Knowledge Mapping of Platform Research: A Visual Analysis Using VOSviewer*

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Abstract—Platform is a topic that has been shaped by numerous articles for years. This study makes a contribution by a bibliometric analysis of academic research on platform in management, business and economics areas. The author analyzes 619 articles on platform from the Web of Science database from 1978 to 2018. Various methods are used to perform the bibliometric analysis: performance analysis and scientific maps. Furthermore, VOSviewer is used to map the bibliographic data. This study shows networks of references, journals and authors, indicating their impacts on the platform's research. The results will enhance understanding of platform research and enable future scholars to focus their own studies effectively.

Keywords—platform; bibliometric analysis; co-citations; VOSviewer

I. INTRODUCTION

With rapid development of the global markets, competition becomes increasingly fierce. To achieve sustainable competitive advantage, an innovator may choose to "open" its technology by allowing outsiders to participate in its development and commercialization [1], which makes the innovation paradigm has evolved from sole firm's R&D behavior into cluster's cooperative R&D behavior [2]. Platform is the very cluster that support multiple interactions across various actors and can facilitate sustainable technical development [3][4][5][6]. As a consequence, firms advocate to build a platform with their various cooperators (such as vendors, customers, governments, intermediary), which results many markets in today's economy are organized around platforms, including mobile and PC operating systems, online games and so on [7]. There are some excellent platform-based companies in China, such as Alibaba and Tencent, both of which are able to obtain sustainable expand in the market because of the platform. The chase of firms towards platform make it a trending topic in academia, and resulting the exponential study rise in this field.

What is a platform? An early definition is that a platform is a common structure including a set of subsystems and interfaces from which a stream of products can be developed [8]. Bresnahan and Greenstein emphasize the role of a platform in promoting cooperation, and consider it as a bundle of standard components around which buyers and sellers coordinate efforts [9]. Hereafter, a more general and straightforward definition is brought forward, platform is the products and services that integrate groups of users in two-sided networks [10]. A platform may encompass physical components, tools and rules to facilitate development, a collection of technical standards to support interoperability, or any combination of these things [4]. There are different kinds of platforms, thus, scholars try to classify it. Gawer and Cusumano classify platform into two categories: internal and external platform [11]. Internal platform is a set of assets organized in a common structure from which a company can efficiently develop and produce a stream of derivative products, which is a firm level definition [8][12]; while external platform is products, services, or technologies that act as a foundation upon which external innovators, organized as an innovative business ecosystem, can develop their own complementary products, technologies, or services [13]. The "network effect" can explain the different value of platforms: the more users who choose the platform, the more valuable the platform becomes to the suppliers, users and owners because of growing access to the network of users and often to a growing set of complementary innovations.

The academia and enterprises studying and practicing platforms has resulted a rapid growth in literature on platform. However, there is a lack of comprehensive, quantitative reviews exclusively focused on platform. Our work in this study provides a thorough and in-depth picture on the status quo of researches in the platform field. We analyze 619 publications on platform from the Web of Science database (WoS) from 1978 to the end of 2018. By analyzing bibliometric indicators achieved on WoS, we illustrate the distribution of publications, most influential journals, most cited publications, most important authors, most outstanding institutions and countries. Furthermore, by analyzing data with VOSviewer, we present the co-citation of cited references, co-citation of authors and co-citation of journals.

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II. METHODOLOGY

A. Bibliometric Analysis

Bibliometric analysis is a quantitative method to retrospect and describe published papers, which are helpful for researchers evaluating academic studies in a focal field [14][15]. By using secondary data, bibliometric analysis examines secondary data acquired on digital database from a quantitative and objective perspective [16]; therefore, it is able to introduce a systematic, transparent, and reproducible review process and, then, enhance the reliability and quality of review [17].

According to Noyons and his co-authors, performance analysis and science mapping are two prime procedures [18]. Performance analysis is used to evaluate the publication performance of various levels, which uses techniques like citation analysis, counting publications by authors, institutions, universities or countries [19]. A unique feature used in performance analysis in this study is citation counts, which provided by WoS and represents the relative importance and influence of publications. Moreover, to evaluate the relative impact of the authors, journals, institutions and countries, we calculated the average citations per articles.

Science mapping is used to explore the structure and evolution of a focal research area [20][21]. In this research, we used co-citation analysis and co-occurrence analysis. Co-citation analysis of authors aims to identify eminent authors by analyzing citation records [22]. Co-citation analysis of journal contributes to understanding related scientific journals in a focal area [23]. Co-citation analysis reflects the importance that researchers attach to a cited article. As a consequence, the more often a publication is referred, the more predominant it will turn out to be for developing a focal area [24]. Co-occurrence analysis contributes to creating a term map, in which the frequency of occurrence of a particular term is defined by label size and the distance between two terms [25]. Therefore, co-occurrence analysis of author keywords can be applied to build a network in a particular area, which aims to explore and exhibit the intellectual framework of a particular research field [26]. In this section, we used VOSviewer software as a tool to perform the co-citation analysis and co-occurrence analysis, and then to realize the visualization of intellectual structure.

B. Data

The WoS is a high-quality digital database that is broadly accepted among researchers all over the world and has become a common tool for both retrieving and evaluating different types of publications [19]. The WoS covers a wide range of publications from different fields, which includes over 15,000 journals and 50,000,000 classified publications in 251 categories and 150 research areas [27]. In addition, the WoS is a proper database because it contains a set of data, such as titles, authors, institutions, countries, abstracts, keywords, references, citations count, impact factors and others [28][29]. In order to understand business research on platform, we collected publication information from the WoS Social Science Citation Index (SSCI), and limited to management, business and economics areas. Our study analyzed 619 publications from 1978 to 2018, as the first publication on platform that contains complete information was in 1978 (here we expurgate three anonymous documents in early years).

III. RESULTS

This section presents the following results of performance analysis, which includes the descriptive statistics, the distribution of the publications, the most cited publications, the most important authors, the most impact journals, the most influential institutions, and the most outstanding countries in the platform research field. In addition, this section also provides the results of scientific maps. In order to gain an overall perspective of developments in research on platform, we perform the co-citation analysis of references, and authors, journals and their clusters respectively; in order to illustrate the related term in platform research.

A. Performance Analysis

1) Descriptive statistics

Through searching and screening, we finally obtained 604 articles and 15 reviews (as we focused on exploring on the intellectual framework of platform research field, we limited publications in article and review categories). The sample in this study were comprised of a total of 619 publications by 741 authors affiliated with 713 institutions in 57 countries, which were published in 228 journals and referred 13,638 references (see “Table I”).

| Criteria     | Quantity |
|--------------|----------|
| Publications | 619      |
| Authors      | 1368     |
| Journals     | 228      |
| Institutions | 713      |
| Countries    | 57       |
| Cited reference | 13638  |

2) Distribution of publications

"Fig. 1" shows the chronological distribution of publications in the platform area. The first traceable article was published in 1978, and from then on, the number of publications is on the rise. The growth trend can be divided into three stages. The first stage is from 1978 to 1992, when just one or two articles are published each year, which shows it is embryonic stage. In the subsequent stage, the number of papers produced from 1994 to 2009 reaches more than quadruple of the previous stage, indicating the seedtime timeline. Within the last stage, from 2010 to 2018, publications meet a considerable increase, which represent blossom in this period.
3) Most cited publications

This study uncovers the most cited publications in WoS. The sample presents an average citation rate of 22 citations. However, 15.76% of the documents have never been cited, and 49.04% have been cited between one and ten times. We show publications which have been cited over 100 times.

(See "Table II")

The first most cited article *Platform Competition in Two-sided Markets* [5], accounting for 956 citations, establishes a platform competition model within two-sided markets, and further analysis the determinants of price allocation and end-user surplus for the two governance structures: for-profit platforms and not-for-profit platforms. The second most cited article *Planning for Product Platforms* [31] focuses on the product platform. Robertson and Ulrich discuss the four fundamentals of product platform planning: components, processes, knowledge and people and relationships, and advocates a loosely structured platform planning process which focus on the product plan, the differentiation plan and the commonality plan [31]. The third most cited article *Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases* [32] introduces a platform approach into the regional advantage constructing issue. By bringing together three notions (related variety, knowledge bases and policy platforms), this study constructs a regional innovation policy model, and implies that the three notions can jointly facilitate economic development within and between regions.

| Rank | Title                                                                 | Journal                                                      | Year | Citations count |
|------|----------------------------------------------------------------------|--------------------------------------------------------------|------|-----------------|
| 1    | Platform competition in two-sided markets                            | Journal of The European Economic Association                  | 2003 | 956             |
| 2    | Planning for product platforms                                       | Sloan Management Review                                       | 1998 | 439             |
| 3    | Constructing regional advantage: Platform policies based on related variety and differentiated knowledge bases | Regional Studies                                             | 2011 | 410             |
| 4    | Internal and external integration for product development: The contingency effects of uncertainty, equivocality, and platform strategy | Decision Sciences                                             | 2005 | 358             |
| 5    | How open is open enough? Melding proprietary and open source platform strategies | Research Policy                                              | 2003 | 288             |
| 6    | The assimilation of knowledge platforms in organizations: An empirical investigation | Organization Science                                         | 2001 | 266             |
| 7    | Crowd-funding: Transforming customers into investors through innovative service platforms | Journal of Service Management                                 | 2011 | 226             |
| 8    | Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics | Information Systems Research                                 | 2010 | 212             |
| 9    | Industry platforms and ecosystem innovation                          | Journal of Product Innovation Management                      | 2014 | 204             |
| 10   | Export-platform foreign direct investment                            | Journal of the European Economic Association                  | 2007 | 199             |
| 11   | Technological platforms and diversification                         | Organization Science                                          | 1996 | 195             |
| 12   | Electronic word of mouth (eWOM): How eWOM platforms influence consumer product judgement | International Journal of Advertising                         | 2009 | 194             |
| 13   | Real options and IF platform adoption: Implications for theory and practice | Information Systems Research                                 | 2004 | 176             |
| 14   | The platform organization: Recombining strategies, structures, and surprises | Organization Science                                         | 1996 | 174             |
| 15   | Open platform strategies and innovation: Granting access vs. devolving control | Management Science                                          | 2010 | 159             |
| 16   | Options thinking and platform investments: Investing in opportunity | California Management Review                                 | 1994 | 159             |
| 17   | Bridging differing perspectives on technological platforms: Toward an integrative framework | Research Policy                                              | 2014 | 155             |
| 18   | Appropriateness and impact of platform-based product development    | Management Science                                           | 2001 | 152             |
| 19   | How companies become platform leaders                                | MIT Sloan Management Review                                   | 2008 | 149             |
| 20   | Two-sided competition of proprietary vs. open source technology platforms and the implications for the software industry | Management Science                                          | 2006 | 143             |
4) Most important authors

About 90.21% of the authors in the sample have published one paper, and 3.07% of the authors have produced three or more documents. Hence, we analyze the authors who have published three or more papers. Furthermore, considered to the impact of the author, we choose the author whose paper have been cited over 50 times.

According to the result shows in "Table III", with 160.67 citations per publication, Bruce Kogut becomes the most important author. The subsequent authors are Michael Cusumano, Annabelle Gawer, Joel West, Marc Meyer. Nevertheless, the top five authors who publish more are Andrei Hagiu, Annabelle Gawer, Marc Meyer, Amrit Tiwana, Carmelo Cennamo. That means Andrei Hagiu published the most with 9 papers. In consequence, Annabelle Gawer and Marc Meyer are authors who are more productive and influential.

| Rank | Authors         | Publication | Citations | Average citation/publication |
|------|-----------------|-------------|-----------|-----------------------------|
| 1    | Kogut, B        | 3           | 482       | 160.67                      |
| 2    | Cusumano, M. A  | 4           | 487       | 121.75                      |
| 3    | Gawer, A        | 8           | 865       | 108.13                      |
| 4    | West, J         | 3           | 313       | 104.33                      |
| 5    | Meyer, M. H     | 5           | 323       | 64.6                        |
| 6    | Huang, P        | 3           | 171       | 57                          |
| 7    | Wu, D. J        | 3           | 171       | 57                          |
| 8    | Parker, G       | 3           | 150       | 50                          |
| 9    | Van Alstyne, M  | 3           | 150       | 50                          |
| 10   | Tiwana, A       | 5           | 248       | 49.6                        |
| 11   | Maffiato, M     | 3           | 146       | 48.67                       |
| 12   | Hagiu, A        | 9           | 388       | 43.11                       |
| 13   | Peitz, M        | 3           | 92        | 30.67                       |
| 14   | Huang, G. Q     | 3           | 82        | 27.33                       |
| 15   | Wright, J       | 3           | 71        | 23.67                       |
| 16   | Chen, J         | 3           | 70        | 23.33                       |
| 17   | Zhang, C        | 3           | 70        | 23.33                       |
| 18   | Evans, D. S     | 4           | 81        | 20.25                       |
| 19   | Cennamo, C      | 4           | 77        | 19.25                       |
| 20   | Belleflamme, P  | 3           | 51        | 17                          |
| 21   | Schmalensee, R  | 3           | 50        | 16.67                       |

5) Most impacted journals

Three or more articles have been published by 33.18% of journals, and four or more articles have been published by 23.58% of journals. Hence, we choose journals which have four or more articles. Furthermore, considered to the effect of journals, the following analysis includes journals with at least 50 citations (as shown in "Table IV").

According to the "average citation per publication" indicator, Organization Science is the most impact journal (160 citation per publication), followed by Regional Studies (121.5 citations per publication), Decision Sciences (99.25 citations per publication), MIT Sloan Management Review (84 citations per publication) and Research Policy (80.83 citations per publication). In the contrary, the top five
journals with more publications are Information Systems Research (23 publications), the Journal of Product Innovation Management (15 publications), International Journal of Industrial Organization (13 publications), International Journal of Technology Management (13 publications), and MIS Quarterly (13 publications).

| Rank | Journal                                                   | Publications | Citations | Average citation/publication |
|------|-----------------------------------------------------------|--------------|-----------|-----------------------------|
| 1    | Organization Science                                      | 4            | 640       | 160                         |
| 2    | Regional Studies                                          | 4            | 486       | 121.5                       |
| 3    | Decision Sciences                                         | 4            | 397       | 99.25                       |
| 4    | MIT Sloan Management Review                               | 4            | 336       | 84                          |
| 5    | Research Policy                                           | 6            | 485       | 80.83                       |
| 6    | Strategic Management Journal                              | 5            | 365       | 73                          |
| 7    | Journal of Product Innovation Management                 | 15           | 749       | 49.93                       |
| 8    | Management Science                                        | 12           | 552       | 46                          |
| 9    | American Economic Review                                  | 8            | 319       | 39.88                       |
| 10   | California Management Review                              | 6            | 234       | 39                          |
| 11   | Journal of Marketing Research                            | 4            | 127       | 31.75                       |
| 12   | Journal of Public Economics                               | 4            | 121       | 30.25                       |
| 13   | MIS Quarterly                                             | 13           | 356       | 28.08                       |
| 14   | Research Technology Management                           | 5            | 129       | 25.8                        |
| 15   | Harvard Business Review                                   | 4            | 101       | 25.25                       |
| 16   | Information Economics and Policy                          | 5            | 126       | 25.2                        |
| 17   | Information Systems Research                              | 23           | 562       | 24.43                       |
| 18   | Journal of Economics & Management Strategy                | 12           | 285       | 23.75                       |
| 19   | Journal of Management Information Systems                 | 11           | 884       | 21.56                       |
| 20   | Tourism Management                                        | 4            | 83        | 20.75                       |
| 21   | Technovation                                              | 7            | 131       | 18.71                       |
| 22   | Industrial Marketing Management                          | 4            | 70        | 17.5                        |
| 23   | Electronic Commerce Research and Applications            | 9            | 154       | 17.11                       |
| 24   | International Journal of Operations Production Management | 5            | 79        | 15.8                        |
| 25   | IEEE Transactions on Engineering Management               | 8            | 110       | 13.75                       |
| 26   | International Journal of Electronic Commerce             | 8            | 106       | 13.25                       |
| 27   | European Journal of Operational Research                  | 6            | 79        | 13.17                       |
| 28   | Electronic Markets                                        | 5            | 65        | 13                          |
| 29   | International Journal of Industrial Organization         | 13           | 152       | 11.69                       |
| 30   | Journal of Information Technology                        | 9            | 98        | 10.89                       |
| 31   | Public Choice                                             | 6            | 63        | 10.5                        |
| 32   | Journal of Business Research                             | 8            | 82        | 10.25                       |
| 33   | Journal of Industrial Economics                           | 5            | 50        | 10                          |
| 34   | Journal of Marketing                                     | 5            | 50        | 10                          |
| 35   | Journal of The Operational Research Society              | 5            | 50        | 10                          |
| 36   | Journal of Advertising Research                          | 9            | 81        | 9                           |
| 37   | Information & Management                                 | 8            | 70        | 8.75                        |
| 38   | International Journal of Technology Management           | 13           | 110       | 8.46                        |
| 39   | Technological Forecasting and Social Change              | 9            | 71        | 7.89                        |
| 40   | Journal of Competition Law Economics                     | 7            | 54        | 7.71                        |

6) Most influential institutions
In the sample, 83.87% of institutions have published one or two articles, and 90.88% of institutions have produced one to three articles. Therefore, we choose at least four publications and 50 citations as criteria to extract the most influential institutions in the platform field (as shown in "Table V").

The University of Pennsylvania in the United States is ranked 1 in the platform area (121.25 citations per publication). The subsequent institutions are Imperial College London (The United Kingdom) and Bocconi University (Italy), with the 95.11 and 56.67 citations per publication respectively. Institutions with the more publications are Harvard University (The United States), MIT (The United States) and Tsinghua University (China) with 19, 14 and 13 publications respectively.
### TABLE V. MOST INFLUENTIAL INSTITUTIONS IN THE PLATFORM RESEARCH FIELD

| Rank | Institution                                | Country               | Publications | Citations | Average citation/publication |
|------|--------------------------------------------|-----------------------|--------------|-----------|------------------------------|
| 1    | University of Pennsylvania                 | The United States     | 8            | 970       | 121.25                       |
| 2    | Imperial College London                    | The United Kingdom    | 9            | 856       | 95.11                        |
| 3    | Bocconi University                         | Italy                 | 6            | 340       | 56.67                        |
| 4    | University of Padua                        | Italy                 | 4            | 224       | 56                           |
| 5    | Massachusetts Institute of Technology (MIT) | The United States     | 14           | 756       | 54                           |
| 6    | Michigan State University                  | The United States     | 5            | 270       | 54                           |
| 7    | Eindhoven University of Technology         | Netherlands           | 4            | 182       | 45.5                         |
| 8    | Northeastern University                    | The United States     | 6            | 271       | 45.17                        |
| 9    | University of Georgia                      | The United States     | 6            | 268       | 44.67                        |
| 10   | Tulane University                          | The United States     | 4            | 176       | 44                           |
| 11   | The University of Maryland                 | The United States     | 11           | 481       | 43.73                        |
| 12   | University of Illinois                     | The United States     | 5            | 214       | 42.8                         |
| 13   | Korea University                           | Korea                 | 4            | 168       | 42                           |
| 14   | Boston University                          | The United States     | 10           | 400       | 40                           |
| 15   | Harvard University                         | The United States     | 19           | 743       | 39.11                        |
| 16   | Georgia Institute of Technology            | The United States     | 6            | 224       | 37.33                        |
| 17   | INSEAD                                     | France                | 5            | 171       | 34.2                         |
| 18   | New York University                        | The United States     | 11           | 324       | 29.45                        |
| 19   | The University of Hong Kong                | China                 | 4            | 116       | 29                           |
| 20   | University of Groningen                    | Netherlands           | 6            | 140       | 23.33                        |
| 21   | Northwestern University                    | The United States     | 5            | 116       | 23.2                         |
| 22   | Tampere University of Technology           | Finland               | 4            | 90        | 22.5                         |
| 23   | Linkoping University                       | Sweden                | 4            | 82        | 20.5                         |
| 24   | University of Oxford                       | The United Kingdom    | 5            | 102       | 20.4                         |
| 25   | University of Cambridge                    | The United Kingdom    | 5            | 99        | 19.8                         |
| 26   | Stanford University                        | The United States     | 7            | 136       | 19.43                        |
| 27   | The University of Chicago                  | The United States     | 5            | 96        | 19.2                         |
| 28   | University College London                  | The United Kingdom    | 6            | 108       | 18                           |
| 29   | National University Singapore              | Singapore             | 12           | 203       | 16.92                        |
| 30   | University of Toronto                      | The United States     | 4            | 65        | 16.25                        |
| 31   | The University of Auckland                 | New Zealand           | 5            | 81        | 16.2                         |
| 32   | University of Missouri                     | The United States     | 4            | 63        | 15.75                        |
| 33   | University Mannheim                        | Germany               | 7            | 101       | 14.43                        |
| 34   | Erasmus University Rotterdam               | Netherlands           | 5            | 70        | 14                           |
| 35   | Stockholm School of Economics              | Sweden                | 4            | 44        | 13.75                        |
| 36   | Catholic University of Leuven              | Belgium               | 5            | 87        | 13.4                         |
| 37   | Fudan University                           | China                 | 7            | 91        | 13                           |
| 38   | City University of Hong Kong               | China                 | 5            | 61        | 12.2                         |
| 39   | Delft University of Technology             | Netherlands           | 6            | 70        | 11.67                        |
| 40   | Aalto University                           | Finland               | 7            | 61        | 8.71                         |
| 41   | Tsinghua University                        | China                 | 13           | 76        | 5.85                         |

7) Most outstanding countries

75.44% of the countries have published less than 20 papers, and 73.68% of countries possess less than 300 citations. Hence, we choose countries which have over 20 publications and 300 citations.

From the data shows in "Table VI", the United States is the most impact country in the platform area (31.34 citations per publication). France and Sweden are ranked two and three with 43.61 and 37.75 citations per publication, respectively. Countries with the most publications are the United States, the United Kingdom and France. Therefore, we can find that, the United States and France are the two countries with both more publications and more citations within platform.
TABLE VI. MOST OUTSTANDING COUNTRIES IN THE PLATFORM RESEARCH FIELD

| Rank | Country           | Publications | Citations | Average citation per publication |
|------|-------------------|--------------|-----------|---------------------------------|
| 1    | France            | 41           | 1788      | 43.61                           |
| 2    | Sweden            | 24           | 906       | 37.75                           |
| 3    | Netherlands       | 31           | 986       | 31.81                           |
| 4    | The United States | 247          | 7742      | 31.34                           |
| 5    | The United Kingdom| 75           | 2172      | 28.96                           |
| 6    | Italy             | 31           | 748       | 24.13                           |
| 7    | Australia         | 21           | 397       | 18.90                           |
| 8    | Finland           | 23           | 383       | 16.65                           |
| 9    | Canada            | 23           | 326       | 14.17                           |
| 10   | South Korea       | 25           | 308       | 12.32                           |
| 11   | Spain             | 31           | 353       | 11.39                           |
| 12   | Germany           | 46           | 516       | 11.22                           |
| 13   | China             | 64           | 514       | 8.03                            |

B. Scientific Maps

1) Map of cited references

The original sample was reduced from 619 publications to 75 publications with at least 15 times. On the basis of these 75 most-cited references, this study built the network within the platform research field by co-citation analysis. Results show the 75 references are divided into four clusters, each color stands for a cluster (See “Fig. 2”).

The first cluster relates platform to the innovation and change issues. Adner and Kapoor identify that external innovation change will influence the firms' outcome within the platform [34]. Boudreau explores the relationship between different open platform strategies and the rate of innovation change [4].

The second cluster seek to explore the industry-wide platform, studies from Rochet, Armstrong and Weyl reveal network effect of multi-sided markets from economic perspective. Rochet and Tirole establishes a platform competition model within two-sided markets on the basis of network externality [5]. Armstrong and Wright analyses two-sided markets when competition exists between two platforms, they introduce "competitive bottlenecks" into the two-sided markets framework [35].

The third part of the cluster analysis relates to open thinking on the platform. West explores the proper strategy for platform, by analyzing the hardware and software company [36]. Chesbrough, Vanhaverbeke and West define open innovation as a paradigm which firm could and should use both internal and external ideas, and internal and external paths to market, and finally advance their technology [2].

Cluster 4 involves research on the product platform topic. Meyer and Lehnerd define the product platform as a set of subsystems and interfaces that form a common structure from which a stream of derivative products can be efficiently developed and produce [8]. Robertson and Ulrich emphasize the importance of planning the product platform for enterprise, and discuss the four fundamentals of product platform planning: components, processes, knowledge and people and relationships, and advocates a loosely structured platform planning process which focus on the product plan, the differentiation plan and the commonality plan [31]. (See “Table VII”)
| Cluster 1 – Innovation and change (521) | Cluster 2 - Network effect of multi-sides markets (769) |
|---------------------------------------|--------------------------------------------------|
| Eisenmann et al., 2006 (59)           | Rochet & Tirole, 2003 (117)                       |
| Boudreau, 2010 (39)                   | Armstrong, 2006 (86)                              |
| Tiwana et al., 2010 (38)              | Rochet & Tirole, 2006 (84)                        |
| Gawer, 2014 (33)                      | Cailiaud & Julien, 2003 (63)                      |
| Boudreau, 2012 (30)                   | Parker & Van Alstyne, 2005 (53)                   |
| Fornell & Larcker, 1981 (30)          | Katz & Shapiro, 1985 (49)                        |
| Cceccagnoli et al., 2012 (29)         | Katz & Shapiro, 1994 (39)                        |
| Gawer & Cusumano, 2013 (25)           | Rysman, 2009 (37)                                 |
| Adner & Kapoor, 2010 (24)             | Anderson, 2005 (26)                              |
| Cennamo & Santalo, 2013 (22)          | Hagiu, 2006 (26)                                  |
| Parker et al., 2016 (22)              | Clements & Ohashi, 2005 (25)                      |
| Zhu & Iansiti, 2012 (20)              | Armstrong & Wright, 2007 (23)                     |
| Barney, 1991 (19)                     | Weyl, 2010 (22)                                  |
| Ghazawneh & Henfridsson, 2013 (18)    | Evans, 2003 (20)                                 |
| Thomas, 2014 (18)                     | Cats & Lederman, 2009 (18)                        |
| Boudreau, 2009 (17)                   | Nair, 2004 (18)                                  |
| Podskakoff et al., 2003 (17)          | Rysman, 2004 (18)                                |
| Yoo et al., 2010 (16)                 | Cailiaud & Julien, 2001 (15)                      |
| March, 1991 (15)                      | Hagiu, 2009 (15)                                 |
| Shapiro, 1999 (15)                    | Kaiser & Wright, 2006 (15)                        |
| Wareham et al., 2014 (15)             |                                                 |
|                                      |                                                 |
| Cluster 3 – Different types of innovation on the platform (390) | Cluster 4 - Product platform (442) |
| Gawer & Cusumano, 2002 (57)           | Meyer & Lehnerd, 1997 (50)                        |
| Gawer & Cusumano, 2008 (33)           | Eisenhardt, 1989 (43)                             |
| Eisenmann et al., 2011 (31)           | Robertson & Ulrich, 1998 (42)                    |
| Gawer & Henderson, 2007 (30)          | Ulrich, 1995 (32)                                |
| West, 2003 (27)                       | Baldwin & Woodward, 2009 (28)                     |
| Bresnahan&Greenstein, 1999 (25)       | Baldwin & Clark, 2000 (27)                       |
| Chesbrough et al., 2006 (26)          | Henderson & Clark, 1990 (26)                     |
| Evans, 2006 (23)                      | Miles et al., 1994 (24)                           |
| Economides & Katsamakas, 2006 (21)    | Krishnan & Ulrich, 2001 (23)                      |
| Iansiti & Levien, 2004 (21)           | Cusumano & Gawer, 2002 (22)                       |
| Shapiro et al., 1998 (19)             | Meyer, 1993 (21)                                 |
| Von Hippi, 2005 (18)                  | Sawhney, 1998 (21)                               |
| Eisenmann et al., 2009 (17)           | Gower, 2009 (17)                                 |
| Farrerl&Saloner, 1985(17)             | Sanchez & Mahoney, 1996 (17)                      |
| Katz & Shapiro, 1986 (17)             | Schilling, 2000 (17)                              |
| Teece, 1986 (16)                      | Baldwin & Clark, 1997 (16)                       |
| Jacobies et al., 2006 (15)            | Meyer et al., 1997 (16)                           |
|                                      |                                                 |

2) Map of most cited authors

With the minimum 40 citations, the sample was declined to a new sample which contains 40 authors, and has 3078 citations in total. This study portrayed the map of the 40 authors consisting of four clusters by co-citation analysis of authors (See "Fig. 3").
Cluster 1 contains authors from strategic management (e.g. Ron Ander, Kevin Boudreau, Annabelle Gawer), economics (e.g. Joseph von R Farrell), political economy (e.g. Michael Katz), technology standards and modularity (e.g. Melissa Schilling), platform ecosystems (Amrit Tiwana).

Cluster 2 encompasses authors from technological innovation (e.g. David Teece), open innovation (e.g. Eric von Hippel, Henry Chesbrough), strategic management (e.g. Joel West), which drew on other theory and method, such as the competitive advantage theory (e.g. Michael Porter) and case study method (e.g. Kathleen Eisenhardt).

Cluster 3 includes two-sided markets (e.g. Mark Armstrong, Jean-Charles Rochet), pricing theory (e.g. Bernard Caillaud, Andrei Hagiu), networks (e.g. Nicholas Economides), most of whom study on economic quantity relationships by constructing economic mathematical model.

Cluster 4 has the least authors with the lowest number of citations in total (469). Nevertheless, this cluster also includes studies from various fields, like modularity (e.g. Carliss Baldwin), leadership (e.g. Michael Cusumano), product platform (e.g. Marc Meyer, David Robertson).

3) Map of most cited journals
By employing the threshold at 120 citations, we got a set of 36 journals that are used for co-citation analysis of cited journals, and finally gained a network consists of management, economics, marketing and information system four clusters (See "Fig. 4").

Fig. 4. Co-citation of cited journals.

The management cluster contains journals concentrating on strategic management (Strategic Management Journal), management practice (Harvard Business Review) and theoretic and empirical researchers on management (Journal of Management, Academy of Management Review, Academy of Management Journal).

The economics cluster basically includes journals that accept microeconomics which focus on the organization level (RAND Journal of Economics, Journal of Economics & Management Strategy), econometrics (Econometrica) and industrial economics focusing on the industry level (International Journal of Industrial Organization).

The marketing cluster encompasses journals that focus on consumer behavior (Journal of Consumer Research), marketing research practice and marketing theory (Journal of Marketing Research) and electronic, interactive and direct marketing environments (Journal of Interactive Marketing).

The information system cluster is an emerging field which is more relevant with platform research that other clusters. This cluster involves journals which publish study on platform (Information System Research), information technology (Decision Support Systems) and ecosystem (MIS Quarterly).

IV. CONCLUSION
This study achieves some insights from the literature review and summarizes the existing studies. By employing the performance analysis which obtained on WoS, this study identified the most cited articles, the most important authors, the most impact journals, the most influential institutions and the most outstanding countries in the field of platform. This study identified the most cited publications by counting the number of citations. The first most cited article "Platform competition in two-sided markets", which was written by Rochet and Tirole. As with the most important authors, this study uses two indicators to identify: Hagiu is the most productive author who published nine articles, while Kogut is the most influential author with the highest average citation per publication.

The journal that published the most articles is Information Systems Research, which suggests that this journal is more interesting in the platform topic. The journal with the highest citation per publication is Organization Science, which represent the most impact status in the platform research field. The countries that published most are the United States, the United Kingdom and France, and...
the countries with the highest average citation per publication are France, Sweden and Netherlands.

By scientific maps method, this study illustrates the map of cited references in the platform field, in which four clusters are confirmed. Co-citation analysis of author identified four invisible cliques, among which Annabelle Gawer is the most influential authors who published a series of articles in the platform field, such as platform leadership, industry platform, technological platform, platform entry mode and other relevant topics. The result of journal co-citation analysis highlighted the theory and research on platform was still fragmently distributed in different disciplines, which called for comprehensive and interdisciplinary researches are necessary in the future.

Through bibliometric analyses, this study is helpful for portraying a comprehensive framework of platform research, and enabling future scholars to focus their own studies effectively. However, we have to acknowledge that this study also has limitations. First, the sample in our study is captured in only one database. Although WoS encompass various journals, it could not cover the whole journals on the platform topic. Second, this work uses two types of publications (articles and reviews). Future study can extend data collection to other types of publications, which may provide more insights and latest findings in the platform field. Finally, although the bibliometric analysis by employing specialized software is objective, the following interpretation of the results is somewhat subjective.

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