

Research Synthesis and New Directions of Prosumption: A bibliometric analysis

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Abstract

The purpose of this paper is to explore research clusters in Prosumption field through co-citation analysis. This study enriches our understanding by systematically reviewing Prosumption articles extracted from Web of Science (WoS) database at January 10, 2018, and consequently, we found only 350 publications. Co-citation analysis approach was applied for investigating research topics and identifying influential entities for the last 20 years with two bibliometric analysis tools, i.e., HistCite and VOSviewer. In total, we analyzed 350 articles and found three research clusters in prosumption; (1) *Business and Sociology* (2) *Energy and Power grid* and (3) *Energy and Economy*. But before exploring research clusters, we used HistCite to determine most influential authors, articles, journals, institutions, and countries in Prosumption field. Results indicated that prosumption is new and emerging field as academia focused their attention just a decade before. This bibliometric analysis reveals important gaps in the existing knowledge on prosumption and identifies relevant areas for future research.

Keywords: Prosumer, bibliometric review, HistCite, VOSviewer, web of science.

1. Introduction

Alvin Toffler was the first person who coined the term “Prosumption (simultaneously consumption and production)” in 1980, but after that, no explicit debate discussed this phenomenon in the academic world. 30 years later, Ritzer and Jurgenson [45] wrote a seminal paper indicating the explicit emergence of prosumption in the digital world and focused the attention of other researchers to this phenomenon. In past eight years, this phenomenon has been dramatically expanded due to the internet, Web 2.0 and ease of access of consumers contribution in production side (manufacturing, design, and distribution), and consequently granting firms new freedom over consumers (see Rayna and Striukova [41] Seran (Potra) and Izvercian [47]). Despite the significant relevance of prosumption in Energy, Business and Sociology fields (see Dusi [14] Seran (Potra) and Izvercian [47]), there is lack of study that explained the bibliometric analysis of

prosumption to explore whether the studies conducted in above fields are interlinked with each other or not. Therefore this research paper employed co-citation analysis by HistCite to capture an in-depth understanding of prosumption phenomenon in Energy, Business and Sociology fields. Furthermore, Prosumption inter-relationship in above fields has been explored through cartography analysis by VOSviewer software.

Co-citation analysis is a type of meta-analytical tool with analytical properties that demonstrates interconnections among research articles and research topics (see Cote et al. [9] Kim and McMillan [23]) by analyzing how often an article is cited and co-cited by other articles, indicating the key research clusters of the topic under study (see Luukkonen [28] Nederhof [31]). Therefore the use of co-citation analysis enables the researchers and authors to have a clear view and understanding of the structure and knowledge of the respective field (see Zupic and Čater [60]). Small (1999) suggested that with the help of co-citation mapping technique, authors can explore research clusters and map out the source and direction for future research. HistCite and VOSviewer software highlighted the most-cited articles, provides sketch visualisation graph of respective citations and determines the subsequent impact of those citations on a respective research article (see Eugene Garfield [19] Thelwall [52]). Therefore, this study has applied HistCite and VOSviewer to conduct a bibliometric analysis by evaluating the networks among highly cited articles as applied by other bibliometric studies (see Byington et al. [7] Sarkodie and Strezov [46]).

HistCite has been used in basic sciences as well as in social sciences for co-citation analysis (see Fetscherin and Heinrich [16] Sun et al. [50]). According to our best knowledge, HistCite bibliometric analysis on the Prosumption has not been used previously. HistCite demonstrates and analyses the citations among the research articles which are retrieved from the Web of Science. Genealogical antecedents of a research field can be discovered and explored through citation behaviour as heavily cited publications are highlighted by co-citation analysis (see Fetscherin et al. [17]). Furthermore, with the help of HistCite, this study also investigated that which authors, journals, articles, and countries contributed most on prosumption research fields. In addition to the HistCite bibliometric analysis, this paper also applied cartographic analysis through VOSviewer using frequently occurring keywords in prosumption research clusters.

Through co-citation bibliometric analysis, cartography analysis and last but not least, content analysis of the literature, this study explores the following research questions on prosumption :

- Which channels (authors, articles, journals, institutions, and countries) are the most influential in prosumption research?
- What are the prominent research fields where prosumption is playing a significant role?

The rest of the article begins with a brief summary of the historical evolution and prominence of prosumption in the digital arena and emergence of HistCite and VOSviewer. The research design and combining co-citation analysis by HistCite and

cartography analysis by VOSviewer is then introduced. The results have been discussed with a series of visual representations showing the emerging research clusters through VOSviewer. Afterwards, relevant insights are presented in the discussion part and finally this paper has been concluded with limitations and recommendations for future research.

2. Theoretical Background

2.1. The emergence HistCite and VOSviewer

HistCite software as a bibliometric analysis tool is used for analysing systematic literature reviews through robust quantitative methods (see Zupic and Čater [60]). Pan et al. [33] investigated 481 research articles that have used HistCite and VOSviewer as the bibliometric mapping software tools. They found a significant upward trend in the use of these tools, but VOSviewer has been extensively used than HistCite. Co-citation analysis is based on the underlying assumption that is the research articles, which are going to publish in scholarly journals, build their research background on similar articles that are already published (see Van Raan [55]). Apriliyanti and Alon [1] applied HistCite as a bibliometric co-citation tool in 336 articles and VOSviewer software as bibliometric cartography tool in 2088 articles to find five research clusters in Absorptive Capacity.

Similarly, Olczyk [32] used HistCite and VOSviewer to identify the growth patterns in the *International Competitiveness* literature with the help of bibliometric citation data (years 1945-2015) extracted from the WoS. The results showed interesting facts that *international competitiveness theory* is originated from *models of competition*, not from *neoclassical theories of international trade*, and competitiveness is mostly measured in term of *trade/export performance*. So with the help of bibliometric analysis, researchers might be able to identify the origin as well as the current significance of the concept under study. From the above co-citation analysis literature, it is evident that HistCite and VOSviewer have been extensively used in previous bibliometric studies. Therefore we have also used these both software for bibliometric analysis of Prosumption.

2.2. The emergence of Prosumption

Over the last decade, the term prosumption (simultaneous consumption and production) is dramatically gaining popularity in the academic research world. “Prosumption” term initially coined by Allan Toffler in early 1980s (see Kotler [24]) as an umbrella term that described the consumers’ emerging phenomenon like “do-it-yourself” (see Wolf and McQuitty [58]) and so it is defined as the simultaneous procedure of consumption and production (see Ritzer [43]) The concept of prosumption has been discussed by eminent research scholars in consumer studies (see Brodie et al. [5]) and socio-economic studies (see Bellekom et al. [2] Cova and Dalli [11] Ritzer and Jurgenson [45]). Since the beginning of the early 2000s, numerous concepts have been explored in different marketing fields that investigated the contemporary and emerging swing in classic production paradigms. Some scholars defined consumers as value co-creators in cooperation with

firms, and this phenomenon was called *value co-creation process* (see Prahalad and Ramaswamy [38]). Others explored the concept of '*working consumer*' (see Cova and Dallı [11]) that analysed consumers as an active player in the value creation process through primarily social relationships and immaterial labour. Campbell [8] developed the concept of '*craft-consumption*' to describe activities in which consumers designed and made their products and use them. Similarly, Watson and Shove [57] used the term '*Do-It-Yourself*' to express those practices in which consumers are builders, designers, inspectors, and evaluators simultaneously about what they have produced and then consumed for their personal use. Leadbeater and Miller [25] used the expression of '*Pro-am*' (*professional-amateur*) that has applied to those individuals who pursue their projects and activities as amateurs while setting professional standards.

In early time, it was thought that prosumers are the persons that produce and consume goods and services for their own personal use, e.g., cooking a meal at home. However, with the passage of time, the prosumer concept has been started to develop new conceptualisation, and that is, the prosumers are the persons who create value for everyone in the related community, (not just for their own use) and that they share it globally (see Tapscott and Williams [51]). So the prosumers are knowledgeable, empowered consumers accompanied with digital technology (web 2.0) to collaborate and participate in product or service design, conception, testing, and usage, and they have a significant influence on their social network and community (see Seran [48]). Similarly in energy smart grid field, Prosumer is conceptualized as the consumer who consume energy as well as share excessive energy with other consumers in a community and/or with grid (see Parag and Sovacool [34] Wolsink [59]). But this bidirectional power flow (sharing excessive energy to Microgrids system) might cause voltage problems (see Hu et al. [21]) therefore they formulate prosumer energy management strategy and proposed distribution system operator (DSO) to manage prosumers energy. Despite of pure energy and power grid studies, previous studies also explained the prosumers economic activity and contribution through game theory (see El Rahi et al. [15] Liu et al. [26] Tushar et al. [53]). The previous literature clearly demonstrates significant role of prosumption in diverse research fields. This evoked authors to conduct bibliometric analysis of prosumption to explore underlying research dynamics and related academics research streams.

3. Methods

In this article, we utilised quantitative and qualitative assessment of the systematic literature review of prosumption. Quantitatively, we have used two types of bibliometric analysis (a) co-citation through HistCite and (b) bibliometric coupling and cartography analysis through VOSviewer. Furthermore, we have analysed the content of the literature by examining all the top WoS articles on prosumption and categorised them into clusters. In this bibliometric analysis, we have examined interconnections among research articles by analysing how often other articles cite and co-cite the specific research article related to their study and research domain.

3.1. Data source and research process

We started our research with the keyword, topic: “*prosumer OR topic: “prosumption”*” in WoS core collection that is now owned by Clarivate Analytics. WoS is a top quality database comprising top journals of basic Science, social science, arts and humanities disciplines (see Fetscherin and Heinrich [16]). It contains more than 22,000 journals, 50 million publications data in 70 languages and 151 research categories (see Merigó et al. [29]). Therefore this study focused WoS top quality database despite of other research engines, such as Google Scholar, SCOPUS or Scientific Electronic Library Online (SciELO). Initially, we found only 357 results from WoS core collection data (10th January 2018) as shown in Figure 1. WoS Core Collection is the premier resource for scholarly and scientific research as it contains full records (authors, research funding, related institutions with countries details) and cited reference of retrieved research articles. This database covered timespan of all years (1985- January 2018) and consisted of Science Citation Index Expanded (SCI-EXPANDED), Social Science Citation Index (SSCI) and Conference Proceedings Citation Index - Science (CPCI-S). In 357 prosumption papers, seven papers were not written in English language (Spanish 4, Polish 2 and German 1) so excluded from analysis. It was surprising that more portion of that 357 research papers was based from Engineering and Energy fields (see Figure 1). Furthermore, the detailed analysis is discussed *in Finding and Discussion part*.

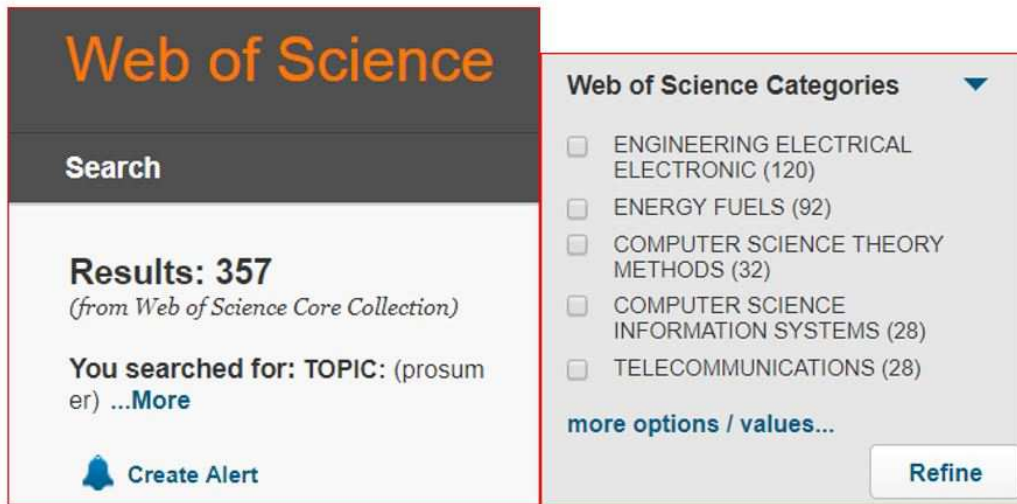


Figure 1: Prosumer literature analysis in web of science (WOS).

3.2. Analytical tool and method

Pan et al. [33] study found 10 software tools that have been used for bibliometric analysis in previous literature. They were named as HistCite, CiteSpace, Sci2Tool, Bibexcel, CitNetExplorer, VOSviewer, CoPalRed, VantagePoint, SciMAT, CiteSpace,

and Net-work Workbench Tool. Furthermore they examined their contribution in WoS Core collection data base (January 2018) and found that CiteSpace, VOSviewer and HistCite have been frequently used in previous bibliometric studies (78, 70 and 30 research papers respectively). Rest of all software tools were used in less than ten academic papers except Bibexcel (19 research papers). Despite of more prominence of CiteSpace, we used VOSviewer and HistCite software in our analysis due to following reasons; first objective of this study was to explore the research dynamics (most influential authors, articles, journals, institutions, and countries) and for this HistCite has been often used in previous studies (see Apriliyanti and Alon [1] Eugene Garfield [19] Thelwall [52]). The second and more significant objective of this study was to explore main research fields where prosumption role is significant and for this we used VOSviewer as extensively used in previous literature (see Byington et al. [7] Llanos-Herrera and Merigo [27] Sarkodie and Strezov [46]).

The significance and emergence of HistCite and VOSviewer was analyzed in WoS core collection database (August 2018). It was found that only 38 studies used HistCite software for bibliometric analysis in which 63% studies (24) were conducted in last five years. Whereas 106 studies used VOSviewer software for bibliometric analysis in which 91% (97) were conducted in the last five years (2014-2018). This analysis clearly shows high significance and emergence of both bibliometric analysis tools in contemporary studies. Therefore we applied both tools for Prosumption bibliometric analysis.

First of all, the data of 350 prosumption articles were extracted from the WoS and saved in Text Document file. This Text Document file comprised of authors' name, title of article, journal's name, and type of document, abstract and cited reference used in the paper. This all information is really valuable for bibliometric analysis. After that, this file was imported in HistCite and authors got the most influential authors, articles, journals and research document; The most influential institutions and countries and Citation Mapping as an output information related to prosumption field in tabular form (see E Garfield et al. [18]). Furthermore, we imported this file in VOSviewer software to get a Bibliometric coupling and Cartography analysis as output information related to prosumption field. Form these outputs authors explored the related research clusters present in business and sociology fields of Prosumption articles.

In a bibliographic coupling analysis, the connection among different authors has been determined based on the degree to which they cite the same research publications. The more often two different authors cite the same publications, the stronger there will be relatedness (see van Eck and Waltman [54]). As compared to the HistCite citation mapping graph, VOSviewer bibliographic coupling highlights the name of the authors and year of publication instead of just number representation in HistCite citation mapping graph. Furthermore, it distributes research articles in different clusters based on their respective similar topics, themes or fields as shown in Figure 6. After that, the authors confirmed the prosumption research clusters through cartography analysis (see Ding et al. [12]).

4. Findings and Discussion

4.1. The 350 presumption articles analysis using HistCite

4.1.1. The type of research document

In this sub-section, we analysed the most influential authors, articles, and journals in 350 presumption research articles using HistCite. Table 1 illustrates the type of documents (**Recs**) of 350 presumption research publications. We found 166 *research Articles*, 14 *Review papers*, 161 *Proceeding Papers*, 07 *Editorial Materials*, 01 *Book Review and Latter* that has been combined to make whole 350 presumption research publications. 166 *research Articles* have been received 164 total local citation score (TLCS) and 1850 total global citation score (TGCS). There are two measurements that have been used for citations score. The first is TLCS that represents the total citations received from retrieved samples (350 Prosumption articles), and the second is TGCS, which reflects the total number of citations not only from retrieved samples but also from other articles that are based on the full counting of WoS (see Apriliyanti and Alon [1]). This table also demonstrates that *Articles* got a major and significant portion of TLCS and TGCS in 350 presumption research documents but *Proceedings paper* having similar amount to *Articles* just got 17 TLCS and 98 TGCS which clearly indicate that *Proceedings paper* did not get significant attentions from academia.

Table 1: The type of research document.

Sr.#	Document Type	Recs	TLCS	TGCS
1	Article	166	164	1850
2	Review	14	4	127
3	Proceedings Paper	161	17	98
4	Editorial Material	7	24	97
6	Letter	1	0	1
7	Book Review	1	0	0

4.1.2. Yearly output and the most influential authors, articles, and journals

From the HistCite analysis, it was found that just 32 research articles out of 350 research articles have been published from 1996 to 2009, and 318 papers have been published from 2010 to 2017 in which 210 articles were published in last four years with an average of 53 papers/year. This indicates that prosumption is indeed new, novel, innovative and contemporary field and recently academia has focused their attention on this field. We also found that 900 authors contributed in the writing of 350 research articles in which the most prominent author is Ritzer G who has written eight research articles (top of the list in Table 2). While five authors (Burgio A, Grijalva S, Menniti D, Pinnarelli A, and Sorrentino N) have written seven research papers. we also found that Ritzer got 91 TLCS and 654 TGCS in Table 2 while rest all authors in top ten list got 6 or below TLCS and 29 or below TGCS except Rathnayaka AJD (15 TLCS & 41 TGCS). This analysis clearly indicated the greater influence of Ritzer G among prosumption academia.

Table 2: The most influential authors in 350 prosumption publications.

Sr.#	Document Type	Recs	TLCS	TGCS
1	Ritzer G	8	91	654
2	Grijalva S	7	5	29
3	Burgio A	7	6	22
4	Menniti D	7	6	22
5	Pinnarelli A	7	6	22
6	Sorrentino N	7	6	22
7	Rathnayaka AJD	6	15	41
8	Alcarria R	6	6	25
9	Robles T	6	6	25
10	Brusco G	5	6	22

To determine most influential research papers in 350 prosumption publications, we ranked them according to TLCS as shown in Table 3. Ritzer and Jurgenson [45], Ritzer et al. [44] and Ritzer [42] studies have attained exponential growth with 49, 24 and 12 TLCS and academia found them most prominent research papers in the prosumption field but they all are related to Business and Sociology fields. After that all research

Table 3: The most influential articles in 350 prosumption publications.

Sr.#	Authors/ Year/Title	TLCS	TGCS	CR
1	Ritzer and Jurgenson (2010). Production, Consumption, Prosumption The nature of capitalism in the age of the digital 'prosumer'	49	481	51
2	Ritzer, Dean, and Jurgenson (2012). The Coming of Age of the Prosumer Introduction	24	89	63
3	Ritzer (2014). Prosumption: Evolution, revolution, or eternal return of the same?	12	87	93
4	Rathnayaka AJD et al. (2014). A Methodology to Find Influential Prosumers in Prosumer Community Groups	7	14	14
5	Brusco G (2014). Energy Management System for an Energy District With Demand Response Availability	6	22	27
6	Rathnayaka AJD et al. (2014). Goal-Oriented Prosumer Community Groups for the Smart Grid	5	14	5
7	Cova B and Cova V (2012). On the road to prosumption: marketing discourse and the development of consumer competencies	4	38	118
8	Pillai GG Et al. (2014). Near-term economic benefits from grid-connected residential PV (photovoltaic) systems	4	30	46
9	Brand L (2014). - A simulation study of prosumers' impact on technical parameters in distribution networks	4	26	34
10	Dujarier MA (2016). The three sociological types of consumer work	4	8	46

Table 4: The most influential journals in 350 prosumption publications.

#	Journal	Recs	TLCS	TGCS
1	ENERGIES	10	2	33
2	RENEWABLE & SUSTAINABLE ENERGY REVIEWS	10	3	80
3	APPLIED ENERGY	9	11	149
4	JOURNAL OF CONSUMER CULTURE	8	70	576
5	AMERICAN BEHAVIORAL SCIENTIST	5	29	146
6	ENERGY	5	8	65
7	IEEE TRANSACTIONS ON SMART GRID	5	8	72
8	ORGANIZATION	5	6	18
9	2016 IEEE INTERNATIONAL CONFERENCE ON SMART GRID COMMUNICATIONS	4	0	0
10	COMUNICAR	4	1	38

papers in 10 most cited articles are related to Energy and Power Grid fields except Cova and Cova [10] and Dujarier [13] papers. The content analysis of top ten papers revealed that prosumption concept has acquired significant attention in social sciences (*Business and Sociology*) and natural sciences (*Energy and Power Grid fields*). Furthermore, these research papers have been published within one decade (after 2009), and five have been published in 2014 which indicate that prosumption is a new, novel and contemporary field.

We found 237 academic journals that have published 350 research articles related to the prosumption field. To determine most significant Journals, we created a top ten journal list with the help of HistCite according to the number of publications (Recs) as shown in Table 4. In top 10 most influential journals, *Journal of Consumer Culture*, *American Behavioral Scientist*, *Organization and Comunicar* are related to pure *Business and Sociology* domain journals while other are related to *Energy and Power grid*. *Journal of Consumer Culture* and *American Behavioral Scientist* got significant higher citations (70 & 29 TLCS; 576 & 146 TGCS) as compared to others top ten journals. Five research papers have been published in *American Behavioral Scientist* in same issue 56 (4) in April 2012. Similarly, five papers have been published in *Organization journal* in same issue 22 (5) in 2015. The analysis again indicate that prosumption concept has been receiving appropriate attention from both fields; social sciences (*Business and Sociology*) and natural sciences (*Energy and Power Grid fields*) but social sciences studies are more going to be cited as compared to natural sciences.

4.1.3. The most influential institutions and countries (centers of excellence)

This section has explored centers of excellence in prosumption research by examining *universities or institutions* and *country of origin* with the help of HistCite as shown in Table 5. We analysed universities' contribution according to the total number of publications (Recs) and their impact (citations received). We founded 405 institutions

Table 5: The most influential institutions and countries in 350 prosumption publications.

#	Journal	Recs	TLCS	TGCS	Countries	Recs	TLCS	TGCS
1	University Maryland	<u>9</u>	91	657	USA	<u>53</u>	107	931
2	Aalto University	<u>8</u>	2	77	Italy	<u>39</u>	19	240
3	Georgia Institute Technology	<u>8</u>	5	29	UK	<u>28</u>	8	164
4	University Calabria	<u>8</u>	6	26	Spain	<u>27</u>	7	118
5	Curtin University Technology	<u>5</u>	8	27	Germany	<u>27</u>	2	63
6	Lulea University Technology	<u>5</u>	0	8	Poland	<u>18</u>	0	16
7	Tampere University Technology	<u>5</u>	0	0	Australia	<u>16</u>	18	96
8	Michigan Technology University	<u>4</u>	1	32	Romania	<u>16</u>	1	14
9	Aalborg University	<u>4</u>	0	3	Finland	<u>15</u>	2	79
10	Calif State University	<u>4</u>	0	0	Peoples R China	<u>15</u>	1	47

and sorted the ten most influential institutions on the base of publications (Recs), and it was found that the only *University of Maryland* got difference with 91 TLCS and nine publications. Despite of publishing eight papers, *Aalto Univ*, *Georgia Institute Technology* and *University Calabria* got only 2, 5 and 6 TLCS as show in Table 5. Forty seven countries were found in 350 prosumption publications in which 53 papers has been written in USA with 107 TLCS and 931 TGCS (highest score). European countries contributed significantly in prosumption research but there is no Asian county in top ten list except China as shown in Table 5.

4.2. Research clusters of 350 Prosumption articles

4.2.1. Citation Mapping using HistCite

In our study, we have applied co-citation mapping technique to present related articles on prosumption that were cited and co-cited simultaneously over time in Web of Science. In order to have meaningful results and interpretations, we identified co-citation networks among the 350 articles from 2007 to 2017 in Figure 2. HistCite graph marker exhibited 30 articles (nodes) and 19 links (relationship among articles) as the most cited ones among 350 articles (TLCS). In citation mapping graph, each article (node) has been expressed by a specific number by HistCite software, e.g. Ritzer and Jurgenson [45] paper has been expressed by 31 number in Figure 2. The size of the node denotes that how much the article is influential in terms of TLCS. An arrow between two nodes represents the citation relationship between two articles. The articles shown in the citation mapping, represented only 9 % of the 350 articles in our database that were the most influential. It would be difficult to make sense of the figure (citation mapping graph) if we include too few citations of given articles in citation mapping graph; but, if we use too many citations of given articles, depth is sacrificed in citation and co-citation patterns (see Apriliyanti and Alon [1]).

In Figure 2, the vertical axis represents the year of publications while each node with specific number denotes an article. It is clear from Figure 2 that some nodes are

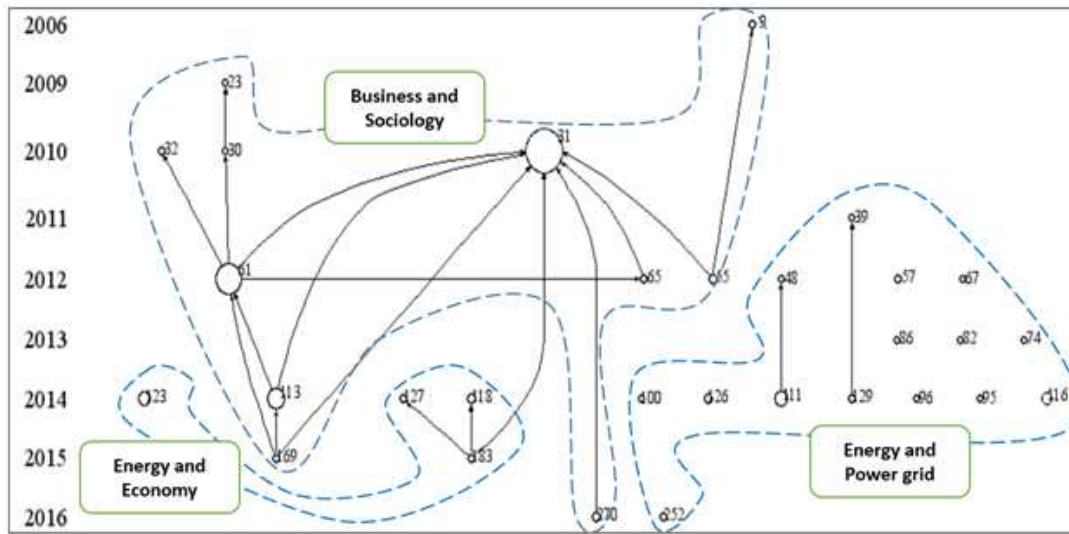


Figure 2: HistCite Citation Mapping of 350 Prosumption articles.

linked with each other forming a cluster while others are separate. Therefore we labelled the clusters after reviewing and investigating the abstract, content and cited reference of those articles. The research articles are assembled into one cluster based on the similarity of their context, topics and the unit of analysis (see Apriliyanti and Alon [1]). We also observed overlapped research clusters during content analysis but cluster presented in citation mapping are discrete and they link related articles to a specific research stream.

By applying co-citation analysis, it was ensured that clusters are internally consistent and externally exclusive so we minimized the overlapping among different clusters. As a consequence, we explored three research clusters through HistCite map citation analysis, as illustrated in Figure 2. Closer nodes represent similar research stream as compared to nodes that are far apart from each other. They are categorized into 1) *Business and Sociology* field: 11 articles; 2) *Energy and Power grid*: 15 articles and 3) *Energy and Economy*: 4 articles as shown in Table 6. Furthermore, we analysed that “Business and Sociology” and “Energy and Power Grid” clusters are externally exclusive and the research papers in their clusters did not cited each other while “Business and Sociology” and “Energy and Economy” clusters are interrelated and a little bit overlapped with each other and it is clearly indicted in citation mapping graph (Figure 2).

4.2.2. Cartography analysis using VOSviewer

After exploring research clusters analysing co-citation mapping graph with the help of HistCite, we confirmed the underlying research clusters with the help of cartography analysis through VOSviewer. In this analysis, we created map based most frequently occurring keywords present in all publications (350) that were extracted from Web of Science. Text data file comprising titles, abstracts and cited reference was used to construct a network (links) between frequently occurring keywords (see van Eck and Waltman [54]). Most frequently occurring keywords were identified in the text data file using

high level natural language processing algorithms in VOSviewer. There is a chance of subjective and selective perception biases when researchers analyse text manually to extract thematic clustering and demonstrate reliability of the concept (see Smith and Humphreys [49]). But text mining through high level natural language processing algorithms in VOSviewer removes such biases (see Biesenthal and Wilden [3]).

In cartography analysis through VOSviewer, we selected “*co-occurrence*” as type of analysis and “*all keywords*” was chosen as unit of analysis. We selected 05 occurrences of key words as a minimum threshold level so as a consequence, we got 63 most frequently occurring keywords present in 350 prosumption research articles as shown in Figure 3. VOSviewer transformed data into a visual form and classified those frequently occurring keywords into three different main clusters (one minor yellow cluster was submerged with blue cluster) in the network visualisation view. The keywords located near each other depict a high frequency of co-occurrences in articles; and those further apart demonstrate low co-occurrence frequency. The larger the circle and the label in the map represents the more importance and significance of the concept. The term or key word with the similar colour belongs to same cluster (see Bornmann et al. [4] van Eck and Waltman [54]). While creating Cartography maps based on a text or corpus file, the researchers can choose between full counting and fractional counting. When authors choose full counting option, all the occurrences (links) among articles are considered. When authors choose fractional counting, then only the presence or absence of a term in a document is counted instead of the total number of occurrences within a document (see Perianes-Rodriguez et al. [35]).

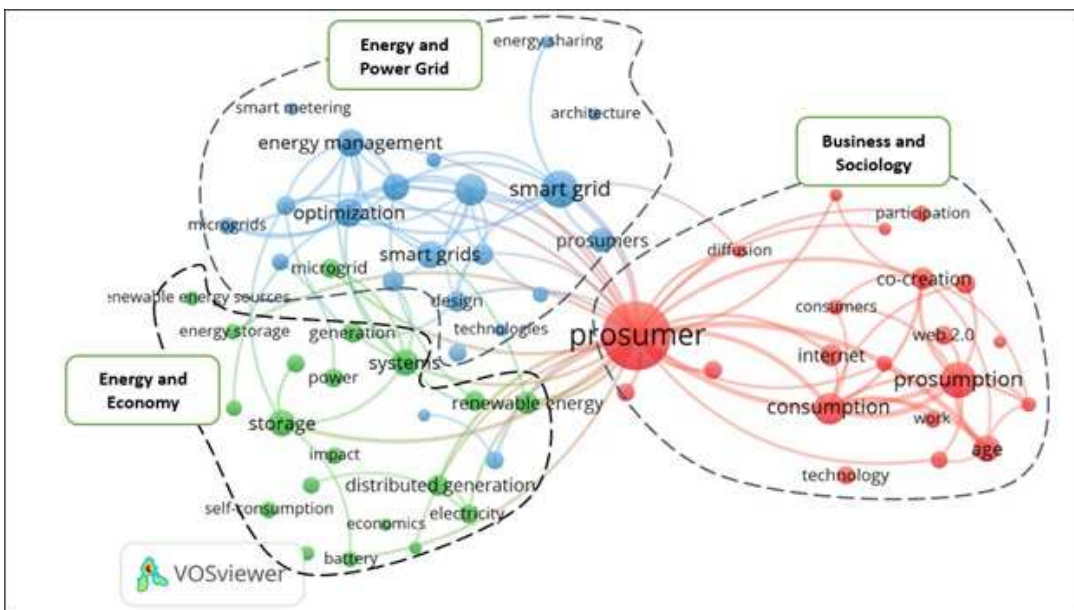


Figure 3: VOSviewer Cartography analysis of 350 Prosumption articles.

As indicated in the Figure 3, clusters are differentiated by pink, blue and green

colours. All three clusters mentioned confirm the research clusters obtained from HistCite citation mapping of 350 Prosumption articles in the above Figure 2.

As mentioned in the Figure 3, *Business and Sociology* cluster (pink colour) exhibits 14 frequently occurring keywords named as Prosumer, prosumption, co-creation, web 2.0, age, consumption, internet, consumers, participation, diffusion, technology, innovation, policy and work. In depth holistic literature review and content analysis of 350 articles revealed that these keywords are significantly related with Business and Sociology fields. The keyword prosumer with relatively very big size is highlighted as the most significant keyword in this cluster and after it prosumption, co-creation, and consumption keywords gained weightage which verify our assumption that prosumption and value co-creation has strong relationship with each other. “*Energy and Economy*” cluster include energy storage, renewable energy, economics, self-consumption, storage, power, generation and so on frequently occurring keywords which is far remote from our area of interest fields (Business and Sociology). Similarly, “*Energy and Power grid*” cluster encompass smart grid, energy management, optimization, micro-grids and so on frequently occurring keywords that don't represent Business and Sociology fields in any case.

4.3. Cluster Analysis of 350 Prosumption articles

4.3.1. Cluster 1: business and sociology

In Table 6, we found 11 research articles in cluster 1 named as *Business and Sociology*. In this cluster all papers are cited with each other but they did not cite articles related to other two clusters. Ritzer and Jurgenson [45], Ritzer et al. [44] and Ritzer [42] papers got significant higher TLCS (49, 24 & 12) as compared to rest of articles in cluster 1. Therefore they are represented by comparatively bigger size in citation mapping (denoted by 31, 61 & 113 numbers in Figure 2 and Table 6). Rest all articles just contained not more than 7 TLCS in 350 Prosumption research articles. Furthermore, all articles have been published within one decade except Pitt et al. [37] paper. It has been published one of the most prestigious journals of marketing field but just got 3 TLCS in 350 Prosumption articles which indicated academia might not consider it significant study in Prosumption field.

4.3.2. Cluster 2: Energy and Power grid

Authors found 15 articles in second cluster named as *Energy and Power grid* as shown in Table 6. In this cluster thirteen three papers out of fifteen have been published just five years before (3 in 2012, 3 in 2013 and 7 in 2014). This indicates that this cluster is in incubation stage and due to this reason, articles in this cluster possess very less TLCS except (see A J Dinusha; Rathnayaka et al. [39]) paper (7 TLCS & 111 number in Figure 2). In this cluster all papers were not cited with each other except four papers; Grijalva et al. [20] cited Nazari et al. [30] paper and Rathnayaka et al. [39] self-cited their own paper Rathnayaka et al. [40] as shown in Figure 2 (two lines with arrows heading to cited papers). This analysis revealed that there is weak relationship among these research papers but they are placed very near to each other due to their similar research area and

Table 6: Cluster analysis of 350 Prosumption articles.

Sr. No.		TLCS	TGCS
Cluster 1: <i>Business and Sociology</i>			
1.	<u>9</u> Pitt LF, 2006, J ACAD MARKET SCI, V34, P115	3	87
2.	<u>23</u> Fuchs C, 2009, EUR J COMMUN, V24, P69	2	75
3.	<u>30</u> Fuchs C, 2010, MEDIA CULT SOC, V32, P141	2	31
4.	<u>31</u> Ritzer G, 2010, J CONSUM CULT, V10, P13	49	481
5.	<u>32</u> Collins S, 2010, J CONSUM CULT, V10, P37	3	14
6.	<u>55</u> Cova B, 2012, CONSUMP MARK CULT, V15, P149	4	38
7.	<u>61</u> Ritzer G, 2012, AM BEHAV SCI, V56, P379	24	89
8.	<u>65</u> Woermann N, 2012, AM BEHAV SCI, V56, P618	3	20
9.	<u>113</u> Ritzer G, 2014, J CONSUM CULT, V14, P3	12	51
10.	<u>169</u> Ritzer G, 2015, SOCIOLOG QUART, V56, P413	3	14
11.	<u>270</u> Dujarier MA, 2016, J CONSUM CULT, V16, P555	4	8
Cluster 2: <i>Energy and Power grid</i>			
12.	<u>39</u> Grijalva S, 2011, IEEE INTL CONF CONTR, P43	2	11
13.	<u>48</u> Rathnayaka AJD, 2012, IEEE INTL CONF IND I, P236	2	6
14.	<u>57</u> Arvidsson A, 2012, INFORM SOC, V28, P135	3	74
15.	<u>67</u> Alcarria R, 2012, SENSORS-BASEL, V12, P8930	2	7
16.	<u>74</u> Martin D, 2013, 2013 SEVENTH INTERNATIONAL CO, P494	2	3
17.	<u>82</u> Larsen GKH, 2013, IEEE T SMART GRID, V4, P828	2	19
18.	<u>86</u> Bompard EF, 2013, IEEE T POWER DELIVER, V28, P2373	2	26
19.	<u>95</u> Luo Y, 2014, 2014 IEEE 39TH CONFERENCE ON , P693	2	5
20.	<u>96</u> Montanari U, 2014, INT CONF SELF, P167	2	2
21.	<u>100</u> Gkatzikis L, 2014, INT CONF SMART GRID, P103	2	4
22.	<u>111</u> Rathnayaka AJD, 2014, IEEE T IND INFORM, V10, P706	7	14
23.	<u>116</u> Rathnayaka AJD, 2014, IEEE TECHNOL SOC MAG, V33, P41	5	14
24.	<u>126</u> Brand L, 2014, APPL ENERG, V129, P39	4	26
25.	<u>129</u> Nazari MH, 2014, IEEE T POWER SYST, V29, P2934	3	16
26.	<u>252</u> Ottesen SO, 2016, ENERGY, V94, P828	3	11
Cluster 3: <i>Energy and Economy</i>			
27.	<u>118</u> Pillai GG, 2014, ENERGY, V68, P832	4	30
28.	<u>123</u> Brusco G, 2014, IEEE T SMART GRID, V5, P2385	6	22
29.	<u>127</u> Velik R, 2014, ENERGEN CONVERS MANAGE, V86, P831	3	15
30.	<u>183</u> Kastel P, 2015, RENEW SUST ENERGEN REV, V51, P718	3	13

this fact was also confirmed from content analysis of these papers' title, abstracts and keywords. One reason of less citing each other might be publication time as mentioned above (7 papers were published in 2014 and hence very difficult for them to cite each other). However, Rathnayaka et al. [39] paper was represented by comparatively bigger size in citation mapping in Figure 2. Furthermore it has been seen in Figure 2 that cluster 2 articles did not possess citation links with other cluster articles. That might be one reason, we assume that this cluster is exclusive from Business and Sociology cluster and Energy and Economy cluster.

4.3.3. Cluster 3: Energy and Economy

In third cluster named as Energy and Economy, we got only four articles in which Brusco et al. [6] paper got maximum TLCS score as compared to rest of papers (6 TLCS & 123 number in Figure 2). Three papers have been published in 2014 and one in 2015 as shown in Table 6. Here we found that Brusco et al. [6] paper was not cited by other three papers in this cluster (see Pillai et al. [36], Velik and Nicolay [56] and Kastel and Gilroy-Scott [22] represented by 118, 127 and 183 numbers in Figure 2). But Pillai et al. [36] and Velik and Nicolay [56] papers were cited by Kastel and Gilroy-Scott [22] in this cluster. The content analysis also revealed that authors have mentioned similar keywords in these three papers; e.g. Cost of energy → Variable grid prices → Levelized cost of electricity (LCOE); Energy management → Renewable energy → Energy-prosumer; Microgrids → Microgeneration → Decentralized energy; Photovoltaic systems → Photovoltaic energy. This analysis also indicates that these papers are not only strongly related with each other but also make nuclei of Energy and Economy cluster in prosumption field.

Furthermore, we found that Kastel and Gilroy-Scott [22] paper also cited Ritzer and Jurgenson [45] paper which is purely related to Business and Sociology cluster therefore authors found that these two clusters are slightly overlapped with each other. At this stage, authors conducted content analysis (titles, keywords and abstract) of underlying papers to explore that which paper is the part of which cluster and this conventional but rigorous method has been used by previous studies (see Apriliyanti and Alon [1] Van Raan [55]).

5. Conclusion

This article makes a singular contribution to our understanding of the Prosumption literature by first exploring most productive and influential research dynamics (authors, articles, journals, institutions, and countries) and then systematically grouping articles into clusters, exploring new research clusters and answering the big question that why citation mapping links are not synchronised (Figure 2). In the quest of this question, we found three key research clusters in the Prosumption literature; (1) *Business and Sociology* (2) *Energy and Power grid* and (3) *Energy and Economy*. Furthermore these research clusters were verified by through cartography analysis through VOSviewer. As a consequence, academic researchers from various disciplines can analyze different aspect

of Prosumption, and hence can demonstrate the evolution of Prosumption by topic, context, and measurement.

5.1. Limitations and future research

Prosumption is an emerging construct and it has been considered by entirely different fields of studies, e.g. in “*Energy and Smart Grid*” and “*Business and Sociology*” clusters, bibliometric citation illustrate this phenomenon in clear way that both clusters did not cite articles of either field with each other. One assumption of bibliometric citation is that highly cited articles are more important and influential as compared to other articles of the same field. But some articles are published much later and despite of their relative contribution, these articles cannot show their true potential in citation mapping. So it is essential to repeat bibliometric analysis after five years or at least once a decade for emerging constructs to see their impact and development on the respective field (see Apriliyanti and Alon [1]).

Second, our study only has focused the research articles extracted from the WoS due to which the articles considered are among the most prestigious journals. Therefore there might be a bias for high quality publications as non-WoS journal articles are not included in our analysis that might have an impact on Prosumption field. Actually, this is one limitation of the HistCite software that it cannot deal with articles from other sources databases, such as Scopus and Google Scholar at this time. Some bibliometric software might be invented that may incorporate publications from lesser quality journals beyond the spectrum of WoS. This will help researchers to compare the significance of same construct influence in WoS and non-WoS journals and in broader spectrum of disciplines for bibliometric meta-analyses. Anyhow, for more deeply and rigorous analysis of a particular construct or relation in a specific field, bibliometric meta-analytic literature reviews will always be forever green technique.

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