Readiness of Indonesian Higher Education Programs in the Big Data Era

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Abstract— **Today the world has entered the 4.0 Industrial Revolution, marked with the Internet of Thing (IoT) which generates the big data. In this big data era, there is a massive amount of digital data scattered, so it requires the presence of data scientists who can process these data into valuable information. Based on the digital competitiveness ranking released by the IMD World Competitiveness Center in 2018, Indonesia's ranking reached only in the 62nd place, far below Singapore (2), Malaysia (27), Thailand (39) and Philippines (56). Higher education as one of the organizers of the educational process that supplies ready-to-work experts, has great potential to take a maximum role to catch up with today's digital competitiveness. This paper discusses the readiness of higher education programs in Indonesia in response to the 4.0 industrial revolution era. We use web scrapping method to obtain data from Higher Education Data Base (Forlap Dikti) webpage from Indonesian Ministry of Research, Technology and Higher Education. This paper is expected to be able to provide an overview of stakeholders to be better prepared to undergo the 4.0 Industrial Revolution in Indonesia.**

Keywords— big data, data scientist, higher education, industrial revolution, web scrapping.

I. INTRODUCTION

At present, the world has entered the era of Industrial Revolution 4.0, indicated by the emergence of Internet of Thing (IoT). IoT on human life has yielded a lot of data connection, or what is known as big data. Yet, unfortunately, there are not so many practitioners who are experts in processing data into information. Such phenomenon needs come into consideration, since data digital in this era is referred to as new oil.

Based on research article of Mishra and Sharma, big data spans across many disciplines, including information science, mathematics, social science, network science, system science, psychology, and economics [1]. There is no doubt that the potential of data science and analytics to enable data-driven theory, economy, and professional development is increasingly being recognized. Data science and analytics involves not only core disciplines such as computing, informatics, and statistics, but also the broad-based fields of business, social science, and health/medical science [2]. If lessons in informatics, computers, information technology and management of technology have long emerged in our country, then actuarial lessons, which are also included in the planning of implementation of science data in economics, are still not well known.

The widely known definition of actuaries is an expert who can apply mathematical theory, probability and statistics, as well as economics and finance to solve actual problems in a business, particularly those related to adhered risk. While the official definition according to the Big Indonesian Dictionary of actuaries is mathematicians in insurance companies that calculate risk, premiums, reserves and dividends [3]. The requirements for an actuary profession in Indonesia is increasing along with the dynamics that occur both in economic, social and regulatory aspects in Indonesia. However, the number of actuary is still very limited.

At present, there are only 536 registered actuaries in our country. The number consists of 265 actuaries holding Fellow of the Society of Actuaries of Indonesia (FSAI), and 271 actuaries holding Associate of the Society of Actuaries of Indonesia (ASAI). Both has role function related to risk management, including pricing, valuation, insurance coverage, and reinsurance. ASAI differs from FSAI in that it has completed 8 of the ten competency tests to become actuaries, while FSAI has fulfilled all of them. When compared with the number of actuary requirements, of course the amount is very far beyond sufficiency.

This research is based on the question: how is the readiness of higher education in Indonesia to answer the challenge of the requirements for data processing experts in the era of big data, including informatics, statistics and actuarial. Data was taken from the Data Base for Higher Education, Ministry of Research Technology and Higher Education which is commonly called as forlap dikti.

II. LITERATURE REVIEW

A. Industrial Revolution and Big Data

Discussing the 4.0 Industrial Revolution could not be separated from big data issues, since the basic needs of the 4.0 Industrial Revolution lays on Cyber-Physical Systems (CPS) and industrial Internet of Things (IoT), and of course the digitalization world is very close to the big data analytical concept [4]. The idea of Industry 4.0 is a global term for a new industry paradigm that includes the concepts of Cyber-Physical Systems (CPS), Internet of Things (IoT), Internet of Services (IoS), Robotics, Big Data, Cloud Manufacturing, and Augmented Reality [5].

One thing that needs to be realized by all parties in this era is that at present data is considered as new oil, an item that has high capital value. In his document, MIT in

collaboration with Oracle said that "*Data is now kind of capital, on par with financial and human capital in creating new digital products and services. Enterprises need to pay special attention to data capital, because it's the source of much of the added value in the world economy*" [6]. Another researcher, Siemens in 2015 also published annual reports entitle 'Data is The New Oil'. When describing The Future Industry, they quoted "*The key to increase productivity and smart use is located in the optimization of processes, and here the digitalization has a central role*" [7].

In 2017, the Policy Department of the United Nations Industrial Development Organization issued a document called Inclusive and Sustainable Industrial Development Working Paper Series under the title Big Data - Its relevance and impact on industrial statistics. This document provides an example of Big Data in industry statistics, where it is given that the main objective and concern of statistics is to develop indicators that are relevant and useful in terms of completing official estimates on economic indicators [8]. For this reason, actuaries are needed. Actuarial combines mathematical theory, probability, statistics, economics and finance, to solve business problems.

Many researchers agree that a large amount of scattered digital data must be utilized to the full. Among them for teaching [9], software engineering [10], making planning [11], and also for competitive intelligence changes [12]. But the quality of the data used must also be considered [13]. So that there is no misuse of data that causes wrong conclusions. For this reason, experts in the relevant data fields are very important.

B. Actuary and Big Data Era

In 2013 ACCA (the Association of Chartered Certified Accountants), the global body for professional accountants, introduced a new concept called accounting and finance professional hybrids. In a document entitled Big data: its power and perils, it was written that: "*Accountants and finance professionals who succeeded in the future will form a bridge between data science and data art, combining analytical skills and sophisticated models developed by mathematicians and statisticians with the skills of data art and data 'storytelling', they will collaborate closely with IT and information management departments in cross-functional and multidisciplinary teams: the future could see the emergence of a new professional 'hybrid', the chief financial technology officer (CFTO) or chief financial information officer (CFIO)*" [14]. Fig. 1 below is a hybrid concept carried by ACCA.

In 2015, the Institute of Actuaries in Belgium issued an information paper entitled BIG DATA: an actuarial perspective. In the document, it was stated that: "*Big data opens the horizon of actuary. Big data also gives access to more information than before: this gives the actuary a mathematical basis for actuarial mathematical analysis. Big data and the calculation power allow to develop innovative algorithms to detect visible and verifiable indicators for a different risk profile*" [15].

In June 2018, the American Academy of Actuaries published a document containing pillars of actuarial professionalism under the title BIG DATA AND THE ROLE OF THE ACTUARY. The document discusses about the framework for actuaries to perform actuarial services related to Big Data. When defining the Role of Actuary it is

stated that: "*In many applications of large number of companies that are employed, multidisciplinary teams are efficient and effectively complete the project. Actual groups are composed of statisticians, computer scientists, data scientists, and actuaries. Actuaries on these teams may be thought of as the subject matter experts. But actuaries may be the quarterbacks of the Big Data teams, with the proper background, an actuary can understand and direct work of the Big multidisciplinary team data based on their professionalism requirements and subject matter expertise*" [16].
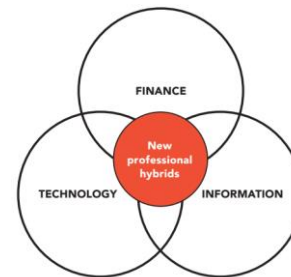

Fig. 1. New Professional Hybrids

Based on above three literature, it can be concluded that actuarial is indeed an interesting science to study in the current era of big data. So the organizers of higher education must also prepare it well so as not to be left behind.

C. Actuary in Indonesian Higher Education.

Based on news search, the establishment of an actuarial department at Higher Education is a mandate from the Ministry of Research and Technology to answer the challenge of the Industrial Revolution 4.0 era. In 2016, five major universities were given the term. The five are UI, ITB, IPB, UGM, and ITS. However, two years after the order was granted, there were only nine undergraduate level actuarial departments (S1) registered in Directorate of Education website which took place at Padjadjaran University (Unpad), Sepuluh November Institute of Technology (ITS), University of Indonesia (UI), Agricultural Institute Bogor (IPB), Taman Siswa University, Trisakti Insurance Management College, President University, Surya University, and Binawan University. The nine department name listed are vary, e.g. *Aktuaria*, *Sains Aktuaria*, and *Ilmu Aktuaria*.

Furthermore, during the National Actuarial Symposium in the Industrial Age 4.0 in Jakarta, held in the end of 2018, the General Secretary of Ministry of Research, Technology and Higher Education, Ainun Naim said that "*the Ministry continue to provide education to public regarding the importance of the actuarial sector to support the financial industry*". He also added that "*The ministry massively continue to disseminate and educate the public and potential students, thus the actuarial field is important to be developed further. Actuarial education is also very relevant to the development of the 4.0 industrial revolution. Today the digital economy is increasingly evolving so that financial risk management in the digital era has also transformed widely. And as a pilot project, Indonesian Ministry of Research, Technology and Higher Education, has commissioned nine universities to develop an actuarial science program. The nine universities are Bogor Agricultural Institute (IPB), University of Indonesia (UI),*

Bandung Institute of Technology (ITS), Gadjah Mada University (UGM), Sepuluh November Institute of Technology (ITS), Pelita Harapan University (UPH), Prasetiya Mulya (UPM) University, Parahyangan University (UNPAR) and Surya University."

Regarding higher education in Indonesia to answer the challenge of Industrial Revolution 4.0, previously there have been education programs related to information technology such as Information Technology, Computer Science, Information Systems, etc. However, until recently no research is conducted in addressing the trend of establishing IT-related education programs. Researchers searched Higher Education Data Base (Forlap Higher Education) to start searching for the name of the course that contains keywords related to Information Technology and the use of web techniques scrapping on url https://forlap.ristekdikti.go.id/ for data retrieval. Analysis and discussion were then carried out toward data taken from the searching results, regarding the trends of the establishment of departments in the scope of Information Technology.

III. METHODS

The diagram in Fig. 2 shows the overall picture of the methodology carried out in the research. The method used is based on the Phases of the reference model of DMME (data mining methodology for engineering applications) [17]. DMME has many stages and is very detailed. But in this study the stages are simplified as long as the purpose of data retrieval can still be carried out.
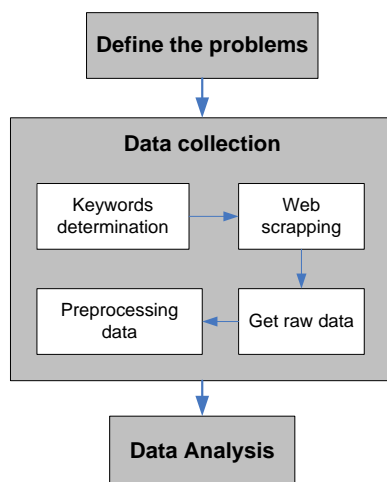

Fig. 2. Research methodology diagram

A. Define the problems

The first step was defining the problem. As defined earlier this research began with questions about the establishment of actuarial departments in Indonesia, thus the idea arises to further analyze toward IT-related department in Indonesia.

B. Web Scrapping

The second step was data collection. It was carried out at web address of official portal web https://forlap.ristekdikti.go.id/. Data collection was conducted in February 1st and 2nd, 2019, and there were four stages as follows:

1. Determine keywords.

The keywords determination was necessary since the results obtained would depend on its accuracy. Referring to APTIKOM based on Computing Curricula ACM, the variant names of department in higher education were Information System / IS (*Sistem Informasi*), Information Technology / IT (*Teknologi Informasi / Teknik Informatika*), Software Engineering / SE (*Rekayasa Perangkat Lunak*), Computer Engineering / CE (*Sistem Komputer*), Computer Science / CS (*Ilmu Komputer*). Thus in this study two keywords related to Information Technology were used, namely "*Informa*" and "*Komputer*", and one keyword related to actuarial and computer was "*statistika*".

The expected program names could be captured by three keywords:

- "*Informa*". This keyword was chosen to capture department data such as Informatics Engineering, Information Management, Information Systems, Information Systems, Information Technology Education, and probably some other departments related to the word Information or Informatics.

- "*Komputer*". This keyword was chosen to capture data from departments in Computer Engineering, Computer Science, and Computer Systems.

- While the keyword "*Statistika*" was used to capture data from Statistics department.

2. Web scrapping

Before web scrapping, researchers have attempted to search for data manually within the web portal https://forlap.ristekdikti.go.id/. However, it turned out that the portal not provided a dashboard that recaps data as the purpose of the study. Web scrapping techniques were conducted with the support of add-ons available in the Chrome browser to collect data. Web crawling methods in Indonesia have been developed to collect information through the internet [18].

3. Obtain raw data

After the web scrapping process was completed, the raw information obtained were then exported into a CSV file extension. Yet, from the web scrapping data result, there were still many typos and nonstandard establishment format of date and year. Therefore the next important step was data cleaning.

4. Preprocessing

Preprocessing is often identified as data cleaning, although actually the process conducted is not just data cleansing, but many other processes. In this study, the results of data cleansing were then analyzed.

C. Data Analysis

This stage was the last step in the research process. After all data collected was clean and ready to be processed, an analysis was then carried out to obtain information according to the research objectives. All results of this process will be presented in the Result section.

IV. RESULT

A. Data Overview

The initial results were in the form of tabulating data on departments related to Information Technology in Indonesia. From the scrapping process, all degree levels of education (from D1 to S3) were obtained as presented in Table 1 below. It is clearly shown in Table 1 that departments with the variant name "*Informa*" such as Information Engineering, Information Management, Information Systems, Information Systems, Information Technology Education was the highest in number, then followed by "*Komputer*", "*Statistika*", dan "*Aktuaria*".

Table 1. Data on education related to Information Technology

Keyword	Level						
	D1	D2	D3	D4	S1	S2	S3
"Informa"	14	23	526	37	1074	40	1
"Komputer"	21	16	288	14	137	13	7
"Statistika"	0	0	7	4	40	7	1
"Aktuaria"	0	0	2	0	9	1	0

When the data obtained were parsed in order to give an overview which departments appear the most, the results have shown that 75.15% of total IT departments in Indonesia used the variant name "*Informa*", and followed by 21.74% used the word "*Komputer*" (Computer Engineering, Computer Science, and Computer Systems). The percentage of departments from all keywords used was presented in Table 2.

Table 2. The distribution of IT-related education

Keyword	Sum	Percentage
"Informa"	1715	75,15%
"Komputer"	496	21,74%
"Statistika"	59	2,59%
"Aktuaria"	12	0,53%

By evaluating the distribution levels of overall department data obtained, it turned out that bachelor degree program (S1) was dominant with the most significant percentage of 55.21%, followed then by the three-year vocational program (D3) of 36.06%.

Table 3. The distribution of IT-related education based on degree stage

Keyword	Level						
	D1	D2	D3	D4	S1	S2	S3
Percentage	1,53%	1,71%	36,06%	2,41%	55,21%	2,67%	0,39%

B. Data from Establishment Trend

In this section, the discussion was focused on departments establishment with "Informa" variant trend. The result showed that the peak of department established with "*Informa*" variant occurred in 2014, with 119 departments established. The trend dropped significantly in 2015 and starting to rise again yet never neared its peak (see Fig. 3).
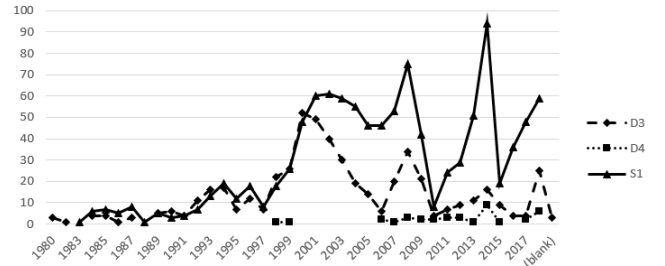

Fig. 3. The trend of education established with the keyword "*Informa*"

In general, by observing the trend in Fig. 1, the "*informa*" department establishment began to emerge massively in early 2000s. Slightly different from previous results, departments with computer variants (Computer Engineering, Computer Science, and Computer Systems) first emerged in late 1900s and quickly disappear in 2007 (see Fig. 4).
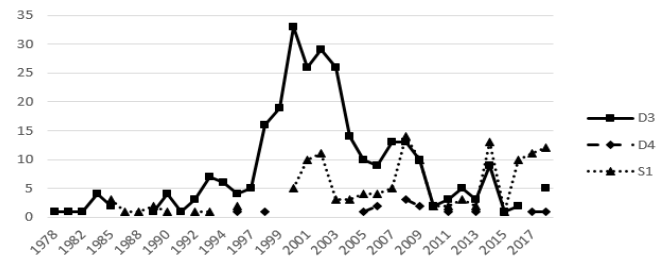

Fig. 4. The trend of education established with the keyword "*Komputer*"

What about Statistics department? Although this department is closely related to data scientist, which massively increased by the digitalisation invention, it turned out that in the year of 2000s it did not have any significant impact. The trend of new department establishment experienced a substantial increase in the range of 2013 - 2017 when people began to realize the need for experts who able to process data accurately in the big data era. Fig. 5 below presented a visual data on the trend of statistics departments established in Indonesia.
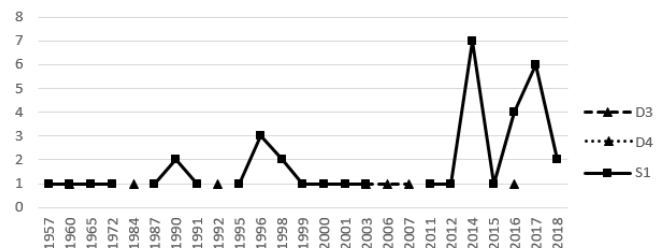

Fig. 5. The trend of education established with the keyword "*Statistika*"

C. The Accumulative Data

When Indonesia department data having direct impact toward big data era were observed and compared as a whole, the finding was that department with keyword "Informa" had significant number far beyond the other two keywords. Up to the research data was obtained, the total departments containing keyword "Informa" was 1828, while departments containing keyword "Computer" was 496 in number. The two departments were still relatively big in

number compared to the number of 'statistical' departments in Indonesia which was only 51 in number. It is definitely necessary to be concerned by all parties, since the need for data and statistic experts is very substantial in this era of big data.

The discussion related to the needs for actuarial departments is unfortunately not so satisfying enough, since the number found is still very small. Such actuarial department which is expected to be the complement for the role of data analysts in this era of economic revolution, in fact in in Indonesia was only found 9 S1 departments, 2 D3 departments and 1 master department which certainly overall are still far beyond sufficient.
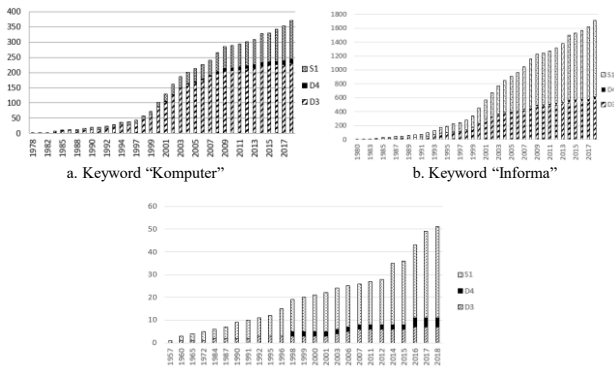

a. Keyword "Komputer"   b. Keyword "Informa"

Fig. 6. Visualization of the accumulative number toward IT-related departments in Indonesia

Fig. 7 below is the data number of Actuarial department in Indonesia, which is indeed still very small.
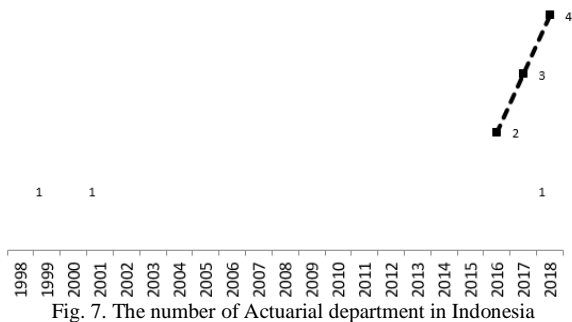

Fig. 7. The number of Actuarial department in Indonesia

As stated by ACCA (the Association of Chartered Certified Accountants), 'the new professional hybrid needed at this time is the professional whom able to expertise the financial sector, while also mastering technology and data processing into information'. Students mastering knowledge of Information Technology and statistics are expertizing technology and information, thus they are expected to be reliable data scientists with the help of tools [19], while for actuarial science, it is different.

Knowledge of an actuary is positioned in the financial sector complements, in the way that the economic prediction on data obtained could be realized into valuable capital. Since the actuarial role is very significant, the authorized government shall take this into concern, by not letting the needs of domestic actuaries be fulfilled with foreign professionals due to the inability of the state to provide from within the country.

CONCLUSION

From overall results of above discussion, it can be concluded that the number of actuarial departments is still inadequate when compared to other IT related departments. However, this may not be interpreted as Indonesia's unpreparedness in welcoming the era of Industrial Revolution 4.0. This is due to university technical students at each education level majoring in Informatics, Information Systems, Computer Science, and Computer Systems, have mastered the tools related to automation. While for filling in the vacancies from two different directions, The IT-related departments still could improve their graduates' competitiveness by adding the primary actuarial material in their curriculum. Still, however, it is necessary for the government to continue encouraging the establishment of actuarial department that is substantially needed at present.

REFERENCES

[1] R. Mishra and R. Sharma, "BIG DATA: OPPORTUNITIES AND CHALLENGES," *Int. J. Comput. Sci. Mob. Comput.*, vol. 4, no. 6, pp. 27–35, 2015.

[2] L. Cao, "Data Science : A Comprehensive Overview," *ACM Comput. Surv.*, vol. 50, no. 3, p. 43, 2017.

[3] D. Sugono, *Kamus Bahasa Indonesia*, vol. 3, no. September. 1981.

[4] A. Rojko, "Industry 4.0 Concept: Background and Overview," *Int. J. Interact. Mob. Technol.*, vol. 11, no. 5, p. 77, 2017.

[5] J. Nagy, J. Oláh, E. Erdei, D. Máté, and J. Popp, "The role and impact of industry 4.0 and the internet of things on the business strategy of the value chain," *Sustain.*, vol. 10, no. 10, 2018.

[6] M. Yousif, "The Rise of Data Capital," *MIT Technol. Revie Cust.*, vol. 2, no. 2, pp. 4–4, 2015.

[7] Siemens, "Data is the 'new oil,'" *Siemens Annu. Rep.*, pp. 1–40, 2015.

[8] U. N. I. D. Organization, "BIG DATA – ITS RELEVANCE AND IMPACT ON INDUSTRIAL STATISTICS," *Incl. Sustain. Ind. Dev. Work. Pap. Ser.*, vol. 11, 2017.

[9] M. Huda, A. Maseleno, M. Shahrill, and K. A. Jasmi, "Exploring Adaptive Teaching Competencies in Big Data Era," no. April, 2017.

[10] R. Deline, "Research Opportunities for the Big Data Era of Software Engineering," 2015.

[11] W. Alzyadat and A. Alhroob, "Development Planning in the Big Data Era : Design References Architecture," no. May, pp. 884–887, 2019.

[12] M. Li, R. Sun, H. Fu, and S. Shen, "Competitive Intelligence Changes in Big Data Era Based on Literature Analysis," no. Icem, pp. 1–5, 2016.

[13] B. Saha and D. Srivastava, "Data Quality : The other Face of Big Data," pp. 30–32.

[14] IMA, "Big data: its power and perils," *Assoc. Chart. Certif. Accountants*, p. 40, 2013.

[15] I. of Actuaries, "BIG DATA : An actuarial perspective," *Inf. Pap.*, no. November, p. 23, 2015.

[16] American Academy of Actuaries, "BIG DATA AND THE ROLE OF THE ACTUARY," *Encycl. Actuar. Sci.*, 2006.

[17] C. Model, H. Wiemer, and L. Drowatzky, "Applied Aciences Data Mining Methodology for Engineering Applications (DMME)— A Holistic Extension," 2019.

[18] I. Ramadhan and H. Sastramihardja, "Pemanfaatan Web Crawler Dalam Mengumpulkan Informasi Melalui Internet," *Konf. Nas. Sist. Inf. 2018*, pp. 8–9, 2018.

[19] C. Ozgur, M. Kleckner, and Y. Li, "Selection of Statistical Software for Solving Big Data Problems," *SAGE Open*, vol. 5, no. 2, pp. 1–12, 2015.