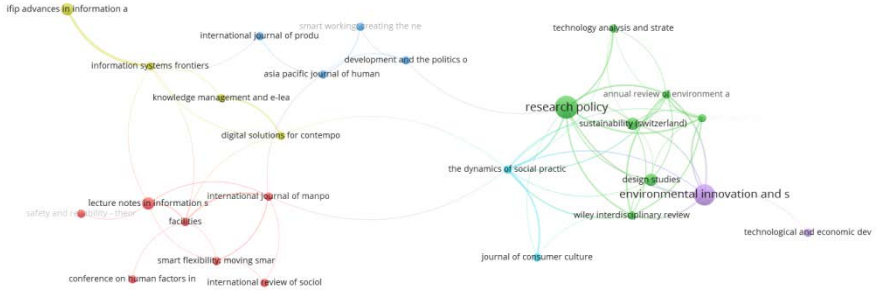

Fig. 5. Journal citation network with the visualization using VOSviewer.

Co-citation analysis on journals can also be done [33]. This provides important information regarding the collective intellectual base of the field of knowledge [34]. The co-citation journal network in this study consisted of 56 journals with a minimum number of citations 5. It is obtained the co-citation relationships of 6 clusters (see Fig. 6).

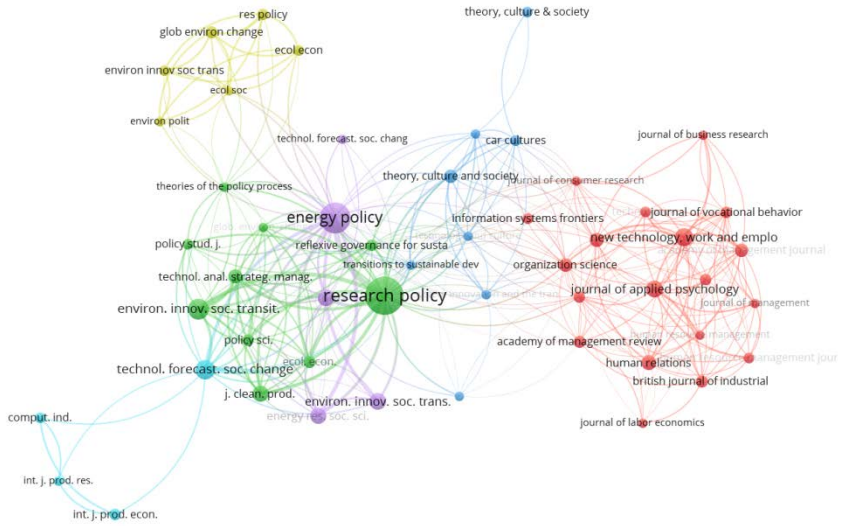

Fig. 6. Journal co-citation network with visualization using VOSviewer.

The top five journals in this analysis are Research Policy, Energy Policy, Environmental Innovation and Societal Transitions, Technological Forecasting and Social Change, Energy Research and Social Science. These results reveal all five are the dominant sources of the work cited for the field of smart working and sustainability using a socio-technical approach.

The interesting part about the identification of these six clusters is the interdisciplinary nature of smart working and sustainability research using a socio-

technical approach. Clusters in green and purple become a liaison with other clusters. Some articles on Research Policy present articles on technology sustainability and smart working fields, such as [35].

3.3. Keyword analysis

The next analysis is keyword co-occurrence, which is useful for reading the scope of knowledge of the research and the main themes of each study. We did this analysis by measuring the co-occurrence of keyword pairs from all articles [18, 33]. The results of the keyword co-occurrence analysis can be seen in Fig. 7. 96 words are obtained. These results are obtained with a minimum number of occurrences of a keyword:

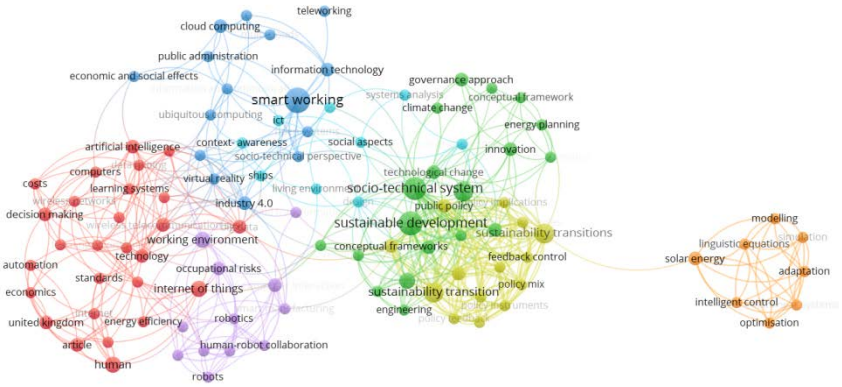

Fig. 7. The keywords co-occurrence network with visualization using VOSviewer.

The network of keywords shown in Fig. 7, which consists of 96 items. The size of the node indicates the frequency in which the keyword appeared. By adding each item that represents the keyword indicated by the size of the node. The results obtained indicate that there are four big keywords, namely "smart working" (10), "sustainable development" (9), "socio-technical system" (8) and "sustainability" (6). It is also seen that "working environment" and "technology" have a strong relationship.

In a broader analysis of this keyword network, there are six dominant clusters, as in Fig. 7, made with the help of VOSviewer. They are shown in six colours, namely red, green, blue, yellow, purple and orange. It appears that the blue cluster is connected to another keyword. It can be indicated that there is a link in the development of research on this matter. The essence of the blue cluster is "smart working". The green cluster focuses on sustainable development and socio-technical. The purple cluster focuses on the development of technology. Meanwhile, the red cluster focuses on the social and humanity aspects.

3.4. Content analysis

At this point, we will show the most relevant contributions in this study. Done by taking ten articles with the keyword "smart working", "sustainability", and "socio-technical" which has the highest citation score. The results obtained in Table 3.

Table 3. Top 30 quoted articles.

Rank	Authors	Title	Source title	Year	Cited
1	Geels F.W.	Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study	Research Policy	2002	2032
2	Geels F.W., Schot J.	Typology of sociotechnical transition pathways	Research Policy	2007	1590
3	Kemp R., Schot J., Hoogma R.	Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management	Technology Analysis and Strategic Management	1998	1215
4	Shove E., Pantzar M., Watson M.	The dynamics of social practice: Everyday life and how it changes	The Dynamics of Social Practice: Everyday Life and How it Changes	2012	1184
5	Smith A., Voß J.-P., Grin J.	Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges	Research Policy	2010	615
6	Geels F.W.	Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective	Research Policy	2010	542
7	Coenen L., Benneworth P., Truffer B.	Toward a spatial perspective on sustainability transitions	Research Policy	2012	405
8	Smith A., Stirling A.	The politics of social-ecological resilience and sustainable socio-technical transitions	Ecology and Society	2010	309
9	Martin C.J.	The sharing economy: A pathway to sustainability or a nightmarish form of neoliberal capitalism?	Ecological Economics	2016	264
10	Kivimaa P., Kern F.	Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions	Research Policy	2016	174
11	Verbong G.P.J., Geels F.W.	Exploring sustainability transitions in the electricity sector with socio-technical pathways	Technological Forecasting and Social Change	2010	170
12	Watson M.	How theories of practice can inform transition to a decarbonised transport system	Journal of Transport Geography	2012	165
13	Woods D.D.	Four concepts for resilience and the implications for the future of resilience engineering	Reliability Engineering and System Safety	2015	149
14	MacKy K., Boxall P.	High-involvement work processes, work intensification and employee well-being: A study of New Zealand worker experiences	Asia Pacific Journal of Human Resources	2008	144

15	Turnheim B., Berkhout F., Geels F., Hof A., McMeekin A., Nykvist B., van Vuuren D.	Evaluating sustainability transitions pathways: Bridging analytical approaches to address governance challenges	Global Environmental Change	2015	123
16	Coenen L., Díaz López F.J.	Comparing systems approaches to innovation and technological change for sustainable and competitive economies: An explorative study into conceptual commonalities, differences and complementarities	Journal of Cleaner Production	2010	117
17	Jørgensen U.	Mapping and navigating transitions - The multi-level perspective compared with arenas of development	Research Policy	2012	116
18	McMeekin A., Southerton D.	Sustainability transitions and final consumption: Practices and socio-technical systems	Technology Analysis and Strategic Management	2012	106
19	Smith A., Stirling A.	Moving outside or inside? Objectification and reflexivity in the governance of socio-technical systems	Journal of Environmental Policy and Planning	2007	102
20	Estrin D.	Participatory sensing: Applications and architecture	IEEE Internet Computing	2010	100
21	Ceschin F., Gaziulusoy I.	Evolution of design for sustainability: From product design to design for system innovations and transitions	Design Studies	2016	88
22	Davis M.C., Challenger R., Jayewardene D.N.W., Clegg C.W.	Advancing socio-technical systems thinking: A call for bravery	Applied Ergonomics	2014	81
23	Rohracher H., Späth P.	The Interplay of Urban Energy Policy and Socio-technical Transitions: The Eco-cities of Graz and Freiburg in Retrospect	Urban Studies	2014	80
24	Ornetzeder M., Rohracher H.	Of solar collectors, wind power, and car sharing: Comparing and understanding successful cases of grassroots innovations	Global Environmental Change	2013	80
25	Quist J., Thissen W., Vergragt P.J.	The impact and spin-off of participatory backcasting: From vision to niche	Technological Forecasting and Social Change	2011	77
26	Loorbach D., Frantzeskaki N., Avelino F.	Sustainability Transitions Research: Transforming Science and Practice for Societal Change	Annual Review of Environment and Resources	2017	72
27	Lenz C., Nair S., Rickert M., Knoll A., Rösel W., Gast J., Bannat A., Wallhoff F.	Joint-action for humans and industrial robots for assembly tasks	Proceedings of the 17th IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN	2008	58

28	Podgórski D., Majchrzycka K., Dąbrowska A., Gralewicz G., Okrasa M.	Towards a conceptual framework of OSH risk management in smart working environments based on smart PPE, ambient intelligence and the Internet of Things technologies	International Journal of Occupational Safety and Ergonomics	2017	21
29	Park J., Koh T., Huh J.-H., Kim T., Lee J., Kang J., Ju D., Kim J., Lee J., Hwang T., Park Y., Seo K.	Design of the real-time mobile push system for implementation of the shipboard smart working	Lecture Notes in Electrical Engineering	2015	21
30	Tagliaro C., Ciaramella A.	Experiencing smart working: a case study on workplace change management in Italy	Journal of Corporate Real Estate	2016	6

Among the 30 list of references cited from Table 3, it was found several works of Geels, including popular works in which he developed the idea of multilevel perspective [36], ranks first among the most cited references in our list. Geels also proposes the idea of several path transitions in a combination of time and nature [37], which ranks second among the most cited references in our list. Furthermore, Geels also increased agency discussions and causal mechanisms in a multilevel perspective [38], which is on rank sixth. And finally, together with Verbong, he try to explore the sustainability transition in the electricity field with a socio-technical approach [39].

The research which is directly related to "smart working" among the 30 reference lists in Table 3 is that suggested by MacKy, ranking 14th among the most cited references on our list. MacKy researched the conditions that occur in workers after technology has progressed, and it was found that organizations that can encourage work smarter and without pressure to work harder tend to improve workers' welfare [40]. In the article put forward by Lenz, ranked 27th among the most cited references in our list, describing an intelligent work environment concept designed so that humans and robots can work together in the real industry.

4. Conclusions

Smart working and sustainability using a socio-technical approach has proven to be important at this time. With the development of the world of work in the era of industry 4.0, vocational education institutions as workforce producers should study smart working. As evidence, we have shown the development of a number of publications originating from various scientific disciplines namely theoretical frameworks and empirical data used by researchers, in this case the subject. Although there is no systematic evidence of chronology and synthesis on the subject in this article, we try to explain the problem indicators, configure and try to link the sharing of literature systematically and analyze its content through scientometrics technology in order to obtain the link between one research and another. Important writers who explained about smart working and sustainability by using a socio-technical approach have been shown and analyzed to show the level of correlation between relevant authors. The use of a single quote database that only comes from the Scopus database might have eliminated some other

relevant works even though Scopus is recognized as a very credible source in scintometrics analysis.

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