IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received June 2, 2020, accepted June 16, 2020, date of publication July 1, 2020, date of current version July 20, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.3006269

Emerging Business Opportunities Based-On Venture Capital Investment Data in the Fourth Industrial Revolution

SUNGJIN KIM[1], YUNJEONG CHOI[1], AND SUCHUL LEE[2]
[1]Technology Commercialization Center, Korea Institute of Science and Technology Information, Seoul 02456, South Korea
[2]Department of Business Administration, Mokpo National University, Muan-gun 58554, South Korea

Corresponding author: Suchul Lee (suchullee@mokpo.ac.kr)

This work was supported by the Research Program funded by Korea Institute of Science and Technology Information (KISTI) under Grant K-20-L03-C05.

ABSTRACT This study aims to propose a methodology for identifying new business opportunities in the fourth industrial revolution. The methodology uses the co-word network analysis approach to analyze the network centralities of keywords of the fourth industrial revolution and association analysis to explore new business opportunities in venture capital firms' investment datasets. Specifically, this study analyzes 1,049 papers related to the fourth industrial revolution published in 2013-2018 and the data on a total of 12,361 venture capital transactions from S&P Capital IQ in 2017-2018. The proposed methodology takes into account the number and size of investments, as well as the association with the fourth industrial revolution for each transaction.

INDEX TERMS Fourth industrial revolution, venture capital firm, co-word network analysis, business opportunity, venture capital investment.

I. INTRODUCTION

At the WEF (World Economic Forum) 2016 held in Davos, the fourth industrial revolution was a key topic and it has ever since been actively discussed on all industrial, academic and governmental levels [1]. Although there may be some differences in views, generally the WEF 2016 regarded the invention of steam engine in 1784 as marking the first industrial revolution; electrical energy generation and mass product production in the late 19th century, the second industrial revolution; the development of electronic devices, IT and internet in the late 20th century, the third industrial revolution; and continuous IT development represented by artificial intelligence (AI) and big data, the fourth industrial revolution.

Specifically, the fourth industrial revolution is defined as a new form of revolution based on the third industrial revolution featuring ubiquitous mobile internet, small and strong sensors, AI and machine learning [2]. The fourth industrial revolution is clearly distinguished from the previous three revolutions in terms of its breakneck speed of change and the scope of paradigm shift occurring on all individual, economic, corporate and societal levels. Bloem *et al.* [3] defined the fourth industrial revolution as the combination of IT and operational technology (OT), and the definition corresponds to Cyber-Physical Systems (CPS) which is considered to be one of the main concepts of the fourth industrial revolution. In addition to AI and big data technologies, convergence technologies across various fields play an important role toward the fourth industrial revolution. Schwab [2] mentioned ten technologies in physical, digital and biological areas that will lead the fourth industrial revolution, and Li *et al.* [4] have also suggested technology drivers of the fourth industrial revolution such as internet of things (IoT), AI and machine learning, big data and cloud computing, digital platform, autonomous cars, 3D printing, genetic engineering, and neurotechnology.

As the fourth industrial revolution is drawing on a wide range of technologies and influencing all industrial sectors, major developed countries are investing great efforts in both public and private sectors to exploit the opportunities it offers. Germany, a global leader in manufacturing, had advocated the concept of Industry 4.0 even before WEF 2016 was held and is preparing for the upcoming industrial revolution [5]. DFKI, the German Research Center for AI, defines CPS as the foundation of Industry 4.0 and is dedicating a great deal of effort in building smart factories which actualize

The associate editor coordinating the review of this manuscript and approving it for publication was Justin Zhang.

the concept [6]. In the United States, IT companies including GE, Cisco, IBM, and Intel are focusing on developing and commercializing industrial internet and IoT technologies. Industrial internet is designed to innovate conventional industrial ecosystems, make substantial cost cuts and create new added value through IoT technology [7]. For example, GE has stopped being a mere electronics manufacturer and released Predix, which is a cloud-based operating system for industrial internet, and is aggressively working to be one of the world's top ten software companies by 2020 [8], [9]. Also, China announced "Made in China 2025" in 2015 and has been implementing the plan to advance its industrial structure. The country is working to strategically nurture IT, robot, bio-pharmaceutical, and electric vehicle industries for the fourth industrial revolution and boost added value with the development of FinTech and O2O industries based on the "Internet Plus" strategy [10].

As above, major economies are actively preparing to respond to changes brought by the fourth industrial revolution. South Korea is also making various attempts in public and private sectors not to fall behind in the tide of change, but the country is still lagging far behind other developed countries in terms of competitiveness related to the fourth industrial revolution and the availability of core technologies. In South Korea, small and mid-sized companies created 2,280,000 new jobs over the past five years, which amount to approximately 90 percent of new jobs made in the period. While the sustainability of small and mid-sized businesses is essential for the development of the society, such companies are less prepared than larger ones for changes arising from the fourth industrial revolution due to their lack of resources and competence. In the circumstances, efforts to preemptively explore and seize new business opportunities are required to adapt to upcoming changes in the environment.

In this sense, this study poses an evidence-based methodology to explore new business opportunities in the fourth industrial revolution. In particular, we establish associations between the fourth industrial revolution and business items being undertaken by global corporations based on global venture capital (VC) investment data and perform analyses to identify business items highly associated with the fourth industrial revolution in each business sector. Since VC firms usually invest in startups that have a weaker financial foundation than large-sized companies but have attractive technological prospects, the latest industry trends can be detected through VC investment data. Also, VC investors continuously collect and analyze industry and market information for successful investment, and thus the analysis of VC investment data is highly significant in illuminating new business opportunities.

This paper consists of six chapters. In Chapter 2, we provides an overview of the theoretical background for identifying new business opportunities through VC investment data. In Chapter 3, the data and methodology used in this research are introduced and the results of the research are presented in Chapter 4. We discusses the meanings and findings in Chapter 5 and limitations and the future direction of this research are immediately followed.

II. RELATED WORKS

A. EXPLORING NEW BUSINESS OPPORTUNITIES

Corporate activities to find new business opportunities have been studied from various different perspectives and such studies can be divided those focusing on the ability of management in authority to make big decisions and those drawing on customer preference, social media, and patent information.

Shane and Nicolaou [11] found that the creativity of management has a great impact on the identification of new business opportunities, and there is research that cross-cultural knowledge increases the possibility of detecting business opportunities [12]. Gielnik *et al.* [13] argue that obtaining more diverse information is advantageous in finding business opportunities, and there is research supporting the hypothesis that profound business experiences of management lead to opportunities for high value-added businesses [14]. A field study by Eller *et al.* [15] found that awareness of adverse consequences and entrepreneurial attitude affect sustainable business opportunity identification. Likewise, finding new business opportunities is largely influenced by the personal characteristics and competency of business managers, but depending on the decision-making of management to find a new business opportunity has limitations, especially as the amount of information being generated and acquired explodes at unprecedented speed in the complicated and diversified business environment. To overcome these limitations and identify new business opportunities, it is of utmost importance for companies to constantly monitor changes in the external environment [16]. In this regard, companies have attempted to conduct deep analysis on the market and technology trends and of the feasibility of emerging business items and devise business development strategies, and some of such attempts have proved to be successful [17].

Patent information has been most commonly used in research aiming to identify new business opportunities through the use of data Yoon *et al.* [18] analyzed patent applications using the SAO (subject-action-object) structure and identified technological opportunities by finding the necessary technologies for making a product and implementing its functions. Lee *et al.* [19] mined text based on patent information, scored the novelty of patents and detected the potential technological opportunities. However, patent information predominantly consists of technical terms and hardly reflects demands and trends of the market. Lee and Lee [20], to overcome such limits of patent information, took advantage of trademark data in addition to patent information, and developed a way to find new business opportunities through collaborative filtering. Another prior study [21] tried to identify new business diversification opportunities using both patent information and merger and acquisition cases. The basic idea of this method is that the business sector of a company acquired by a company with characteristics

similar to focal company can be a new business opportunity. Kim *et al.* [22] attempted to analyze the network between product keywords using product databases of B2B e-marketplaces, find structural gaps, and develop new business opportunities through fusion. Jin *et al.* [23] tried to understand customer demands in the eyes of customers through online purchase reviews and thereby derive ideas for new product development. Research on reading user demands and generating new product ideas by text-mining social media and online communities is also actively under way, utilizing advancements in text-mining and machine learning technologies [24], [25].

B. VENTURE CAPITAL INVESTMENT DATA FOR EXPLORING BUSINESS OPPORTUNITIES

As an increasing number of new businesses are launched all over the world, VC invested in startups, small and mid-sized businesses and venture companies is playing a more and more important role. A VC firm is defined as an investment company that invests in venture businesses that run risks that are too high to obtain funds from general financial institutions [26]. An empirical study by Kim and Yang [27] showed that greater VC investment brings greater technological outcomes, and Kim and Seo [26] also demonstrated that the growth of venture businesses injected with VC funds is stronger than those with no such funds, and that the growth and profitability increase in proportion to the scale of VC investment. This indicates that VC firms tend to discover promising early-stage businesses with great growth potential to maximize investment returns, and in turn, business items in which VC firms invest have high potential to develop into prosperous business opportunities. In other words, in the screening process for investment, VC firms are likely to pick out promising businesses. Consequently, crucial information leading to promising business opportunities can be found by analyzing the group of businesses that have attracted VC investment [28].

A study by Grilli and Murtinu [29], using the VICO dataset on 8,370 companies in seven European countries including France, Germany and England, showed that VC investment contributes to sales progress of new European technology-based firms. Based on Thompson's VentureXpert and AVCJ (Asia Private Equity and Venture Capital Intelligence) databases, Nahata *et al.* [30] analyzed 9,813 items of VC investment data collected from 30 countries, and argued that VC investment in culturally diverse countries requires stricter screening procedures, which in turn influence the success of investment decisions. These researchers also demonstrated that VC investment in one's own country relieves liability of foreignness and improves the chance of investment success. Popov and Roosenboom [28] analyzed investment data from 21 European countries and proved that VC investment exercises a positive impact on new business creation.

In summary, VC investment is selectively made to companies with bright business prospects as shown in the studies mentioned above, and it has a positive effect on business success. However, studies based on VC investment data have mostly been designed to analyze the factors of investment success or general industrial impact; few studies have utilized VC investment information to develop emerging business opportunities. This research will suggest a new methodology for finding new business opportunities based on VC investment information. The new method draws associations between VC investment information and the fourth industrial revolution, which has a massive influence on all industry areas, and it identifies new business opportunities in the fourth industrial revolution. The proposed methodology and new business opportunities found in this research will have profound implications for corporations and industrial policy makers in their efforts to prepare for the fourth industrial revolution.

III. RESEARCH FRAMEWORK AND METHODOLOGY

The methodology that this study proposes is designed to identify new business opportunities through VC investment information and its association with the fourth industrial revolution in four steps.

The first step is to build co-word networks between the keywords related to the fourth industrial revolution. For this, research data on the fourth industrial revolution are extracted from the Web of Science database. Since this methodology is based on relevance to the fourth industrial revolution, the words related to the fourth industrial revolution (e.g. Next Production Revolution, Industry 4.0, etc.) rather than the names of specific technologies are used for data extraction. With this extracted research data, co-word networks are built based on the frequency of the simultaneous appearance of each author keyword. The nodes of a built co-word network are author keywords of published papers related to the fourth industrial revolution, and the edges are created when two keywords appear in the same paper. As a result, the co-word networks form the Keyword Network of the Fourth Industrial Revolution that shows the association between various keywords pertinent to the fourth industrial revolution.

Subsequently, we analyzed the network centrality of each node that comprises the Keyword Network of the Fourth Industrial Revolution, to determine the level of their association with the fourth industrial revolution. In accordance with prior studies, four types of centralities are primarily used, and the definitions and descriptions of those centralities are presented in Table 1. Because the four types of network centralities have different ranges of values depending on their characteristics as shown in Table 1, each centrality value is normalized and applied as a z-score and t-score in the following association analysis.

To analyze how closely the investment cases are associated with the fourth industrial revolution, the network centrality values of the nodes in the Keyword Network of the Fourth Industrial Revolution are calculated firstly. Subsequently, the association scores of VC investment data are calculated based on how frequently the keywords related to the fourth

TABLE 1. Network centralities in prior studies.

Centrality	Description	References
Degree centrality	- The number of direct relations a node has with other nodes - Simply count the number of in-/out-degree of each node	[31], [32], [33], [34], [35], [36], [37], [38]
Betweenness centrality	- For a given node v, calculate the number of shortest paths between nodes i and j that pass through v, and divide by all shortest paths between nodes i and j	[32], [35], [37], [38]
Closeness centrality	- Calculate the mean length of all shortest paths from a node to all other nodes	[32], [33], [35], [37], [38]
Eigenvector centrality	- A node's eigenvector centrality is proportional to the sum of the eigenvector centralities of all nodes directly connected to it - Global influence of a node considering the influence of the related nodes	[31], [32], [37], [39];

TABLE 2. Descriptive statistics of VC transaction datasets.

Items	Values
Number of transactions	12,361
Communication Services	1,284
Consumer Discretionary	1,370
Consumer Staples	393
Energy	85
Financials	488
Health Care	1,896
Industrials	928
Information Technology	4,767
Materials	198
Real Estate	225
Utilities	67
Etc.	660
Number of investees	11,542
Number of investors	9,226
Amount of investments	
Total amount of investments	USD 450,615.7 mm
Maximum amount of investments	USD 20940.9 mm
Minimum amount of investments	USD 1,000

industrial revolution appear in the business description, product name and product description fields of VC transaction datasets. The scores should not only reflect the frequency of appearance, but also measure accumulated network centrality values of the keywords appearing under the three fields above.

Since VC investment data include the investments of multiple VC firms in the same company and the values of VC investments are closely related to their scale, however, it is necessary to incorporate these aspects into the association scores. According to prior studies [26], companies that have received a large scale of VC investment showed a significant difference in growth and profitability compared to those receiving a small or mid-sized VC investment. Similarly, companies that attracted investment from multiple VC firms showed a significant difference also in growth and profitability compared to those receiving funds from a single VC firm. To reflect the scale and overlapping of investment in the association scores, an impact factor has been devised as follows.

$$(VC\ investment\ IF) = (number\ of\ transactions) \times (t - score\ of\ amount\ of\ total\ investments) \quad (1)$$

Accordingly, the final scores are calculated by multiplying the VC investment IF and the fourth industrial revolution association scores for VC investment data, and they are also normalized to 100 for convenience of comparison.

IV. DATASETS AND ANALYSIS RESULTS

A. DATASETS

This study analyzes 12,361 cases of global VC investment data from 2017 to 2018 extracted from S&P Capital IQ.

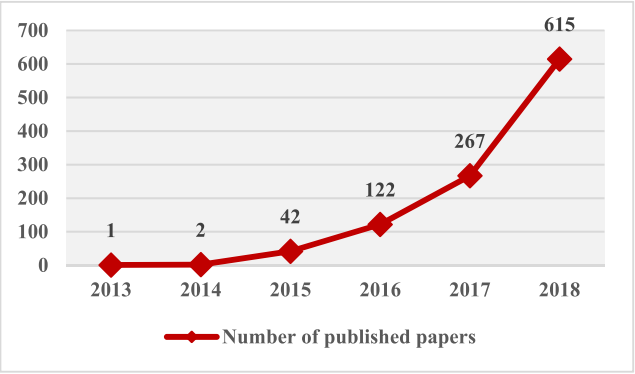

FIGURE 1. Papers related to fourth industrial revolution published in 2013-2018.

VC investment data are provided by multiple institutions including VentureXpert, Venture Source, Crunchbase, CB Insights, and DataFox, but S&P Capital IQ was deemed most appropriate for this study mainly because it provides financial and investment information of unlisted companies as well as listed ones and includes information on their business projects and products. The investment data on the 12,361 cases were comprised of 12 business sectors, 11,542 investees and 9,226 VC firms (or groups), and the total amount of investments was 450,615.7 million dollars. The descriptive statistics are in Table 2.

By performing searches on the Web of Science database for the terms related to the fourth industrial revolution, including fourth industrial revolution, next production revolution, next manufacturing revolution, and Industry 4.0, we extracted 1,049 papers published for five years from 2013 to 2018 (Fig. 1). Papers published in the most recent six years were

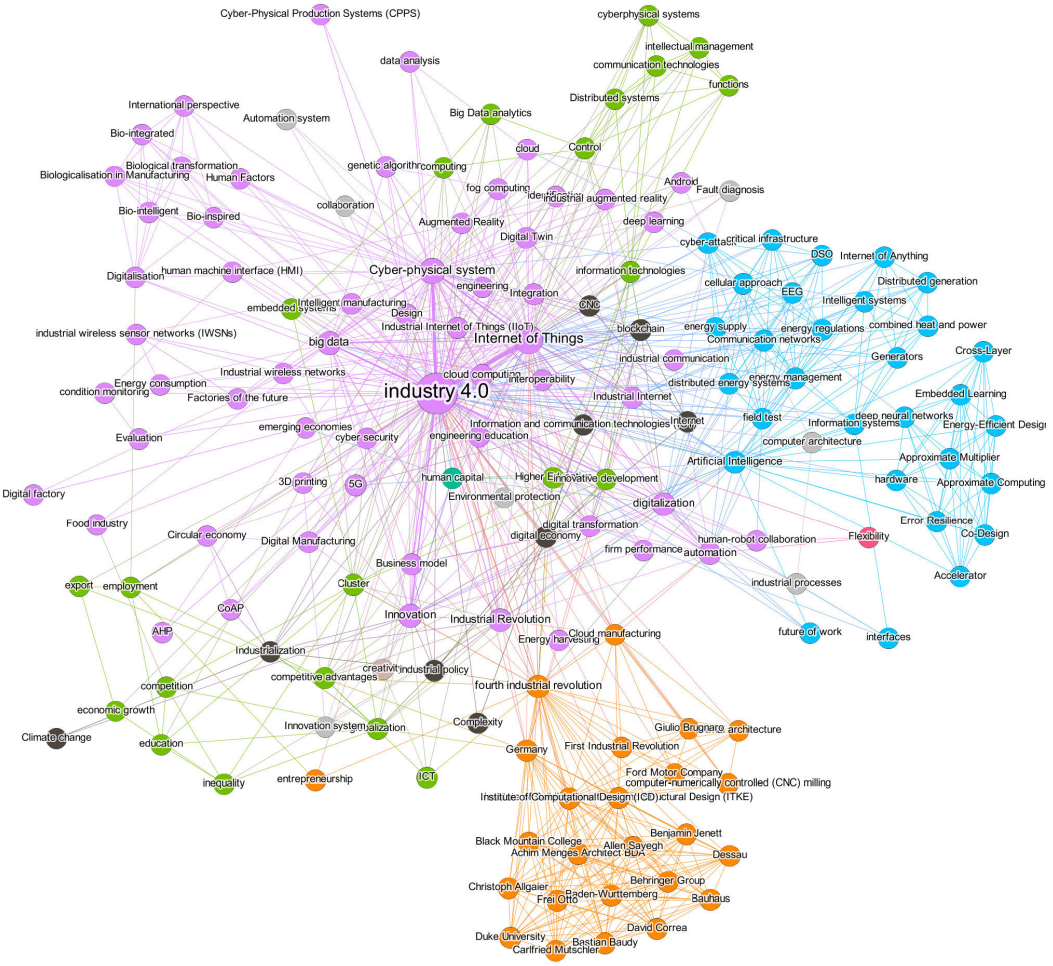

FIGURE 2. Keyword network of the fourth industrial revolution (selected nodes with higher degree centrality).

analyzed because the words related to the fourth industrial revolution began to emerge in 2013. In fact, the search formula devised for this research did not find any paper published earlier than 2013. The number of papers related to the fourth industrial revolution was only one in 2013, and the number drastically increased to 267 in 2017 and to 615 in 2018.[1]

B. ASSOCIATION ANALYSIS WITH KEYWORD NETWORK OF THE FOURTH INDUSTRIAL REVOLUTION

Fig. 2 illustrates the Keyword Network of the Fourth Industrial Revolution based on the 1,049 papers and Fig. 3 shows a part of the results from four types of centrality analyses of the keyword network. To build and analyze the network, we used the software Gephi-0.9.2. For example, for degree centrality that shows the number of direct relations, Industry 4.0 has the highest value as it is connected with 618 other keywords, and ''internet of things,'' ''cyber physics systems,'' ''big data,'' and ''digitalization'' also have high degree centrality values.

[1]The search was made as of February 2019

Id	Label	Degree centrality	Eigenvector centrality	Closness centrality	Betweeness Centrality
ID_1074	industry 4.0	618	1	0.703576	380670.7001
ID_1182	Internet of Things	231	0.461408	0.536164	71205.87958
ID_0458	Cyber-physical system	149	0.328834	0.512782	37381.95026
ID_0181	big data	90	0.228275	0.487375	13737.0945
ID_1102	Innovation	87	0.198146	0.486679	29115.04457
ID_1060	Industrial Revolution	72	0.159414	0.476923	30851.15583
ID_0835	fourth industrial revolution	66	0.163231	0.473392	22667.18133
ID_0581	digitalization	63	0.169314	0.46691	9744.75127
ID_0138	automation	53	0.138992	0.469913	21893.70147
ID_0110	Artificial Intelligence	51	0.145055	0.477146	19510.55101
ID_0287	cloud computing	48	0.157429	0.473611	9321.110416
ID_1047	Industrial Internet	34	0.131874	0.460811	5764.492984
ID_0298	Cluster	31	0.095921	0.452655	10289.39556
ID_0347	competitive advantages	30	0.094627	0.448095	6071.86156
ID_0875	Germany	30	0.105011	0.44614	5180.659457
ID_0554	digital economy	29	0.092804	0.450264	7126.291348
ID_0577	digital transformation	29	0.126797	0.460396	1936.441578
ID_0204	blockchain	26	0.108776	0.445557	2286.383122

FIGURE 3. Sample results of centrality analysis.

To apply the centrality values for the keywords related to the fourth industrial revolution and score the associations between VC investment data and the fourth industrial revolution, we used degree centrality, among the four types of network centralities seen in Table 2. Although degree centrality indicating direct relation was determined to be the most appropriate for this association analysis, different types of centrality values can be used depending on the circumstances. The association scores were then normalized to 100. Darktrace Limited, an AI company for cyber defense, turned out to have the highest association score followed by Wind

TABLE 3. Sample results of association analysis (top 10).

Ranking	Investee	Business sector	Association score
1	Darktrace Limited	Information Technology	100.0
2	Wind River Systems, Inc.	Information Technology	96.5
3	Aras Corporation	Information Technology	88.9
4	IDInvest Partners SA	Financials	86.6
5	EPiServer AB	Information Technology	79.5
6	StreamSets, Inc.	Information Technology	77.2
7	Umanis SA	Information Technology	77.1
8	NCI, Inc.	Information Technology	76.5
9	Applied Systems, Inc.	Information Technology	74.7
10	MetricStream, Inc.	Information Technology	74.2

TABLE 4. Sample results of association analysis with impact factors (top 10).

Ranking	Investee	Business sector	Association score
1	Toshiba Memory Corporation	Information Technology	100.0
2	Meituan Dianping	Consumer Discretionary	85.3
3	Darktrace Limited	Information Technology	62.1
4	Envision Healthcare Corporation	Health Care	61.1
5	GLP Pte. Ltd.	Real Estate	52.2
6	CrowdStrike, Inc.	Information Technology	48.6
7	WalkMe Inc.	Information Technology	48.5
8	Neustar, Inc.	Information Technology	43.7
9	DataRobot, Inc.	Information Technology	42.9
10	Apttus Corporation	Information Technology	42.7

River Systems, Inc., which provides embedded software for intelligent connected systems, and the Aras Corporation, which develops and delivers enterprise open source solutions (Table 3).

The final scores were calculated by multiplying the fourth industrial revolution association scores for VC investment data and VC investment IF (Table 4). They were then normalized to 100 for ease of comparison. As a result, Toshiba Memory Corporation ranked highest followed by Meituan Dianping, Darktrace Limited, Envision Healthcare Corporation, and GLP Pte. Ltd., in that order. Toshiba Memory Corporation designs, develops, manufactures, and sells non-volatile memory solutions. Meituan Dianping provides an e-commerce platform that uses technology to connect consumers and merchants. Darktrace Limited develops security solution for organizations to detect emerging cyber-threats and defend them against cyber-attacks. Envision Healthcare Corporation provides various healthcare services in the United States. GLP Pte. Ltd. owns, manages, and develops logistics facilities.

TABLE 5. Emerging business opportunities with highest association score by business sectors.

Business sector	Investee	Business item
Communication Services	H2O.ai	Data analytics platform
Consumer Discretionary	Meituan Dianping	E-commerce platform
Consumer Staples	Prose	Cosmetics and hair products using AI
Energy	Amyris, Inc.	Renewable products
Financials	IDInvest Partners SA	Venture capital
Health Care	Envision Healthcare Corporation	Healthcare services
Industrials	HNAC Technology Co., Ltd.	EPC services and automation solutions to hydropower stations
Information Technology	Toshiba Memory Corporation	Non-volatile memory solutions
Materials	Canam Group Inc.	Construction solutions and fabricates customized products
Real Estate	GLP Pte. Ltd.	Logistics facilities
Utilities	Naturgy Energy Group, S.A.	Supply, liquefaction, regasification, transport, storage, distribution, and sale of natural gas
Etc.	Onica	IT consulting, infrastructure solutions, and managed services to enterprise organizations

C. EMERGING BUSINESS OPPORTUNITIES

Emerging business opportunities in the era of the fourth industrial revolution have been identified based on high ranking VC investment data in the association analysis for each business sector. Business sectors were considered in the process of identifying the business opportunities for the following reasons. First, the scale of investment varies depending on business sector. Second, the fourth industrial revolution is built on IT technology including big data and AI, and companies classified as Information Technology by business sector tend to rank high. As this study aims to identify emerging business items in various sectors in the fourth industrial revolution, the results are provided by business sector and these sectoral results are presented in Table 5 (see Appendix Table 6 for details; Top 10 in each sectors).

V. DISCUSSIONS

VC investment is a recommended strategy for achieving corporate business development objectives. [40]–[43] VC firms make investment for a variety of strategic purpose. For example, they like to develop business relationships, find potential acquisitions, assist spin-outs from the corporations, and identify new opportunities. [43] According to prior studies, identifying new opportunities ranked a top priority among the various strategic objectives of VC investment [44] mainly because the investment may provide a source of potential new business areas. [43]

The investment process usually begins with the identification of new business opportunities. [45] A new business opportunity may lead firms to subsequent innovation and yield future profitability, but there is obvious uncertainty because the degree of novelty differs greatly among firms and industries. [46] Under this uncertainty, while VC investment has become an increasingly important source of financing for startups and small and mid-sized companies [45], [47]–[49], it is not easy for companies to achieve investments. Companies that like to achieve financial investments often rely on their own business knowledge to market their potential business opportunities. [45]

There are clear differences between business ideas and business opportunities. While business ideas are difficult to share with others because it is often subjective and abstract [50], [51], business opportunities are more conceptualized in terms of product or service including target markets. [52] In this sense, it is difficult to identify new business opportunities without novel knowledge. The knowledge can be classified into two different types: technical knowledge and market knowledge. [53], [54] Relatively, technical knowledge may be well known and common to a large population of experts [46] from the perspective of business opportunities in the fourth industrial revolution, which is the focus of this study. Meanwhile, market knowledge may be less well known in the case of markets and industries that are emerging. Changes due to the fourth industrial revolution are currently underway, so obtaining relevant market knowledge may be challenging.

In this sense, this study endeavored to exploit market knowledge to identify business items in the fourth industrial revolution based on the VC firms' investment datasets. The changes referred to the fourth industrial revolution are in fact based on IT developments including AI, big data, and sensing technologies, and thus a large number of expected business items were drawn in Information Technology and Telecommunication Services sectors. A variety of business items were, however, also found in other business sectors. For example, the business for developing connected toys, an open architecture, and a cloud platform to drive child friendly content (Dynepic, Inc.), the computer science education training services (Lambda Inc.), the online recruitment platform business (Zhaopin Limited), the environmental risk information services (Environmental Data Resources, Inc.), and the business for developing and providing materials and software for additive manufacturing (Sigma Labs, Inc. and AREVO, Inc.) turned out to be emergent with strong future potential. From a practical perspective, these findings are expected to offer new insights to startups and small and mid-sized companies looking for new possibilities in this fast-changing era.

This study has also achieved several academic contributions. It provides a new research direction by exploring new business items through a quantitative data-based methodology that utilizes the author keywords of papers, builds co-word networks from them, and establishes their associations with the fourth industrial revolution. Since prior studies relied on expert-dependent, qualitative methodologies to find new business items, the new quantitative analysis in this paper will usefully complement the earlier qualitative ones.

VI. CONCLUSION

This research has offered methodology for exploring new business opportunities in preparation for the ongoing fourth industrial revolution. The methodology finds associations between the fourth industrial revolution and VC investment transaction data extracted from the S&P Capital IQ database and draws new business opportunities. It builds co-word networks based on the search results of author keyword on the Web of Science, calculates network centrality values for keywords to score their association with the fourth industrial revolution, and identifies new business opportunities by business sector in consideration of the scale and overlapping of investments.

However, the methodology suggested herein has the following limitations. First, it does not reflect the information about investees. The age, sales record and size of investees are not considered. Because these aspects are related to the possibility of attracting investment from VC firms, future research should find way to incorporate them. Second, while we believe that our findings partially succeeds in giving relevant market knowledge to startups and small and mid-sized companies looking for new opportunities in light of the ongoing industrial changes of the fourth industrial revolutions, it does not provide complete market knowledge for each business sector. In this sense, differences between business sectors are also not considered. Most of the high-ranking companies referred to in this paper belong to the Information Technology business sector. The business sector is clearly indicated in the outcome of this research and the differences between business sectors are not included in the process of analysis, but it will be more useful if a comprehensive approach to incorporating even the sectoral differences is developed. Furthermore, in-depth case studies on the selected investees will give help to companies who are planning to conduct related business projects.

APPENDIX

See Appendix Table 6.

TABLE 6. Emerging business opportunities by business sectors (top 10).

A. Communication Services		
Ranking	Investee	Business item
1	H2O.ai	Data analytics platform
2	Jitterbit, Inc.	Data analytics platform
3	ZPG Plc	Property-related digital platform
4	Telxius Telecom S.A.	Telecom infrastructure services
5	Radius Global Market Research L.L.C.	Market research
6	Epic Games, Inc.	Game
7	Ding Ao (Shanghai) Network Technology Co., Ltd.	Cloud platform services
8	RiskSense, Inc.	Cyber risk management solutions
9	CityFibre Infrastructure Holdings Plc	Fiber for network
10	Carnegie Learning, Inc.	Education materials (including software)
B. Consumer Discretionary		
Ranking	Investee	Business item
1	Meituan Dianping	E-commerce platform
2	NIO Inc.	Electric vehicles
3	Dynepic, Inc.	Internet of Toys (connected toys)
4	Belle International Holdings Limited	Shoes and footwear products
5	Guangzhou Chengxing Zhidong Automobile Technology Co., Ltd.	Electric vehicles
6	Lambda Inc.	Computer science education training services
7	Supermarket Grocery Supplies Pvt Ltd	Online food and grocery store
8	Sodexo S.A.	Comprehensive on-site service solutions
9	Blink Charging Co.	Electric vehicle charging equipment and services
10	LS Automotive Corp.	Automobile parts
C. Consumer Staples		
Ranking	Investee	Business item
1	Prose	Cosmetics and hair products using AI
2	Upfield Foods	Plant-based nutrition bread spreads
3	J Sainsbury plc	Food, general merchandise and clothing retailing
4	Refresco Group N.V.	Soft drinks and fruit juices serving retailing
5	Ojia'o Network Technology (Shanghai) Co., Ltd.	Checkout-free convenience stores
6	Pelsis Ltd	Building maintenance chemical products
7	Impossible Foods, Inc.	Meats and cheeses from plants
8	Letus Legend	Supermarkets
9	Noho Health, Inc.	Vitamins and supplements
10	PAX Labs, Inc.	Loose-leaf vaporizers
D. Energy		
Ranking	Investee	Business item
1	Amyris, Inc.	Renewable products
2	Genesis Energy, L.P.	Midstream segment of the crude oil and natural gas industry
3	Shanghai Zhaoyou Information Technology Co., Ltd.	B2B marketplace for petroleum related products
4	Ambyint Inc.	Artificial lift optimization solutions for exploration & production companies
5	Evolution Engineering Inc.	Purpose-built measurements while drilling products
6	Armour Energy Limited	Discovery, development, and production of natural gas
7	Victory Oilfield Tech, Inc.	Technology driven oilfield services
8	MATRRIX Energy Technologies Inc.	Horizontal and directional drilling equipment and services
9	Buckeye Partners, L.P.	Liquid petroleum products pipelines
10	Silicon Microgravity Limited	Sensor devices for the oil and gas sector
E. Financials		
Ranking	Investee	Business item
1	IDInvest Partners SA	Venture capital
2	Innovacom Gestion	Venture capital
3	Lendingkart Technologies Private Limited	Fin-tech
4	Britam Holdings Plc	Insurance, investment management, private equity, and property businesses
5	Salesforce Ventures	Venture capital
6	Brex Inc.	Corporate credit card
7	OANDA Corporation	Internet-based foreign exchange trading and currency information services
8	American Securities LLC	Private equity
9	Asoko Insight Limited	Market research
10	Ess Kay Fincorp Limited	Non-banking finance

TABLE 6. *(Continued.)* **Emerging business opportunities by business sectors (top 10).**

F. Health Care		
Ranking	Investee	Business item
1	Envision Healthcare Corporation	Healthcare services
2	Shenzhen Deep Intelligent Pharma Technology Co., Ltd.	Drugs discovery
3	Albany Molecular Research, Inc.	Drugs discovery
4	PharMerica Corporation	Institutional pharmacy services
5	Gossamer Bio, Inc.	Drugs discovery
6	TraceLink, Inc.	Track and trace network solution for connecting the life sciences supply chain
7	Harbour BioMed	Therapeutics for cancer with a focus on immuno-oncology
8	DNAnexus, Inc.	Cloud-based genome informatics and data management tools
9	Esaote SpA	Medical diagnostic systems
10	Certara, L.P.	Biosimulation and regulatory writing consultancy company
G. Industrials		
Ranking	Investee	Business item
1	HNAC Technology Co., Ltd.	EPC services and automation solutions to hydropower stations
2	ARBE Robotics Ltd.	Radars for the detection of small objects
3	Transplace Inc.	Transportation management and logistics technology services
4	DT&C.Co.,Ltd	Testing and certification services
5	Zhaopin Limited	Online recruitment platform
6	otego GmbH	Independent energy supply for wireless sensors and actuators
7	Capewell Aerial Systems LLC	Engineered products for aerial delivery, life support, and tactical gear for military
8	QPark N.V.	Parking facilities
9	Sigma Labs, Inc.	Software applications primarily for 3D metal printing and additive manufacturing industries
10	Environmental Data Resources, Inc.	Environmental risk information services and solutions
H. Information Technology		
Ranking	Investee	Business item
1	Toshiba Memory Corporation	Non-volatile memory solutions
2	Darktrace Limited	Cybersecurity solutions and services
3	CrowdStrike, Inc.	Cybersecurity solutions and services
4	WalkMe Inc.	Cloud-based guidance and engagement platform
5	Neustar, Inc.	Real-time information and analytics platform
6	DataRobot, Inc.	Machine learning automation software for enterprises
7	Apttus Corporation	Quote-to-cash software solutions
8	ecobee, Inc.	Smart thermostats and light automation equipment
9	Laird PLC	Solutions and components for connecting and protecting electronics
10	Snowflake Computing Inc.	Cloud based data warehousing software solutions
I. Materials		
Ranking	Investee	Business item
1	Canam Group Inc.	Construction solutions and fabricates customized products
2	C&A Tool Engineering, Inc.	Metalworking products
3	TemperPack Technologies, Inc.	Thermal packaging for insulated, temperature-sensitive goods
4	Italmatch Chemicals S.p.A.	Performance Additives for the Lubricant, Plastics, Water & Oil markets
5	Osisko Gold Royalties Ltd	Acquiring and managing precious metal and other royalties
6	STCube, Inc.	Therapies to treat novel immune evasion mechanisms in cancer
7	SOCOMORE S.A.S.	Chemical solutions for preparation, protection, treatment, and control of metallic or composite materials
8	Monarques Gold Corporation	Acquisition, exploration, and development of mining properties
9	Recochem Inc.	Automotive and household chemical products
10	AREVO, Inc.	Composite thermoplastic filaments for additive manufacturing
J. Real Estate		
Ranking	Investee	Business item
1	GLP Pte. Ltd.	Logistics facilities
2	Sawbuck Realty, Inc.	Online real estate brokerage
3	D&J (Shanghai) Investment Management Consulting Co., Ltd.	Integrated industrial property development, operation, investment, property leasing and fund management services
4	Prontopiso, S.L.	Real estate agency
5	CE Serviced Offices Pvt Limited	Fully serviced offices, virtual offices, meeting rooms, and co-working spaces for companies
6	Merritt Properties, LLC	Commercial properties development and management

TABLE 6. *(Continued.)* **Emerging business opportunities by business sectors (top 10).**

7	EV Hive	Co-working chain that provides individuals and companies with access to workspaces
8	TenX, LLC	Online real estate marketplace
9	Ziwutong (Beijing) Asset Management Co., Ltd.	Apartment rentals
10	Beijing Dream Plus Information Technology Co., Ltd.	Shared working spaces

K. Utilities

Ranking	Investee	Business item
1	Naturgy Energy Group, S.A.	Supply, liquefaction, regasification, transport, storage, distribution, and sale of natural gas
2	Hokkaido Electric Power Company, Incorporated	Electricity generation, transmission, and distribution
3	Concord New Energy Group Limited	Power generation
4	Energy World Corporation Ltd	Power and natural gas production
5	Arctic Green Energy Corporation ehf	Electricity production from geothermal energy
6	Bulb Energy Limited	Renewable electricity produced from solar, wind, and hydro
7	Esperanza Transmissora de Energia S.A.	Construction, deployment, operation, and maintenance of electricity transmission facilities
8	Guzman Energy LLC	Power trading
9	Elenia Oy	Electricity distribution network
10	NextEra Energy Partners, LP	Clean energy projects

L. Etc.

Ranking	Investee	Business item
1	Onica	IT consulting, infrastructure solutions, and managed services to enterprise organizations
2	Reali, Inc.	Residential real estate
3	Holberton School	Project-based learning and peer learning to software engineers
4	Eta Compute, Inc.	Power embedded computing platform
5	OpenIO	Software-defined storage solutions
6	Intengine Technology	AI and robotics solutions
7	Price f(x) AG	SaaS based price management and CPQ (Configure, Price, Quote) software solutions
8	1touch.io	Software that provides data and privacy management and control solutions
9	Shenzhen Roadstar AI Co., Ltd.	Autonomous driving solutions
10	Catalyst Software Corp.	Intuitive customer success platform

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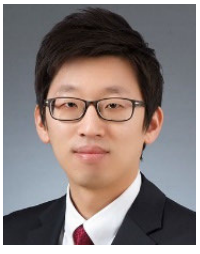
SUNGJIN KIM received the Ph.D. degree in industrial and management engineering from the Pohang University of Science and Technology. He is currently a Senior Researcher with the Korea Institute of Science and Technology Information. His research interests include technology commercialization, industry and market information analysis, and knowledge management.

YUNJEONG CHOI received the Ph.D. degree in chemistry from the Korea Advanced Institute of Science and Technology. She is currently the Director of the Technology Commercialization Center, Korea Institute of Science and Technology Information. Her research interests include discovering business opportunities, technology commercialization in SMEs, and market competitiveness assessment.



SUCHUL LEE received the B.S. and Ph.D. degrees in industrial and management engineering from the Pohang University of Science and Technology (POSTECH), South Korea. He is currently an Assistant Professor with the Department of Business Administration, Mokpo National University, South Korea. His primary research interests include strategic management of technology, information and knowledge management, and management science. His article appeared in the *Journal of Knowledge Management*, the *International Journal of Technology Management*, *Technology Analysis and Strategic Management*, *Information Technology and Management*, IEEE Access, and many others.