

Predicting Job Skills in Demand: A Big Data Approach

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Abstract: *The number of unemployed graduates is increasing due to a mismatch in the job skills and skill shortage. The mismatch in job skills has increased further due to technological changes like digital transformation. In Bangladesh, many companies hire skilled people from abroad because of the lack of training among graduates. Therefore, the study aims to apply big data analysis to find and predict job skills in demand. The data was mainly collected from the largest job-posting website (i.e., bdjobs.com) in Bangladesh. Natural Language Processing (NLP) was used for linguistic analysis components (for pre-processing) and tagging named identity. The finding shows business development skills, data visualization, oral communication, Microsoft Excel and working under pressure have the most demand in the categories of business knowledge skills, analytical problem skills, interpersonal communication skills, computer literacy skills, and organizational skills respectively. The study shows that big data analysis and the use of the Auto Regressive Integrated Moving Average (ARIMA) model can predict job skills in demand, which can help reduce the mismatch and gaps in job skills in demand. Overall, this study will contribute to reducing the number of unemployed graduates in Bangladesh.*

Keywords: *Big Data, Skill Gap, Data Mining*

1. Introduction

The International Labour Organization (ILO) reports that young graduates worldwide are having trouble finding entry-level jobs due to the mismatch in job skills (ILO, 2020). Similarly, while addressing the global challenges of job-skills mismatch, UNICEF reports that the rate of job skills mismatch is above 50% in 57 out of 108 countries globally (UNICEF, 2020). Skill mismatch commonly occurs when there is more demand for a particular job but less supply and when skills become obsolete because of technological advancement, digital transformation and globalization. If new graduates do not possess the required skills, it can hurt the country's economic growth.

The World Economic Forum reports that the mismatch of skills is a substantial liability that is causing the financial loss of billions of dollars in North American countries (Bajaj, 2022).

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The mismatch of job skills is a common issue in China, Malaysia, India, Pakistan and Bangladesh (Jun, 2017). While investigating the impact of COVID-19 on the job market in Bangladesh, the issues of skill gap have been found as one of the reasons for unemployment faced by graduates (Khan, 2020). Previously, it was reported that lack of relevant job skills is one of the major reasons causing unemployment in Bangladesh, where 37% of the male graduates and 43% of the female graduates are unemployed (TheDailyStar, 2019). Therefore, there is a need for investment in skills training to ensure the development of the skills in demand in the job market among graduates.

To reduce the unemployment issue faced by new graduates, the development of skills to meet job demands has been highly recommended (Rahman et al., 2020). Research shows that low skills can cause long-term unemployment issues in a country (Duell et al., 2016). On the other hand, ILO reports that young people are three times more likely to be unemployed due to a lack of relevant experience and low skills (ILO, 2020). Hence, appropriate education and training for developing the skills can be a 'bridge to jobs' and prevent the gap in job skill. Skills can enable graduates to successfully participate in the job market. Hence, to decrease the issue of difficulty in recruiting that about 60% of the organizations face, researchers recommended training students in skills in higher demand (PHE, 2014).

It is recently predicted that due to fast changes in technology, a lack of relevant knowledge in the education programs and not having suitable training, about 20% of the employees and workforce will not have the skills required to do any particular job by 2030 (Chastney, 2020). The increase of unemployed graduates will significantly but negatively affect the Sustainable Development Goal 8 (SDG 8), which advocates for employment for everyone (Bandyopadhyay, 2020). Therefore, the importance of job skill development as a strategic means of preventing unemployment of new graduates has been stressed in previous studies (Pang et al., 2019).

Furthermore, the report shows that 40% of the young people in Bangladesh are unemployed (a2i, 2020). According to the Bangladesh Bureau of Statistics (BBS), about 8 million people in Bangladesh, aged 15 to 24, are unemployed (Alam, 2021). Like most developing countries, Bangladesh is vulnerable to the Fourth Industrial Revolution (4IR) consequences, due to a lack of preparation in addressing the skill shortage (Biswas, 2020; Nile, 2022). But 4IR will also open up exciting new job opportunities for young graduates in the future. However, without fulfilling the demand for new job skills created by the advent of disruptive technologies, neither it is possible to make use of new job opportunities, nor can countries decrease the population of unemployed young graduates.

Hence, by considering the profundity of unemployed young graduates, this study aims to apply big data analysis to find and predict the job skills in demand for new graduates in Bangladesh. The study will help find and fill the job skills in demand and thereby contribute to achieving SDG 8, which focuses on reducing unemployment. Overall, the beneficiaries of the findings of this study include new graduates, the government and employers in any industry.

2. Literature Review

It is reported that the number of studies on the job skill mismatch among graduates has increased in the last decade (Aminu, 2019). The researchers have paid a great deal of attention to the job skill mismatch or misalignment that is causing the rise in unemployment. A good number of studies have identified job skill mismatch as one of the reasons behind the increase in unemployment in the entire job market (Ncube et al., 2018). As a result, Seng (2018) has emphasized increasing the graduates' employability skills to avail employment opportunities. In another study, Mamun et al. (2020) pointed out the lack of job skills among young graduates and recommended acquiring skilled-based expertise and vocational training in different subject areas. Similarly, without having the skills that are critical to digital transformation and Industry 4.0, the unemployment issue arises. Nanthagopan and Vivek (2021) showed that graduates from government universities are increasingly failing to find suitable jobs in various private sectors because of not having the needed job skills that are in demand in the job market.

As the rise of unskilled employees increases companies must pay more to fill their job vacancies (Said et al., 2021). Therefore, Mayombe (2020) has emphasised the need for skills training of unemployed young graduates to achieve success in gaining employment for new graduates. Also, Robinson and Garton (2008) suggested the need for specific employability skills needed to gain specific jobs. In addition, Vutsova and Arabadzhieva (2021) mentioned the necessity of meeting the gaps in job skill in demands and employers' expectations of having specific job skills among job candidates. Moreover, Rashid & Islam (2020) recommended addressing the issues of skill shortages and skill mismatch in the 4IR. Additionally, Cabral and Dhar (2019) concluded that there is a need for addressing the challenges of job skill mismatch by closing the gap between theory and practice, facilitating e-learning for skill development, funding in-house training in companies, and increasing private-public partnerships to increase participation in skill development programs.

In the context of Bangladesh, many companies hire skilled people from abroad which not only incurs higher costs for the companies but keeps a good number of local graduates out of

the job workforce (Rahman et al., 2021). Also, publicly available data show there is a mismatch in job skills due to the lack of proper policy related to human resource development in Bangladesh. Subsequently, being unemployed has long-term negative impact on the individual, social and sustainable development. As the new graduates fundamentally need various employability skills, especially to meet the demand for specific job skills related to the global, economic, technological, and social changes, the issue of skill mismatch has to be addressed with vocational and technical training for unemployed graduates (Kadir et al., 2020). Otherwise, the mismatches in the job skills creates barriers for the enterprises to reach their full potential but also leads to the problems of under-usage of human resources in any country (Şahin, 2020).

Many previous studies (Chang et al., 2019; De Mauro et al., 2018; Lovaglio et al., 2018; Lunn et al., 2020; Ramasubbareddy et al., 2021; Rios et al., 2020) have applied big data analysis to identify the job skill in demand. Olszak and Gajowska (2017) uses big data for IT job market demand analysis in Poland. Their study was able to check how demand in the IT labour market is changing. Matsuda et al. (2019) used big data based on job advertisements for labour market analysis in Pakistan to provide timely information about job skill demand and supply. Kale and Balan (2016) used big data for job trend analysis, and found important patterns in specific job demands according to specific locations in the state of New York. Meyer (2019) conducted big data content analysis of job postings to understand the skills required for data scientist jobs in the USA and found that their method enhanced understanding of the qualifications and skills needed to apply for the data scientist positions.

Furthermore, De Mauro et al. (2017) identified the nature of skills required by analysing a large number of job posts published online. Their finding will enable the human resource (HR) managers to meet the skill in demand in the job marketplace. Likewise, Verma et al. (2019) used content analysis of job advertisements to assist in finding relevant job skills belonging to the specific categories of job positions. Gardiner et al. (2018) also conducted content analysis to investigate skills in demand in the area of big data analytics. Their findings increase the alignment between big data and the emerging discipline of data science. Also, Sibarani et al. (2017) conducted a study for identifying data science skills in job posts. Researchers used a vocabulary-guided skill extraction method that yielded a performance of around 94% F-measure a very high level of performance when comparing the automatic extraction method with the manual extraction method. On the other hand, by understanding the importance of predicting the job skills demand for sustainable economic growth, Vankevich and Kalinouskaya (2020) have used artificial intelligence-based classifiers to

analyse and forecast the job skills in demand. However, no studies have been found that used the big data approach to predict the job skills in demand in the context of Bangladesh.

Methodology

This study involves following a methodology to build a harmonised database based on various data sources. While data collection tools were used for web-data scraping for feeding to the unstructured data bank, data mining techniques are used for creating statistical indices based on trending skill keyword frequency, patterns, and ranking (Figure 1). Data was mainly collected from the largest job-posting website, namely bdjobs.com, in Bangladesh. In total, 1734 job posts were collected and analysed using Python.

The data mining step primarily focused on the frequency of job skills posted in the job advertisement. After data collection and during the data mining step (Figure 1), NLP was used for linguistic analysis components (for pre-processing) and tagging named identity to make a list of keywords to be searched. The purpose of NLP was to identify meaningful classifications and analyse patterns and frequency to obtain valuable and new insights regarding the job skills in demand. Then the tokenization and stemming and lemmatization process were followed accordingly. The classification of job skills helped in grouping the respective job skills against each job category. Table 1 shows the specific steps in data collection and pre-processing.

Table 1: Steps in data collection and pre-processing

Step no.	Steps	Tasks
1	Extract job post URLs	Identify the job-post URLs using a Python-based parser that can target relevant URLs (based on job-post-tag in HTML tag related to the job description field).
2	Gather job descriptions	Use the Python library named “Beautiful Soup” as a keyword scraper.
3	Extract keywords from job ads	A list of keywords was used for storing the keywords to be searched.
4	Find keyword frequencies	Then the aggregate statistics were used to calculate the frequencies of job skills in demand in each category.

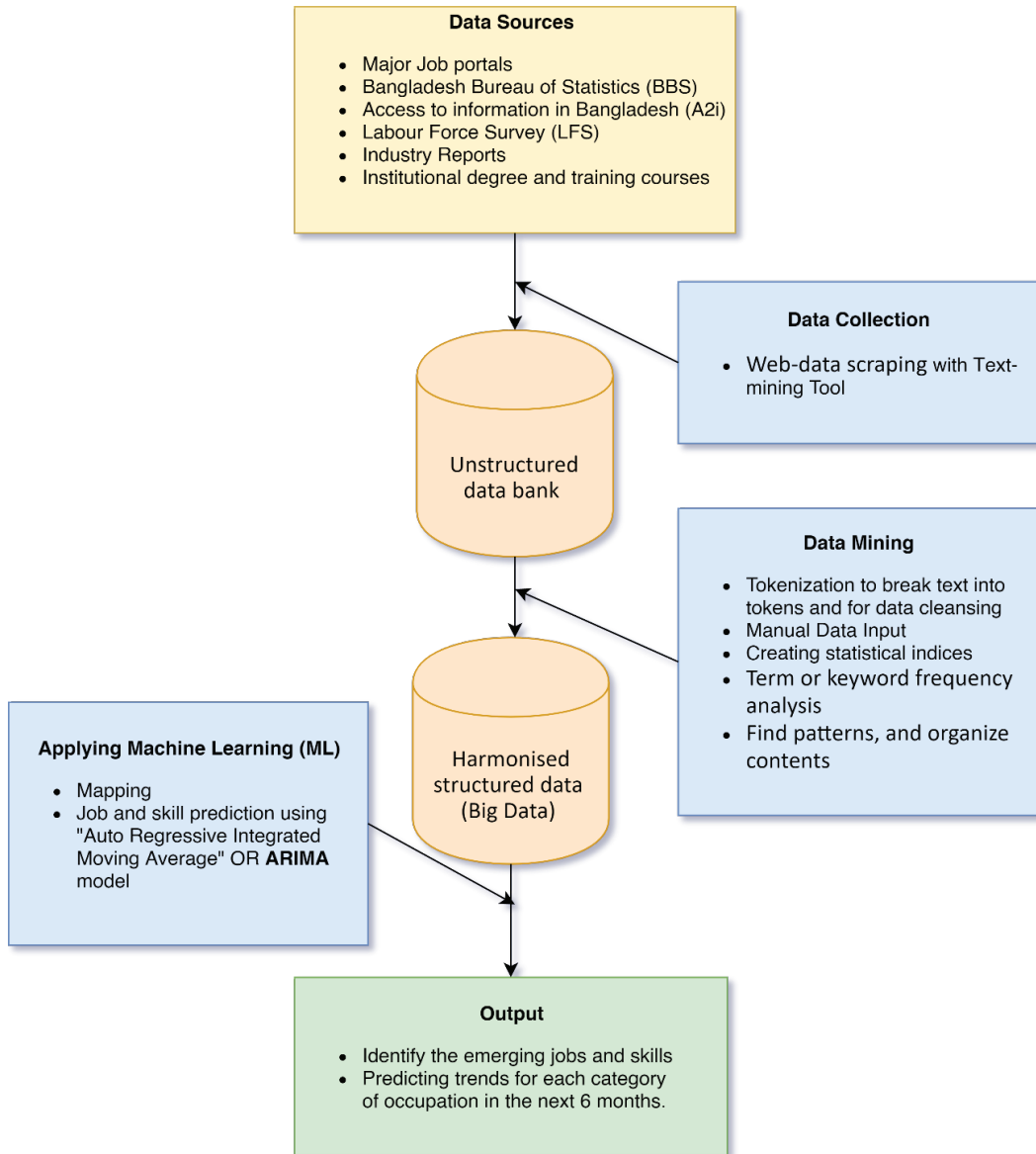


Figure 1: Flow chart of data collection, mining and predicting

To fulfil the objective of the study after data mining or identifying the job skills in demand, the Auto Regressive Integrated Moving Average OR ARIMA model (Carta et al., 2019; Konarasinghe, 2017; Torbat et al., 2018) was used to identify the emerging jobs and skills as well as predicting trends for each category of occupation in the next one to six months. For

accuracy testing for the ARIMA prediction model, mean squared error (MSE) and mean absolute percentage error (MAPE) indicators were used. As a big data analysis tool, the Python libraries such as “nlk”, “Beautiful Soup”, “wordfreq”, and, “pmdarima” were used respectively for web-data scraping, frequency calculation and ARIMA model development.

Result and Discussion

Bdjobs.com is one of the most popular job portal websites in Bangladesh. To retrieve job data, the data was mined every 15 days from September 1, 2020 to January 29, 2022. The extracted records were saved and accumulated over time in a SQL database. Figure 2 shows three categories of data mining focusing on experience levels posted over time. In 1734 job posts, there were more job postings for entry-level job positions (45.22%) than the mid-level positions (35.78%) and top-level positions (19%).

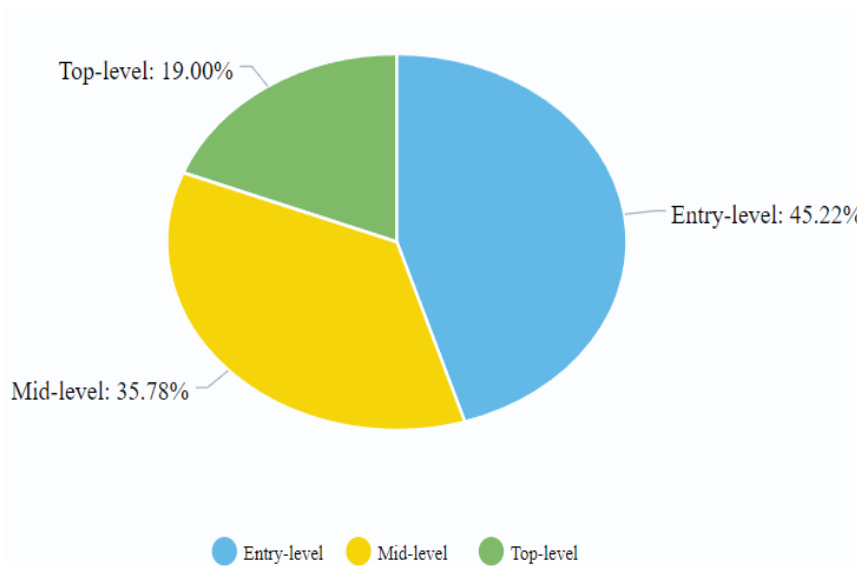


Figure 2: Pie chart of data collection for entry-level job positions, mid-level positions, and top-level positions.

When it comes to identifying the job skills in demand, NLP extracts the predefined keywords (e.g., analytics, management) for identifying job skills in demand. Figures 3 to Figure 7 shows the frequency of the job skills in demand in five categories of “Business knowledge skills”, “Analytical problem skills”, “Interpersonal communication skills”, “Computer literacy skills”, and “Organizational skills” respectively. From Figure 3 to Figure 7, each figure shows the rankings of the job skills in demand and the percentages of the overall demand (job skills) in each category. For example, Figure 3 shows that business development is the most solicited job skill (16.63%) in demand in the category of “Business knowledge

skills”. Similarly, Figures 4, 5, 6, and Figure 7 show that data visualisation (17.37%), oral communication (9.94%), Excel (8.78%) and working under pressure (18.54%) are the most solicited job skills in demand in the categories of “Analytical problem skills”, “Interpersonal communication skills”, “Computer literacy skills”, and “Organizational skills” respectively. This data analysis also shows an increase in different types of job skills such as digital technology skills and technology savviness due to the COVID-19 outbreak.

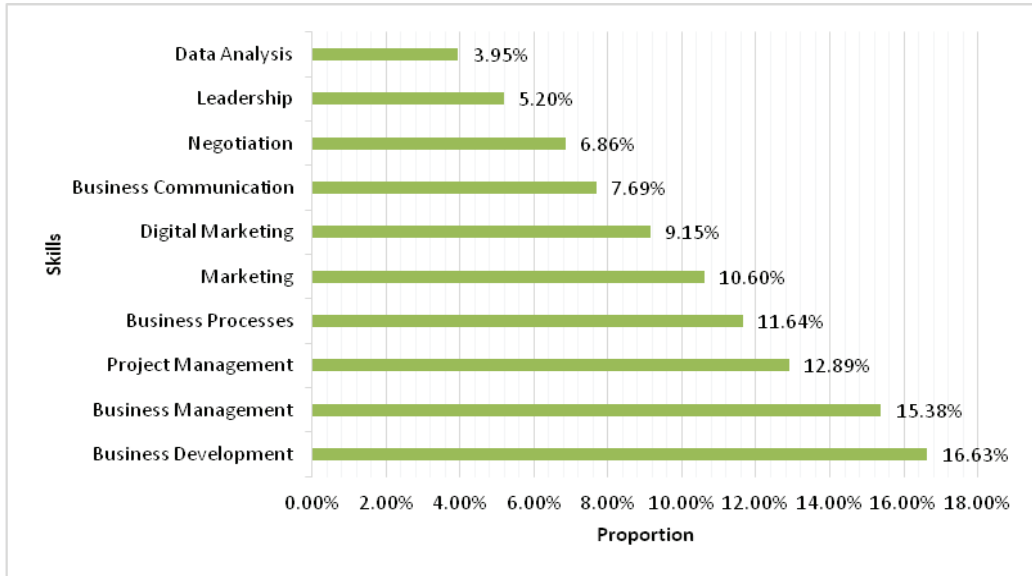


Figure 3: Most job skills in demand in the “Business knowledge skills” category.

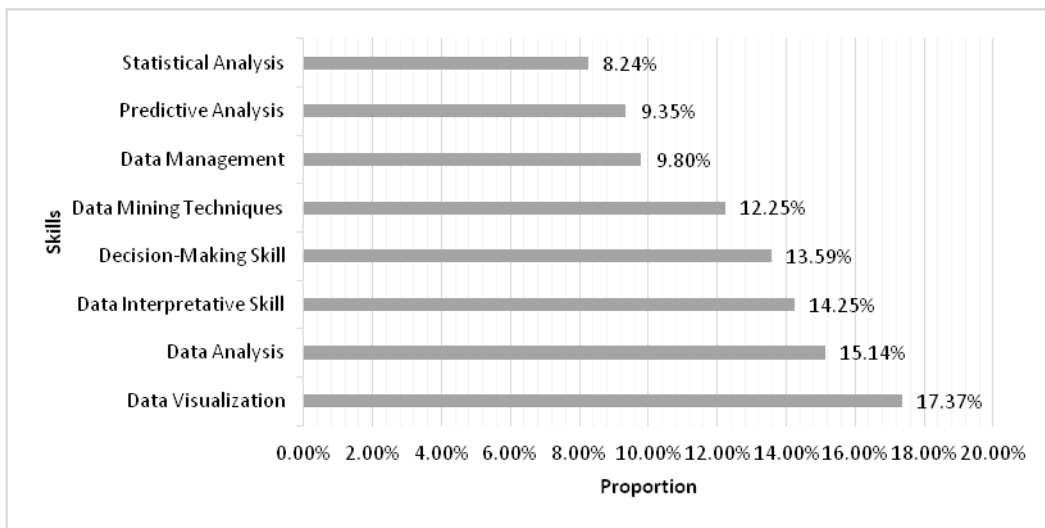


Figure 4: Most job skills in demand in the “Analytical problem skills” category.

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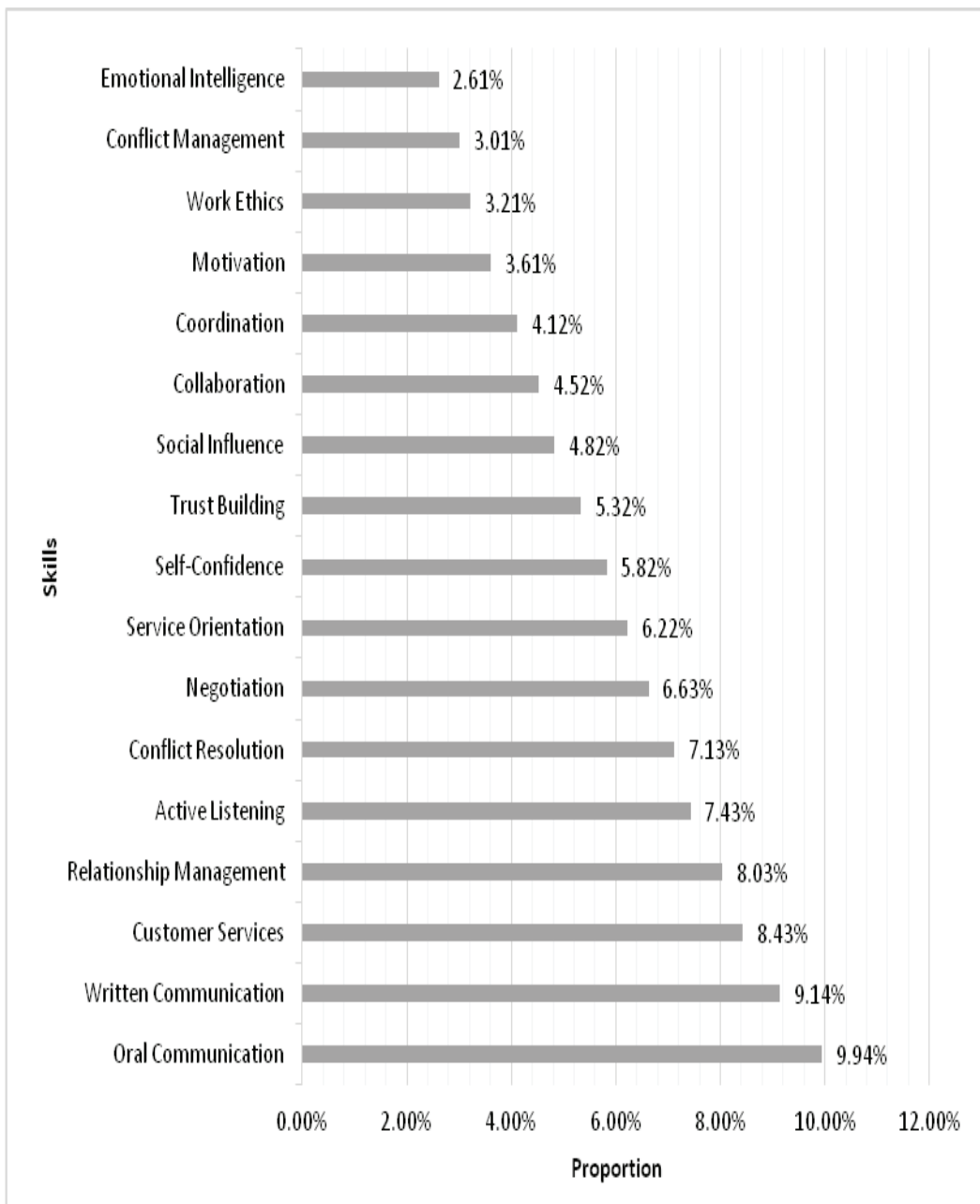


Figure 5: Most job skills in demand in the “Interpersonal communication skills” category.

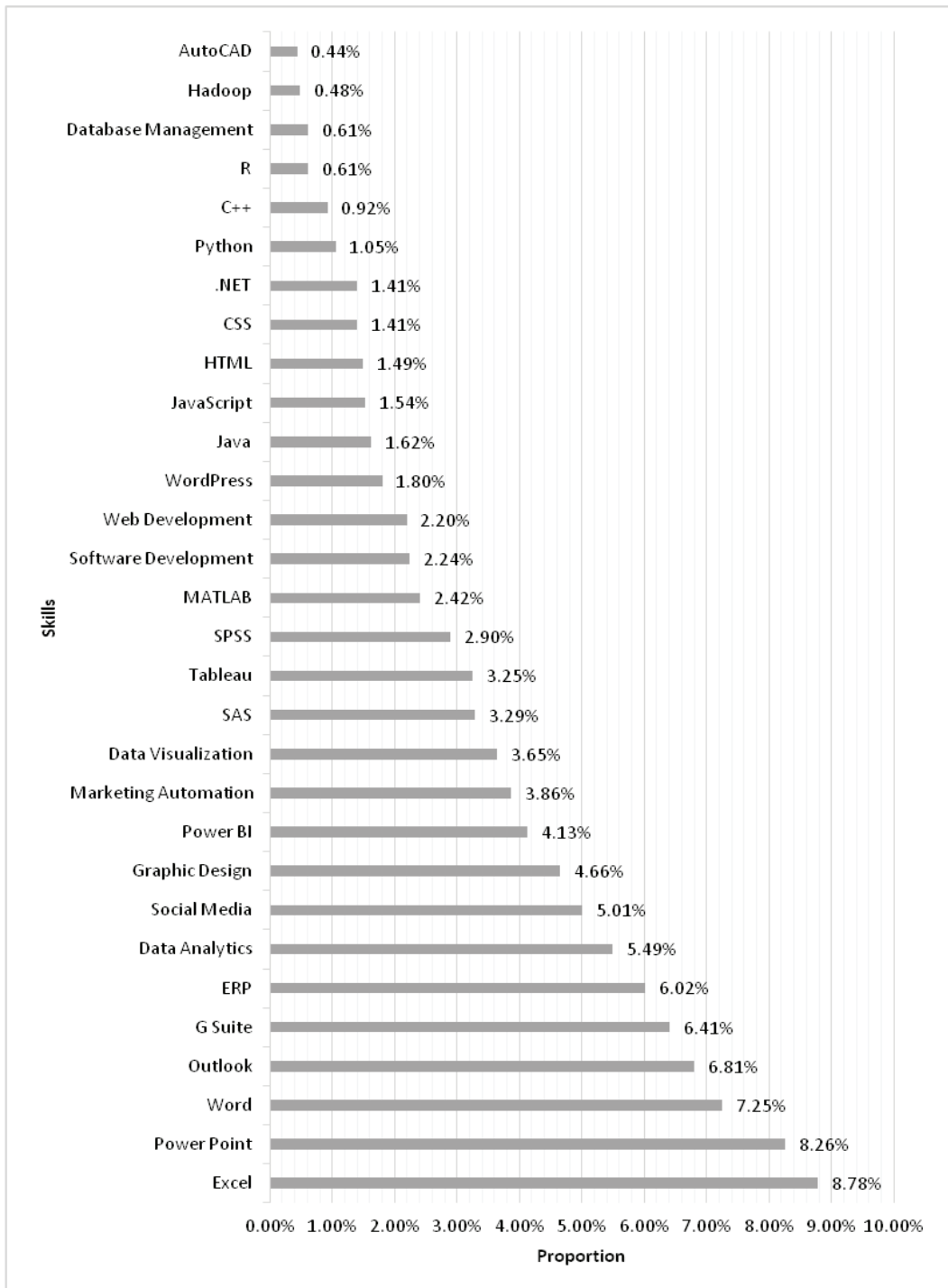


Figure 6: Most job skills in demand in the “Computer literacy skills” category.

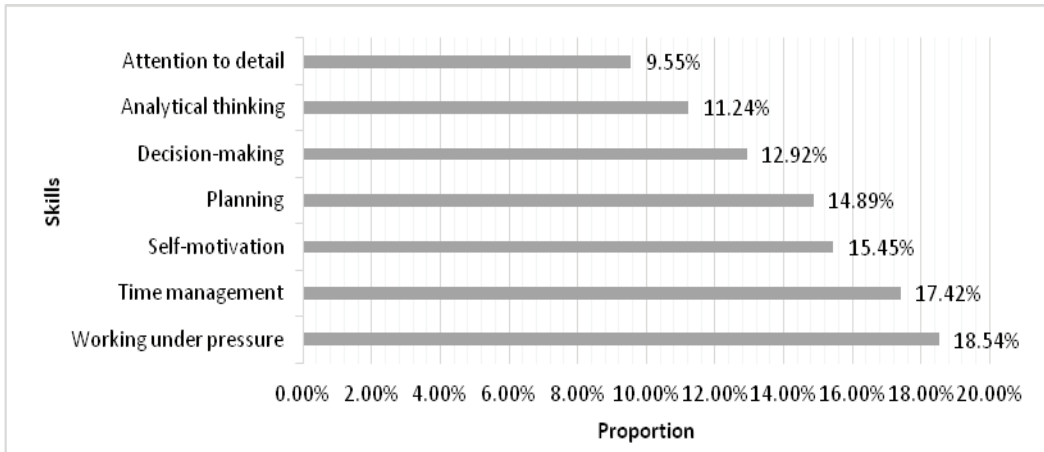


Figure 7: Most job skills in demand in the “Organizational skills” category.

On the other hand, Figure 8 shows word clouds to represent the most job skills in demand in the five categories in the three levels (i.e., Entry level, Mid-level, and Top-level). In Figure 8 (a), it is found that the top five most frequent job skills in demand are found in job posting for entry-level jobs. These are: “sales”, “marketing”, “Excel”, “cooperation and coordination”, and “oral communication” that are high to low in demand respectively. In contrast, Figure 8 (b) shows that the top eight most frequent job skills in demand for mid-level jobs are “marketing,” “customer services”, “business development,” “project management”, “data visualization”, “relationship management”, “social media marketing”, and “multi-tasking” that are high to low in demand respectively. For top-level jobs, “leadership skills,” “project management”, “business management,” “data analysis”, “SAS”, “predictive analysis”, and “research” respectively were the top seven most frequent job skills in demand (Figure 8 (c)).



(a) Most frequent job skills in demand in Entry-level



(b) Most frequent job skills in demand in Mid-level



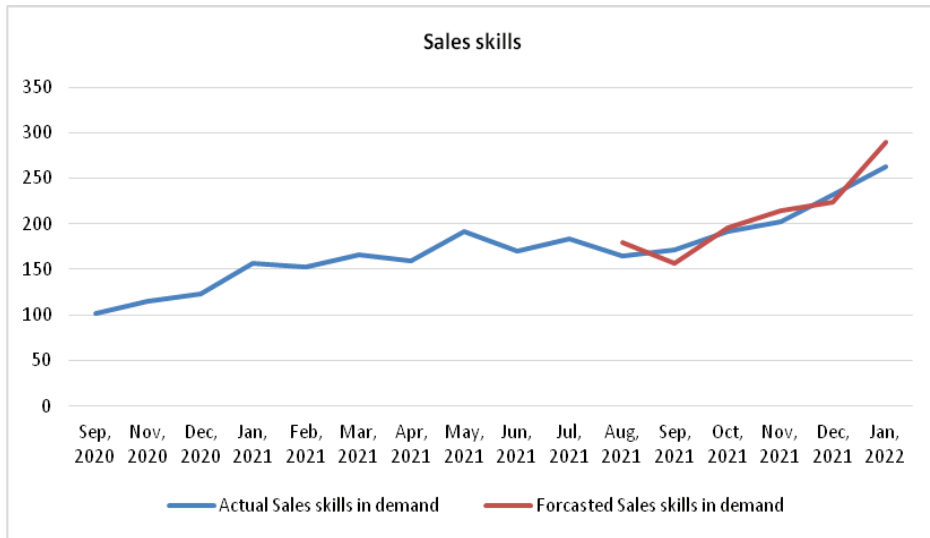
(c) Most frequent job skills in demand in Top-level

Figure 8: Word clouds to represent the most job skills in demand in the three levels (i.e., Entry level, Mid-level, and Top-level).

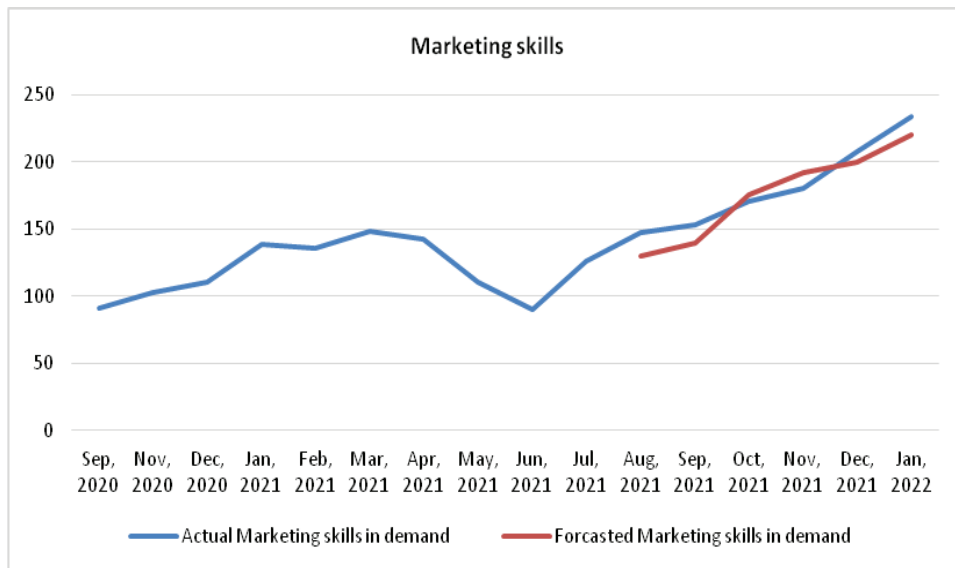
Later, when the ARIMA model was tested for predicting the job skill in demand, Figure 9 (a), Figure 9 (b), and Figure 9 (c) respectively show the predictions for six months for sales skills, marketing skills, and leadership skills for the entry-level, mid-level, and top-level positions for August 2022 to January 2022. Both the actual demand and predicted demand for sales skills, marketing skills, and leadership skills showed increasing demand (Figure 9). ARIMA models have shown an efficient capability to generate short-term forecasts (Pradhan, 2020). In an ARIMA model, the future value of a variable is a linear combination of past values and past errors. A standard notation is used for ARIMA (p,d,q), where ‘p’ is a number of lag observations included in the model, ‘d’ is the number of times that the raw observations are different, and ‘q’ is the order of the moving average. A forecast at time=t is denoted as, Y_t in

Equation (1), which is a function of, ε (random error at t), coefficients φ_i and θ_j , autoregressive term as p, and moving average q.

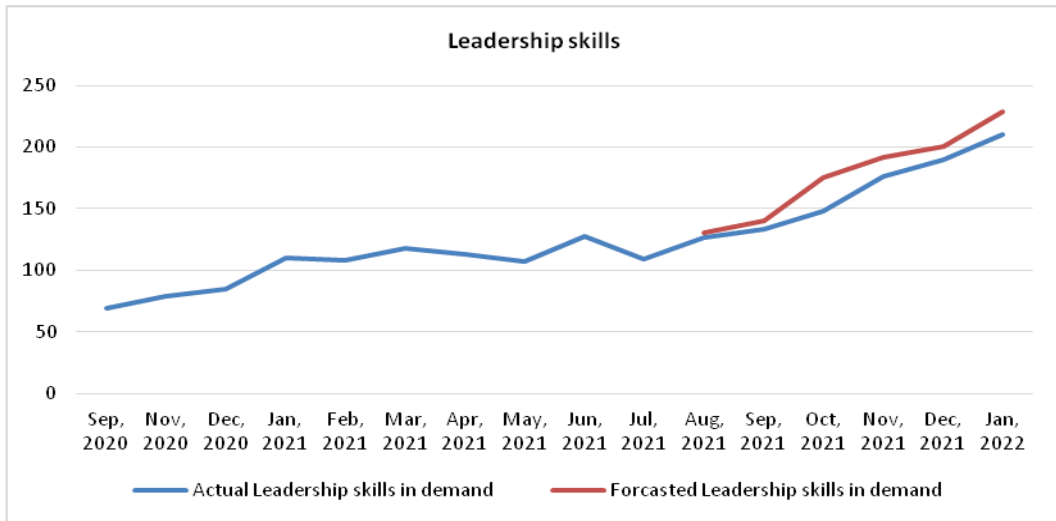
$$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \dots + \varphi_p Y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \dots - \theta_q \varepsilon_{t-q} \dots \dots (1)$$



(a) Forecasting Sales skills in demand in Entry-level



(b) Forecasting Marketing skills in demand in Mid-level



(c) Forecasting Leadership skills in demand in Top-level

Figure 9: Prediction of the top three job skills in demand in the three levels (i.e., (a) Entry-level, (b) Mid-level, and (c) Top-level).

Conclusion

By introducing the issue of unemployment of new graduates, this study has emphasised skill development and bridging skill gaps in recent literature. Accordingly, as a way to reduce the unemployment of new graduates, this study aims to use big data analysis by data mining to find and predict the job skills in demand. Findings show the skills of business development, data visualisation, oral communication, Microsoft Excel, and working under pressure are the most in demand in the categories of business knowledge skills, analytical problem skills, interpersonal communication skills, computer literacy skills, and organisational skills respectively. When applied the ARIMA model generates forecasts for six months from February 2022 to June 2022, both the actual demand and predicted demand for sales skills, marketing skills, and leadership skills respectively for the entry-level, mid-level, and top-level positions show an upward trend with a slight difference.

Unlike previous studies, the objective of this study is extended as the focus of this study was not only finding the job skills in demand but also predicting the job skills in demand quantitatively. Therefore, the methodology of this study is different in terms of techniques used. For instance, Gardiner et al. (2018) applied consensus pile-sort protocol (CPSP) to find the skills that has manifested in job ads, whereas, Vankevich and Kalinouskaya (2020) applied artificial intelligence to classify the job skills in demand but did not use any algorithm to predict the skills demand. Also, Sibarani et al. (2017) applied co-word analysis method for

clustering and finding the job skills in demand. As well as, De Mauro et al. (2017) applied both machine learning algorithms and expert judgement to find the most required job skills. Besides, in two recent studies, Arcelay et al. (2021) and Verma et al. (2021), respectively, used classification framework and European skills/competences, qualifications, and occupations (ESCO) framework for finding the job skills in demand. However, in contrast, none of the studies have used ARIMA model for identifying as well as quantitatively predicting the jobs skills in demand. To fill this gap, the authors of this study have undertaken a different technique which is the use of ARIMA model to fulfil the research objective of this study. Therefore, the contribution of this study is unique, especially in the context of Bangladesh.

The application of big data analysis in this study will help in reducing the fundamental mismatch between the skills that are sought after by employers and the skills that are possessed by the new graduates. The study contributes to the need for curriculum development to meet skill gaps in the current industry. It is also found that there is an increase in different types of job skills, such as digital technology skills and technology savviness in response to the COVID-19 outbreak. Therefore, the use of big data analysis as shown in this study will help to understand the sudden changes in demand for new types of jobs and skills following the sudden and massive impact of events like COVID-19. Moreover, if the method of this study is implemented, it will reinforce the candidacy of young graduates for specific job positions by allowing to train them with the right set of skills in the fast-changing job market. Consequently, this study will contribute in the achievement of SDG 8 goal that focuses on inclusive and sustainable economic growth through creating opportunities and provisioning productive employment and decent work for everyone. Specifically, this study can guide future researchers in implementing advanced machine learning techniques to identify and fill job skill gaps in various job sectors.

Additionally, this study will contribute to progress in the implementation of the “National Skills Development Policy” adopted in 2011 for increasing skills and employability of youth, women, and disadvantaged individuals. Besides, it is a known fact that transforming the disorganised and unproductive young people into a disciplined and productive workforce is a big challenge for many countries, especially for developing countries like Bangladesh, which is vulnerable to the consequences of the 4IR, mostly due to lack of preparation for such massive changes in skill development. Despite about two million new job creation yearly, educational institutions have been failing to reduce the huge skill gaps according to the demand of industries. Therefore, this study will help in identifying the emerging job skills in the national job market, which is most likely to create more skill gaps in the local industries due to fast change technology and automation in production and service.

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