

Global Perspective on Payroll System Patent and Research: A Bibliometric Performance

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Abstract: *This study explores the global perspective of payroll research and patent innovations for the past 50 years. The aims are to offer insights into payroll research and publication characteristics, and to highlight patterns and trends of the payroll systems development. Data are based on the Scopus database up to year 2018. Articles related to payroll were assessed by many aspects including growth of patent and publication, documents and source types, language of publications, subject area, geographical distribution of publications, keyword and citation analyses. From the result of the bibliometric analysis, it can be concluded that payroll systems patent developments are increasing, while publication of payroll empirical studies are quite low in number. Consequently, apart from uncovers innovation and commercialization efforts of payroll systems, this paper proposes that more empirical studies are needed in the area. Greater number of empirical studies will enable exploration of further insights on socio-technical elements and behavioral impacts of payroll systems implementation in organizations. Such studies could discover whether developed and patented systems are worth-investing and impacting on the quality of work and life of the users.*

Index Terms: Payroll System, Patent, Innovation, Bibliometric Analysis.

I. INTRODUCTION

As the world faces rapid change in technology nowadays, there is no doubt that payroll processing system, a core component of human resource management, is also experiencing a transformation into a digital platform. When payroll process is automated, the tedious and clunky manual calculations of employees pay would require less work, effort and time especially for big organizations. The idea of taking control of the process through innovation of computerized payroll system is advantageous as it minimizes human calculation errors, increases data security from breaches, and enhances competitiveness [1, 2]. Ever since there is increases of innovations in payroll system [3], it is imperative to identify whether the innovations are patented.

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The purpose of patent is to acknowledge original inventor an intellectual property right so that the innovation is protected [4]. In addition, a patent of innovations is a measurement of output from innovation activity and an indicator of company technological strengths [5, 6]. To achieve a better understanding of the extent to which companies patents their computerized payroll system, we would like to know the number of innovations that are patented. To our knowledge, no yet data exists on this matter.

Therefore, the objectives of this study are twofold. First, this study aims to identify payroll systems innovation patent trends from previous research conducted and the patent organizations involved. Secondly, due to the importance and advantages offered by the computerized payroll system, this study examines the temporal trends of research publications in the field of computerized payroll system to identify high priority issues.

II. LITERATURE REVIEW

Payroll processing is vital for an organization and it is regularly incorporated in human resource management system. It is a special-case purchasing system as organization 'purchases' and pay for their employees instead of raw materials or goods [7]. Payroll processing system helps organizations to efficiently, accurately, timely and systematically process employees' salary, allowance, overtime and deductions [8]. In addition, it assists employers to comply with the government regulations such as tax authorities as well as meet the moral and statutory obligation to the employees by contributing in the employee provident fund and social security [9].

In processing payroll, organizations must alert with latest rules or acts by the government authorities such as re-allocation of employee's contribution in EPF and taxes legislation that may change periodically. Therefore, it is important for organization to adopt payroll system that is reliable, reduce errors and help organization to easily adjust to the changes [1]. Indirectly, these would then increase the motivation and productivity of the employees [10, 11].

Computerized payroll system is a software packages to record, organize, and maintain employee data, such as names, addresses and pay rates, electronically. During each pay period, it calculates payroll deductions (e.g., EPF, SOCSO), allowances (e.g., meal, transportation) and taxes, produces pay slips and keep all data up-to-date.



Small-scale payroll software can be obtained off-the-shelf, such as SQL, Autocount and MYOB, to name a few. Mid-range software is typically can handle management and accounting tasks, such as producing tax documents (EC Form) and financial statements.

High-end payroll software is commonly part of the enterprise resource planning (ERP) software that integrate the whole business functions and can be tailored towards businesses' needs. Regardless of the size of a business and the type of payroll software, all businesses should employ a computerized payroll system to drive business to success.

Prior study has reported that payroll system literature is expanding in the past five years and largely published as journal articles and academic dissertations [3]. The study found that most the literatures focused on the development and implementation of payroll system in organizations. However, the study is limited to certain characteristics in its bibliometric analysis. It is argued that more studies can be included in the analysis to establish further direction in the payroll literature. Therefore, this study is conducted to fill the gap with a wider selection of characteristic in the payroll system bibliometric analysis and extends its coverage to include innovation patent trends of payroll systems.

III. METHODS

This study employs a bibliometric analysis that aims to discover a recent trend in payroll system studies and innovations. Bibliometric analysis refers to a quantitative method that uses statistics to measure text and information and enables analysis of physical publications of articles or bibliographic units [12,13]. The analysis could provide descriptive patterns of publications completed based on a domain, field, country, period, among all [14]. Additionally, a systematic approach required in performing a bibliometric analysis could discover more details information related to the publications, including authors, frequency of keywords and citations. Most importantly, bibliometric analysis allows researchers to explore patterns of past studies from historical data and consequently indicates topics visibility and future development in the area [13].

The bibliometric analysis in the current study was conducted based on the online version of publications in the Scopus database. Scopus is the largest database of peer reviewed literature that includes scientific journals, books and conference proceedings [15]. The database consists of approximately 36 000 titles from almost 11000 publishers with citation references mainly in peer-reviewed journals across subject fields of social, physical, health and life sciences. The online database was searched using the following query with keywords of (TITLE-ABS-KEY ("payroll system" OR "payroll software" OR "payroll application")). The data was retrieved on 7th March 2019 consisting of data up to year 2018. This query produced a total of 2,367 patents and 110 documents. After conducting a review on the documents, we find out that 10 documents were not within the scope of payroll system related study and there

was one duplicate item. Thus, 2,367 patents and 99 documents will be used to conduct the bibliometric analysis.

IV. ANALYSIS AND FINDINGS

All the articles referring to payroll that met the query search characteristics were assessed from the following aspects: growth of patent and publication, documents and source types, and language of publications, subject area, geographical distribution of publications, keyword and citation analyses, and number of authors for publication.

A. Annual Growth of Patent and Publication

Table 1 summarizes the details about the total patents registered related to payroll system since 1916. As per Scopus records, the first patent registered on payroll system was based on the work by Amos H. Hawley (International Money Machine Company) on Platen-Feed Mechanism [16]. The growth on the patent is quite slow due to the slow trend of the information technology until in the year of 2001 where the percentage of its growth were increase more than 1%. Since then, there were increasing numbers of payroll systems innovation-related have been registered. The highest number of registered patents was observed in 2013, where a total of 202 representing 8.53% of patents were registered.

Table 1. Total Patents Registered by Year

Year	Frequency	% (N=2367)	Cumulative Percent
1916	1	0.04	0.04
1932	2	0.08	0.13
1937	1	0.04	0.17
1938	1	0.04	0.21
1940	1	0.04	0.25
1949	1	0.04	0.30
1950	1	0.04	0.34
1952	1	0.04	0.38
1954	3	0.13	0.51
1955	1	0.04	0.55
1956	1	0.04	0.59
1957	1	0.04	0.63
1958	1	0.04	0.68
1959	1	0.04	0.72
1960	3	0.13	0.84
1961	2	0.08	0.93
1963	1	0.04	0.97
1964	1	0.04	1.01
1965	1	0.04	1.06
1967	3	0.13	1.18
1968	2	0.08	1.27
1969	2	0.08	1.35
1974	1	0.04	1.39
1978	2	0.08	1.48
1979	1	0.04	1.52



1980	1	0.04	1.56
1981	1	0.04	1.61
1982	1	0.04	1.65
1983	4	0.17	1.82
1986	1	0.04	1.86
1987	1	0.04	1.90
1988	2	0.08	1.99
1989	1	0.04	2.03
1991	4	0.17	2.20
1992	2	0.08	2.28
1993	3	0.13	2.41
1994	2	0.08	2.49
1995	7	0.30	2.79
1996	7	0.30	3.08
1997	9	0.38	3.46
1998	12	0.51	3.97
1999	16	0.68	4.65
2000	20	0.84	5.49
2001	34	1.44	6.93
2002	53	2.24	9.17
2003	80	3.38	12.55
2004	114	4.82	17.36
2005	74	3.13	20.49
2006	107	4.52	25.01
2007	114	4.82	29.83
2008	133	5.62	35.45
2009	119	5.03	40.47
2010	135	5.70	46.18
2011	149	6.29	52.47
2012	156	6.59	59.06
2013	202	8.53	67.60
2014	168	7.10	74.69
2015	137	5.79	80.48
2016	154	6.51	86.99
2017	195	8.24	95.23
2018	113	4.77	100.00
Total	2367	100.00	

At the same time, we also analyzed the organizations where those patents were registered. It was revealed that more than 93% of the patents were registered in the United States Patent and Trademark Office. Table 2 summaries the details.

Table 2. Patent Office

Patent Office	Frequency	% (N=2367)
United States Patent & Trademark Office	2206	93.198
World Intellectual Property Organization	66	2.788
European Patent Office	50	2.112
Japan Patent Office	26	1.098
United Kingdom Intellectual Property Office	19	0.803
Total	2367	100.000

While there is a substantial growth in the innovation of patents registered for payroll systems and applications, the number of article publications was not as significant as

patents. There are only 99 documents published on the payroll system, from 1969 to 2018, and have been indexed in Scopus database. As per Scopus records, the first published research on payroll system was by Reizer and Harbison [17] with a title By-Products of a Hospital Payroll System. The total number of articles written every year were less than 10 and the highest number of publications, which is 7 in total, was recorded in 2017. It represents 7.07% of the total documents. Table 3 shows the growth of publications related to payroll systems.

Table 3. Growth of Publication by Year

Year	Frequency	% (N=99)	Cumulative Percent
1969	2	2.02	2.02
1970	1	1.01	3.03
1973	1	1.01	4.04
1974	1	1.01	5.05
1975	2	2.02	7.07
1976	1	1.01	8.08
1977	1	1.01	9.09
1978	2	2.02	11.11
1982	3	3.03	14.14
1983	3	3.03	17.17
1984	5	5.05	22.22
1985	4	4.04	26.26
1987	3	3.03	29.29
1988	1	1.01	30.30
1989	4	4.04	34.34
1990	1	1.01	35.35
1991	1	1.01	36.36
1992	1	1.01	37.37
1993	2	2.02	39.39
1994	2	2.02	41.41
1997	5	5.05	46.46
1998	2	2.02	48.48
2000	3	3.03	51.52
2002	1	1.01	52.53
2003	1	1.01	53.54
2004	4	4.04	57.58
2005	3	3.03	60.61
2006	2	2.02	62.63
2007	2	2.02	64.65
2009	3	3.03	67.68
2010	3	3.03	70.71
2011	4	4.04	74.75
2012	1	1.01	75.76
2013	3	3.03	78.79
2014	4	4.04	82.83
2015	3	3.03	85.86
2016	2	2.02	87.88
2017	7	7.07	94.95
2018	5	5.05	100.00
Total	99	100.00	



B. Document and Source Type

Document type refers to a type of document based on the originality of the document either from article, conference paper, book chapter etc., while source type is the type of a source document whether it is journal, conference proceedings, book series, book or trade publication. According to Sweileh et al. [18], a conference paper that appeared under document type could differ from those appeared under the source type. For example, a paper presented in a conference will be classified as a conference paper under document type.

However, the same paper maybe classified as a full journal article, conference proceeding or book chapter under source type, depending on its publication status. As summarized in Table 4, the documents published on payroll system is spread into seven document types. As indicated further, more than half of the total publications is in the form of article (50.51%) and followed by conference paper (37.37%). Other type of documents represented less than 5% of the total publication respectively.

Table 4. Document Type

Document Type	Frequency	% (N=99)
Article	50	50.51
Conference Paper	37	37.37
Review	4	4.04
Book Chapter	3	3.03
Short Survey	3	3.03
Conference Review	1	1.01
Editorial	1	1.01
Total	99	100.00

Meanwhile, as presented in Table 5, the documents are classified into five different source types, of which journal represents the highest type of source with 47 documents (47.47%) and followed by conference proceedings with 35 documents (35.35%).

Table 5. Source Type

Document Type	Frequency	% (N=99)
Journal	47	47.47
Conference Proceedings	35	35.35
Trade Publications	11	11.11
Books	3	3.03
Book Series	3	3.03
Total	99	100.00

C. Languages of Documents

Based on Table 5, English is the common language used for publications in this research domain (91; 91.92%). Five of the documents are undefined, while others which represent one document each, was written in Chinese, German and Japanese respectively.

Table 6. Languages Used for Publications

Language	Frequency	% (N=99)
English	91	91.92
Chinese	1	1.01
German	1	1.01
Japanese	1	1.01
Undefined	5	5.05
Total	99	100.00

D. Subject Area

This paper next classifies the published documents based on the subject area as summarized in Table 7. As reported, about 38% of the documents examined are from the computer science field, followed by engineering (37.37%), medicine (17.17) and business, management and accounting (12.12%). The distribution of studies on payroll systems were also emerged from other subject areas including mathematics, social science, decision sciences and material science. This indicate most studies were concentrated on the technical, rather than managerial perspectives.

Table 7. Subject Area

Subject Area	Frequency*	% (N=99)
Computer Science	38	38.38
Engineering	37	37.37
Medicine	17	17.17
Business, Management and Accounting	12	12.12
Mathematics	9	9.09
Social Sciences	9	9.09
Decision Sciences	5	5.05
Materials Science	5	5.05
Economics, Econometrics and Finance	3	3.03
Energy	3	3.03
Physics and Astronomy	3	3.03
Chemical Engineering	2	2.02
Environmental Science	2	2.02
Immunology and Microbiology	1	1.01
Nursing	1	1.01
Undefined	4	4.04

*Some documents are classified in more than one subject area

E. Keywords Analysis

In terms of keywords analysis, authors mapped the keywords supplied for each document using VOSviewer.



According to the software developer, “VOSviewer is a software tool for constructing and visualizing bibliometric networks. These networks may, for instance, include journals, researchers, or individual publications, and they can be constructed based on citation, bibliographic coupling, co-citation, or co-authorship relations. VOSviewer also offers text mining functionality that can be used to construct and visualize co-occurrence networks of important terms extracted from a body of scientific literature.”

Fig.1 presents a network visualization of the authors’

keywords produced by VOSviewer in which color, font size, and thickness of joining lines indicate strength of the relationship amongst the keywords. Related keywords as indicated by the same color are frequently listed together. For instant, the diagram suggests that payroll systems, wages, computer software, database systems, personnel and data processing (which is colored as red) are closely related and usually co-occur together. Same goes to the other group which are colored in blue, green and yellow.

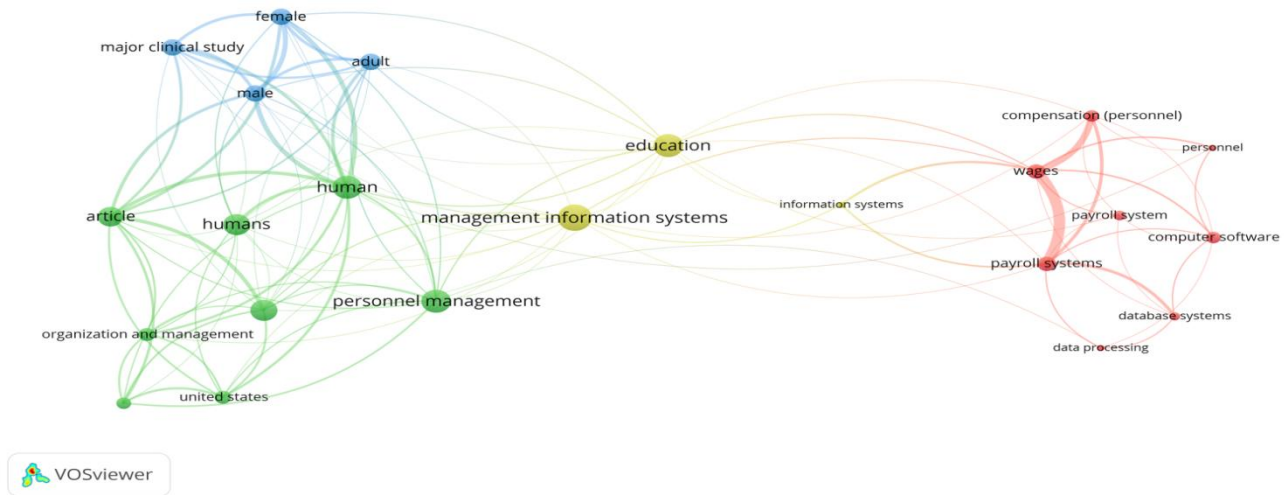


Fig 1. Network visualization map of the author keywords

Specifically, the VOSViewer has generated 23 items in 4 difference clusters based on the 5-minimum number of occurrences for the keywords as follow:

Cluster 1 (8 items)

- compensation (personnel)
- computer software
- data processing
- database systems
- payroll system
- payroll systems
- personnel
- wages

Cluster 2 (8 items)

- articles
- human
- humans
- information systems
- organization and management
- personnel management
- salaries and fringe benefits
- united states

Cluster 3 (4 items)

- adult
- female
- major clinical study
- male

Cluster 4 (3 items)

- education
- information systems
- management information systems

We also analyzed the keyword in the spreadsheet document to count the total number of occurrences. Prior to that, keywords data has been cleaned to standardize the usage. For example, “payroll system” and “payroll systems” were combined as it represents the similar meaning. Table 8 shows the total frequency of the keywords used from the retrieved documents. Wages and payroll system appeared to be the keywords with highest occurrences.

Table 8. Keywords

Author Keywords	Frequency	Percent
Wages	27	27.27
Payroll System (s)	27	27.27
Compensation (personnel)	10	10.10
Human (s)	9	9.09
Article	8	8.08
Computer Software	8	8.08
Database Systems	8	8.08
Information System	7	7.07
Personnel Management	7	7.07
Salaries and Fringe Benefits	7	7.07
Organization and Management	6	6.06
United States	6	6.06
Data Processing	5	5.05
Education	5	5.05
Information Systems	5	5.05
Management Information Systems	5	5.05
Personnel	5	5.05
Automation	4	4.04
Hospital Management	4	4.04
Human Resource Management	4	4.04
Industrial Management	4	4.04
Information Management	4	4.04
Payroll	4	4.04
Personnel Staffing and Scheduling	4	4.04
Information Systems		

F. Geographical Distribution of Publications

Overall, researchers from 25 different countries have contributed to the related publications in payroll system. All countries contributing to the productivity of publications in this research area are listed in Table 9. Top on the list are the United States of America (USA) with a total of 25 (25.25%) documents followed by the Canada (6: 6.06%) and Indonesia (5: 5.05%).

Table 9. Countries contributed to the publications

Country	Frequency	% (N=99)
United States	25	25.25
Canada	6	6.06
Indonesia	5	5.05
Australia	3	3.03
India	3	3.03
Taiwan	3	3.03
United Kingdom	3	3.03
Greece	2	2.02
Malaysia	2	2.02
New Zealand	2	2.02
Romania	2	2.02
Brazil	1	1.01
China	1	1.01

Congo	1	1.01
Egypt	1	1.01
Finland	1	1.01
Germany	1	1.01
Iran	1	1.01
Italy	1	1.01
Japan	1	1.01
Jordan	1	1.01
Mexico	1	1.01
Mozambique	1	1.01
Philippines	1	1.01
Sweden	1	1.01
Undefined	29	29.29

G. Number of Author

Table 10 shows the number of author(s) per documents. While 39 (39.39%) documents are single-authored, the remaining documents are reported as multi-authored publications with the number of authors ranging between two and 15.

Table 10. Number of Author(s) per Document

Author Count	Frequency	% (N=99)
0*	6	6.06
1	39	39.39
2	20	20.20
3	16	16.16
4	7	7.07
5	5	5.05
7	3	3.03
8	2	2.02
15	1	1.01
Total	99	100.00

*Author name not available

H. Citation Analysis

Table 11 summarizes the citation metrics for the retrieved documents as of 7 March 2019. As indicated, there are 387 citations reported in 50 years (1969 – 2018) for 99 retrieved articles with an average of 7.74 citations per year.

Table 11. Citations Metrics

Metrics	Data
Reference date	07/03/2019 11:10
Publication years	1969-2018
Citation years	50 (1969-2018)
Papers	99
Citations	387
Citations/year	7.74
Citations/paper	3.91
Citations/author	222.72



Papers/author	57.83
Authors/paper	2.34
Age-weighted citation rate	23.97
Hirsch h-index	8
Egghe g-index	19
PoP hI,norm	6
PoP hI,annual	0.12

Meanwhile, Table 12 discloses top 20 most cited articles (based on number of times being cited) as per Scopus database. In addition to total citations reported by Scopus, the table also discloses total number of citations reported by Google Scholar. While Scopus only count the citation for the documents that have been indexed in their database, Google Scholar counts all citations based on all documents that are reachable. This explains the reason for the differences between the total citations in Scopus compared to the total citations in Google Scholar. The document entitled “A disaster for everyone to see: An interpretive analysis of a failed IS project” by Myers [19] has so far received the highest number of citations (105 citations or an average of 4.20 citations per year).

Table 12. Top 20 Cited Articles

No.	Authors	Title	Year	Cites	Cites per Year	GS Cites	GS Cites per Year
1	M.D. Myers [19]	A disaster for everyone to see: An interpretive analysis of a failed is project	1994	105	4.20	292	11.68
2	M.D. Fraser, K. Kumar, V.K. Vaishnavi [20]	Informal and formal requirements specification languages: Bridging the gap	1991	77	2.75	187	6.68
3	J.E. Hunton, K.H. Price [21]	Effects of the user participation process and task meaningfulness on key information system outcomes	1997	46	2.09	105	4.77
4	R.W. Jeffery, J.L. Forster, M.K. Snell [22]	Promoting weight control at the worksite: A pilot program of self-motivation using payroll-based incentives	1985	27	0.79	61	1.79
5	R.L. Arenson, F. Van Der Voorde, J.F. Stevens [23]	Improved financial management of the radiology department with a microcosting system	1988	13	0.42	19	0.61
6	B. Stepien, A. Felty, S. Matwin [24]	A non-technical user-oriented display notation for XACML conditions	2009	11	1.10	23	2.3

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7	S. Cota [25]	For certain eyes only	2004	9	0.60	12	0.8
8	T. Clear, B. Raza, S.G. MacDonell [26]	A critical evaluation of failure in a nearshore outsourcing project: What dilemma analysis can tell us	2013	7	1.17	15	2.5
9	R.L. Nolan, J. Brennan, K.P. Coyne, S. Spong, J. Spar, N. Strauss, T. Milan, D. Speight, R.S. Tedlow, D. Gillotti, E. Yardeni, D.J. Block, S.A. Radin, S. Sheinheit, B. Robbins [27]	Connectivity and control in the year 2000 and beyond	1998	7	0.33	13	0.62
10	J. C. Sampaio Do Prado Leite, , M. Sant'anna, & A. Francisco Do Prado [28]	Porting COBOL programs using a transformational approach	1997	7	0.32	20	0.91
11	C. Lu, M. Chang, Kinshuk, E. Huang, C.-W. Chen [29]	Story decorated learning activity generation in a context-aware mobile role-playing game	2011	5	0.63	7	0.88
12	R. Rozbehani, S.E. Maleki, M. KazemPour-Dizaji, S.E. Maleki, A. Javanbakht [11]	The effect of implementing a performance-based payroll system on employee satisfaction in a state hospital (a case study of Masih Daneshvari Hospital)	2016	4	1.33	0	0.00
13	C.J. Stefanou, A. Skouras [30]	E-government: applications in the labor and social security regulatory area	2015	4	1.00	9	2.25
14	M. Thite, K. Sandhu [31]	Where is my pay? Critical success factors of a payroll system - A system life cycle approach	2014	4	0.80	9	1.80
15	W. Austin, C.F. Phillips [32]	Development and implementation of a health surveillance system	1983	4	0.11	10	0.28
16	Donald F. Cooke [33]	Map storage on CD-ROM	1987	3	0.09	15	0.47
17	B. Soewito, F.L. Gaol, E. Simanjuntak, F.E. Gunawan [34]	Smart mobile attendance system using voice recognition and fingerprint on smartphone	2017	2	1.00	6	2.00
18	J.-R.L. Esanga, C. Viadro, L. McManus, J. Wesson, N. Matoko, E. Ngumbu, K.E. Gilroy, D. Trudeau [35]	How the introduction of a human resources information system helped the Democratic Republic of Congo to mobilise domestic resources for an improved health workforce	2017	2	1.00	3	1.50
19	B. Soewito, E.W.M. Simanjuntak, I.P. Gunawan	Absence system using your own device	2015	2	0.50	2	0.50

[36]

20	W. Feng, E.A. Slaoui [37]	Functional approach for the architecture design of a payroll system	2006	2	0.15	4	0.31
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*GS – Google Scholar

of the users.

V. DISCUSSION AND CONCLUSION

The current study has examined payroll systems innovation patents and publications development for the period of almost 50 years. The study was conducted using a bibliometric analysis based on payroll data retrieved from the Scopus database. Despite a slower growth in payroll empirical publications, findings highlighted an increasing trend in payroll systems patents since the early decade of the new millennium. That period was a beginning for a phenomenal growth of technology innovation around the globe. Patents were mostly registered in the United States, implying a progressive payroll systems development along with encouraging number of publications produced in the country.

Within the limited number of payroll publications globally, almost 80% of were published as journal articles and conference papers in proceedings. Almost all publications were written in English and originates from more than 20 countries. This implies that despite the slow progress of payroll publications, this area of research is still considered relevant across countries.

Common keywords used in these publications are wages and payroll system. Further network visualization analysis suggests that keywords that are highly-related are human resource management, information management, resource allocation, information system, information technology and outsourcing, among all.

Majority of these publications are from the technical area i.e. computer science, which is aligned with the encouraging numbers of patents registered, reflecting the facts that most payroll works focus on developing innovative payroll systems that can be commercialized, thus requiring patents registration.

In line with the limited number of payroll publications, there is also low citation rate in the period of 50 years. An interesting finding reveals that the paper with highest citation is a study on failure in payroll system implementation, which reflects a high interest to understand the real stories and outcomes from payroll systems implementations.

Due to the lack of empirical payroll studies published, the question that remains unclear is how many of those patented payroll systems are successful in meeting users' expectations and systems' objectives. Consequently, apart from innovation and commercialization efforts of payroll systems, more empirical studies are needed in the area that examines socio-technical elements and behavioral impacts of payroll systems implementation in organizations. The findings are crucial to explore and ensure developed and patented systems are worth-investing and resulting in improving quality of work and life

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