Master's Thesis of Soohyun Lim

Effects of Artificial Intelligence on Korean Economic Growth
- from Human Resource Perspective -

휴먼 리소스 (Human Resource) 시각에서 본 인공지능이 한국 경제 성장에 미치는 영향

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Abstract

In the era of Artificial Intelligence (AI), human resources are one of the main issues which many people assume AI will destroy existing jobs by replacing human labor via automation or efficiency increases. In this matter, diverse research papers have argued that in reality, there are more jobs created than replaced due to the emergence and the spread of AI. However, still depending on industries as well as occupations, some occupations are decreased in terms of the number of employees, while others have decreased in proportion of total industry employees, even though the number of employees has increased. In this situation, this paper provides changes in human resources and employment between 2009 and 2019 specifically in Korea, starting from 2009 when the wide application of deep learning, which is the representative techniques of AI, was initiated. From the analysis based on the data of Korean employment from 2009 and 2019, this paper provides which designated industries are classified as AI industries as well as changes in terms of employment and proportions of industry. Also, it suggests that there is a positive relationship between the number of AI companies and the number of employees. Finally, it suggests a policy recommendation specifically focusing on AI jobs and further research based on the limitations of research.

Keyword: human resource, Artificial Intelligence (AI), employment, AI industries, industry changes, Korean economic growth

Abstract

인공지능 (AI) 시대에는 인공지능이 기존 직업을 자동화하거나 효율성을 높여 인력을 대체한다는 것이 인력시장의 주요 이슈 중 하나이다. 이와 관련하여, 다양한 연구들은 인공지능의 등장 및 보편화로 인해 대체되는 직업보다 새로운 직업이 더 많이 창출된다고 주장한다. 하지만, 여전히 산업 혹은 직업 성격에 따라 일부는 종사자 수가 감소하고, 다른 일부는 종사자 수가 증가하더라도 산업 전체에서 차지하는 비율이 감소하는 등 다양한 변화가 일어나고 있다. 이와 관련하여, 본 논문은 특히 인공지능의 대표적인 기술인 딥러닝(Deep Learning)의 적용이 본격적으로 시작된 2009 년부터 2019 년까지 한국 시장 내 인력 변화를 조사한다. 2009 년부터 2019 년까지 한국의 총 인력 데이터를 기반으로 분석한 결과, 본 논문은 어떠한 산업이 인공지능 산업으로 분류되며, 이에 따른 고용 및 산업 비중 변화가 있는지 제시한다. 또한, 산업 내 인공지능 기업 수가 늘어날 수록, 고용 인구가 늘어난다고 시사한다. 마지막으로, 본 연구 결과를 바탕으로 한 정책 제언과, 한계에 기반한 인공지능 직업에 초점을 맞춘 추가 연구를 제시한다.

키워드 : 인력, 인공지능 (AI), 고용, 인공지능 산업, 산업 변화, 한국 경제 성장

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Chapter One. Introduction

1.1. Research Background

Artificial Intelligence (AI) became a pivotal technology in terms of economic growth. Considering all of the potential influences, its effect on human resources is one of the controversial parts that many people are curious about. Does AI create or destroy jobs? Do people really have to prepare for upcoming destruction in the human resource market due to this new technology? According to (Gaskell, 2022), it foresees that AI actually disrupts the job market instead of destructing it. The introduction of AI was found to be 28.4% more likely to create jobs than similar investments in other technologies, while it was also 26% more likely to result in job destruction. Therefore, what appears from this research is that AI and its associated technology actually do disrupt the labor market with some of the occupations and others emerging. However, across the various fields, there are more jobs created than lost.

In this matter, it is important to compare this figure with other technological impacts in history. Does only AI have this impact on the job market? Was there any other technology which influenced significantly like AI before? According to (Autor, 2020), over 60% of the jobs of today did not exist a generation ago. Figure 1 indicated the evolution of jobs since 1940. According to this, with the changes in the employment share, out of the total 12 categories of occupation from 1940 to 2018, 7 categories have more than 60% of employees employed in the jobs that did not exist in 1940. Different jobs emerge and disappear, and this is not only the case related to AI. So, from this, we can assume that the job disruption has happened in history not only limited to AI, since technology development as a whole has led to an evolution of jobs by replacing previous ones and creating new.
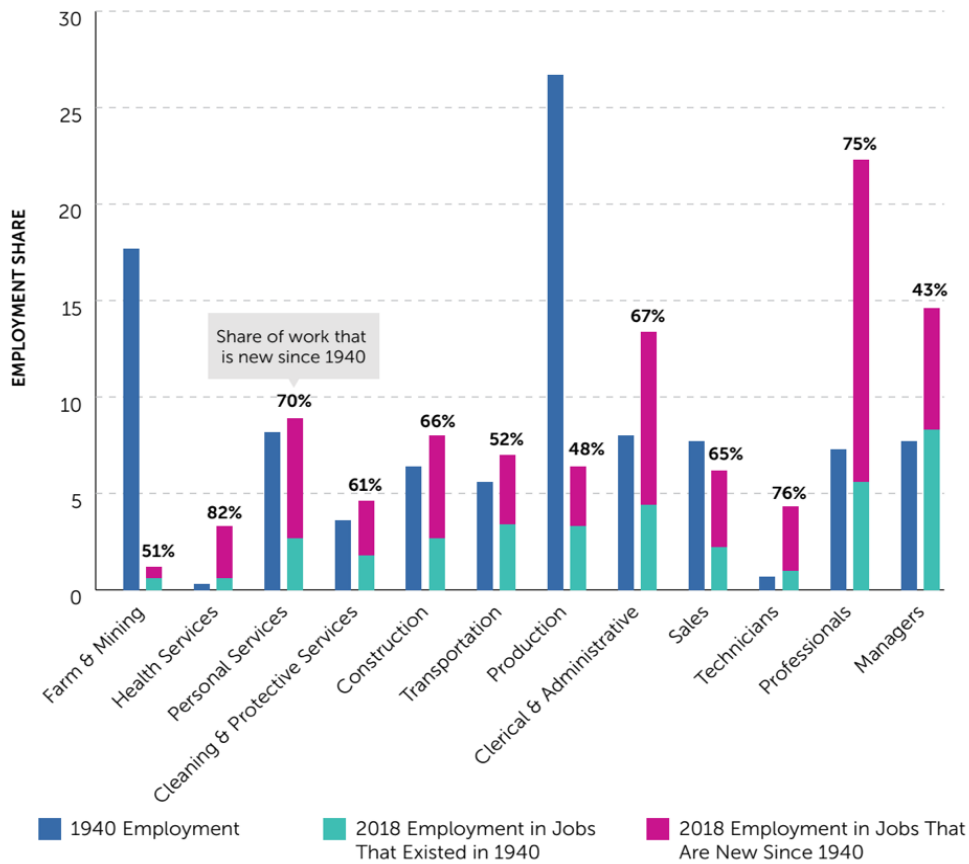
Figure 1. More than 60% of Jobs Done in 2018 Had Not Yet Been "Invented" in 1940, (Source: MIT Work of the Future, pp 10)

Different studies support the fact that in the era of AI, the number of jobs will be increased. Even though AI will automate some of the jobs based on the repetitive routine, according to (Hawksworth, 2018), it is proposed that job losses due to the automation will be offset by the emergence of new jobs, which is the result of an expanded economy from new technologies. Furthermore, according to the (World Economic Forum, 2020), by 2025, 97 million jobs will be created and 85 million jobs will be displaced. Figure 2 provides what kind of job roles are in the process of increasing demand and decreasing demand. For the jobs with increasing demand, Data Analysts and Scientists, AI and Machine Learning Specialists and Big Data Specialists are ranked in top positions. These high ranked jobs are specifically related to Data and AI, which directly indicate transition in human resources due to the technological development related to AI. For the jobs with decreasing demand, Data Entry Clerks, Administrative and Executive Secretaries and Accounting, Bookkeeping and Payroll Clerks

are ranked in top positions. These jobs are based on administrative work possibly replaced by automation via technology like AI. Based on these, we can conclude that in the era of AI, there will be a net increase in the number of jobs due to the expansion of AI related fields and the increasing need for human resources. However, jobs with decreasing demand are not directly related to the development of AI, which potentially gives the impression to employees in those fields that AI actually replaces human resources. The skewed pattern of changes in jobs on demand should be fully addressed and explicitly explained to make people aware that it is a trend that also happened in history with many other technological evolutions.

↗ Increasing demand		↘ Decreasing demand	
1	Data Analysts and Scientists	1	Data Entry Clerks
2	AI and Machine Learning Specialists	2	Administrative and Executive Secretaries
3	Big Data Specialists	3	Accounting, Bookkeeping and Payroll Clerks
4	Digital Marketing and Strategy Specialists	4	Accountants and Auditors
5	Process Automation Specialists	5	Assembly and Factory Workers
6	Business Development Professionals	6	Business Services and Administration Managers
7	Digital Transformation Specialists	7	Client Information and Customer Service Workers
8	Information Security Analysts	8	General and Operations Managers
9	Software and Applications Developers	9	Mechanics and Machinery Repairers
10	Internet of Things Specialists	10	Material-Recording and Stock-Keeping Clerks
11	Project Managers	11	Financial Analysts
12	Business Services and Administration Managers	12	Postal Service Clerks
13	Database and Network Professionals	13	Sales Rep., Wholesale and Manuf., Tech. and Sci.Products
14	Robotics Engineers	14	Relationship Managers
15	Strategic Advisors	15	Bank Tellers and Related Clerks
16	Management and Organization Analysts	16	Door-To-Door Sales, News and Street Vendors
17	FinTech Engineers	17	Electronics and Telecoms Installers and Repairers
18	Mechanics and Machinery Repairers	18	Human Resources Specialists
19	Organizational Development Specialists	19	Training and Development Specialists
20	Risk Management Specialists	20	Construction Laborers

Figure 2. Top 20 Job Roles Increasing and Decreasing Demand Across Industries
(Source: Future of Jobs Report 2020, pp 30)

In alignment with this, re-skilling of workers becomes one of the possible solutions. According to (Banina, 2022), the investment in AI actually contributed to a revenue increase of about 15%, by allowing firms to expand their business. The revenue growth also encourages firms to make further investments, such as human resources. From this, our future with AI technology has more room to help people develop the skills needed to do the jobs of today as well as tomorrow, while with more revenue produced, it also ensures jobs of high quality. According to the 2020 World Economic Forum, about 50% of all employees in the world will need reskilling by the year of 2025. From this, it

is expected that people currently having jobs with decreasing demands will receive reskilling to fully equip required skills following the job evolution.

1.2. Literature Review

According to (World Bank, 2023), Korea's research and development expenditure on Science and Technology as a % of GDP has been steadily increasing since 1996. In 1996, it was 2.3% and as of 2020, it has reached up to almost 5% of GDP; this shows that the Korean government considers investment in Science and Technology further required for the nation's future. Next, Korea's unemployment rate, according to (World Bank, 2023) in 2020 is 3.9%. Compared to the steady increase in Korea's research and development expenditure on Science and Technology, there have been fluctuations in unemployment rates since 1996. For example, in 1998, Korea was suffering from the financial crisis and the unemployment rate increased up to 7%. However, other than this period, it has stayed between 2.5% and 4.0%. As the OECD defines full employment when the unemployment rate is below 5%, Korea is the country with full employment for the last 20 years. To find out whether this figure is big or small, comparison with other countries' unemployment is necessary.
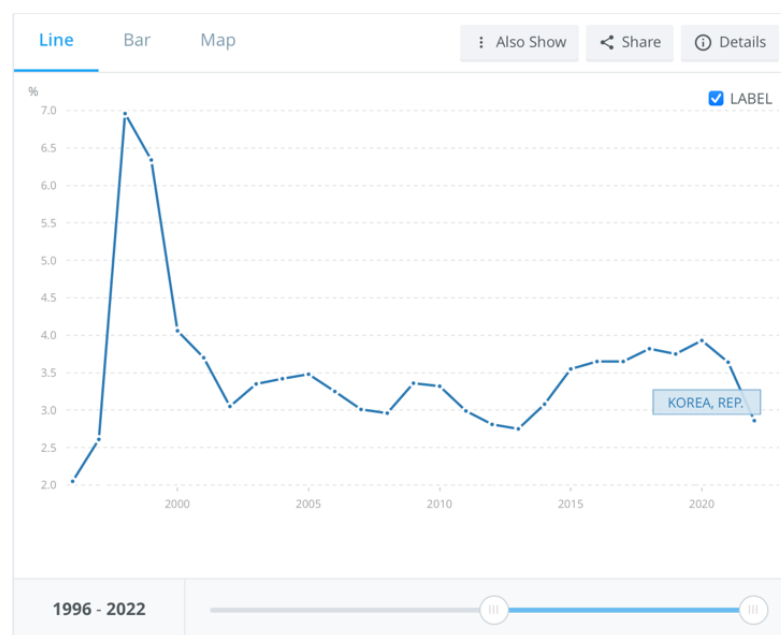
Figure 3. Unemployment, Total (% of Total Labor Force), Korea, Rep (Source: World Bank Indicator)

According to (Koseet, 2020), Korea's unemployment rate is below the average of the OECD countries. Figure 4 shows the selected OECD countries' unemployment rates from 1960 to 2020. Unemployment rates for selected countries stay around 5% except for the financial crisis in 2010 which were around 8%. From this comparison with other OECD countries, Korea does not have exceptional problems in terms of employment. However, the kinds of jobs are likely to change due to the fact that Korea's increase in investment in research and development for Science and Technology. In this regard, we can expect the number of employee changes across different job categories in Korea with increasing and decreasing labor demand.
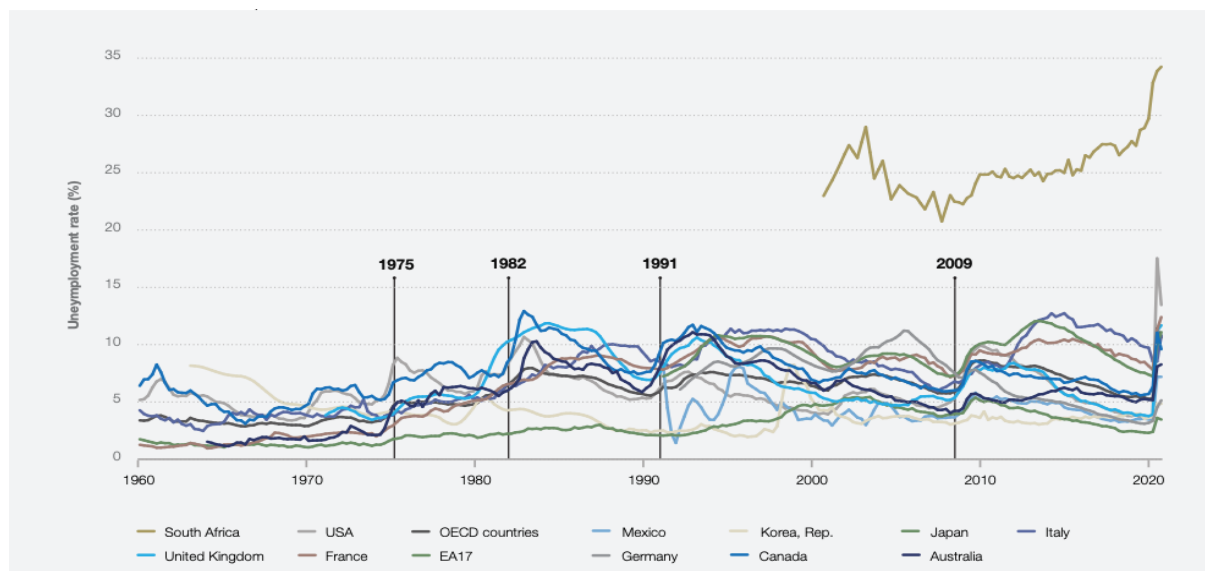
Figure 4. Unemployment, Selected Countries and Regions, 1960 − 2020
(Source: OECD Economic Outlook 2020, Statistics and Projections)

In 2020, according to (World Bank, 2023), Korea's high-technology exports were $164 billion. Although there was a huge decrease in 2019 due to COVID-19, Korea's export of high-technology has surely shown an increasing pattern since 2007. Regarding this, the Korean economy is strongly based on a technological foundation and the Korean government also aligns its investment in the field of Science and Technology. Therefore, it is expected to find relevant changes in terms of employment in the Korean context.

Along with this, (Korea Ministry of Employment and Labor, 2021) listed 55 jobs that emerged related to the Korean Digital New Deal. The Korean Digital New Deal is the government's initiative to promote digitalization through different technology implications and this is represented by the fields of AI, Big Data, 5G and IoT. Including human resource development, the Korean government currently implementing various policies to promote relevant industries.

Table 1. List of Korean New Deal Jobs (Source: Korea Employment Information Service)

No	Technology Category	Name of the Jobs
1	AR / VR	XR Graphic Designer
		XR Device Developer
		XR Client Developer
		XR Contents Manager
2	Space / City	3D Space Modeler
		Building Information Modeler
		Smart City Expert
		Intelligent Transportation System (ITS) expert
		Geographic Information System (GIS) expert
3	Data / AI / Software	Data Transaction Expert
		Database Engineer
		Data Labeler
		Data Analyst
		Data Scientist
		Data Engineer
		Data Consultant
		Bigdata Quality Manager
		Backend Developer
		Frontend Developer
		Blockchain Developer
		Business Intelligence Expert
		Application Software Developer
		AI Developer (engineer)
		AI Ethics Inspector
		Embedded System Developer
4	Digital Infrastructure	Smart Hardware Installer
		Ultra-High-Speed Communication Technician
5	Robotics / Drone / Car	Drone Technician
		Drone Pilot

		Drone Developer
		Service Robot Developer
		Medical Robot Developer
		Autonomous Car Technician
		Eco-friendly Autonomous Car Technician
		Collaborative Robot Teaching Engineer
6	Semiconductor	Intelligent Semiconductor Developer
7	Hygiene / Medical	3D Bioprinting Expert
		Smart Medical Devices Developer
		Smart Medical Devices Designer
8	Smartification, Automation	Smart Logistics System Expert
		Smart Logistics Operation Manager
		Smart Censor Developer
		Smart Farm Technician
		Smart Factory System Developer
		Smart Factory Management Technician
9	Safety	Smart Safety Designer / Operator
10	E-learning	Digital Learning Designer
		Digital Learning System Developer
		Digital Learning Operator
		Digital Learning Contents Developer
11	Information Security	Information Security Expert
12	Commerce / Marketing	IT Technology Management Consultant
		Digital Marketing Expert
13	Cloud / Platform	Cloud Engineer
		Cloud Consultant

Out of 55 jobs, table 2 is the list of AI jobs. There are 16 different jobs in AI and the figure below provides a detailed job description. From this table, specific duties as well as related fields in each occupation can be expected. The list of AI jobs is well aligned with figure 2 with jobs of increasing demand. Although the names of jobs in the Korean context can be different, high-ranking jobs in figure 2, such as Data Analysist and Scientist, AI and Machine Learning Specialist and Big Data Specialists are explicitly indicated within the job description in table 2. From this, we can expect that in the Korean context, AI jobs are more required, along with the development of AI and relevant technologies.

Table 2. List of AI Jobs (Source: Korea Employment Information Service)

No	Job Category	Job Description / Related Field
1	Data Transaction Expert	Business
	Data Transaction Experts assist data intermediaries or companies that hold data to sell and purchase data by connecting sellers and buyers, and facilitate data transactions. They evaluate the value as well as the quality of data on the data platform and operate the data transaction platform. They propose data-based products meeting the needs of companies as well as explain data solutions to clients for technical sales and marketing purposes.	
2	Database Engineer	Computer Science
	Database Engineers analyze and design the data, and establish pertinent database management systems. They review the data related to computerization tasks and examine technology, software and hardware components needed for information systems. Also, they review the entire process of establishment of an information system.	
3	Data Labeler	Linguistics
	Data labelers perform the task of pre-processing data including photo images, videos and sounds by tagging labels for objects, animals or specific words indicating the data characteristic. Their tasks assist AI to easily recognize the data for developing AI programs. For example, autonomous driving and natural language processing. The typical way of labeling is to tag explanations in existing data, but if there is no existing data, they also create qualitative data by taking photos or recording audio and labeling it.	
4	Data Analyst	Statistics, Business
	Data Analysts analyze and refine data, and then provide figures so that business and service designers can gain insight from them. They also conduct tests for user interface as well as service/product usability. Through analysis of datasets, they identify growth trends, and new opportunities as well as conduct data mining, analysis and visualization to produce reports for best practices. They evaluate the efficiency, related issues and inaccuracies of internal systems and perform tasks of data processing.	
5	Data Scientist	Mathematics, Statistics
	Data Scientists use AI technologies, including machine learning, and then analyze big data to extract useful information. This includes prediction of user behavior, which is usually utilized to improve products and services. Their work involves research, designing new statistical models for data analysis and implementing tasks for smarter business processes.	
6	Data Engineer	Computer Science
	Data Engineers construct data pipelines, implement data lakes and big data platforms to provide a foundation for data processing conveniently as well as securely. Through data utilization, they create systems to enable decision making in services and support advanced data analysis. By designing and establishing large data pipelines, they process data safely and utilize different applications for further data collection. They use programming for data processing.	
7	Data Consultant	Business
	Data Consultants build systems for data collection and establish strategies by analyzing collected data. They discover new opportunities in sales and business, conduct market	

	analysis, find competitors and plan business strategy. They are in charge of writing business proposals and presentation bids.	
8	Bigdata Quality Manager	Computer Science
	Bigdata Quality Managers enhance the quality of big data, through data standardization management, data quality diagnosis and data error management. They manage data in terms of completeness, uniqueness, validity, consistency and accuracy, as well as establish processes to ensure data is reliable quality.	
9	Backend Developer	Computer Science
	Backend Developers connect and develop new features within the same system to provide user system output correspondingly. Their scope of work is broad, ranging from development of applications, data analysis and developing distributed file systems and database management. They can also be in charge of server management as well as frontend development. They develop server components and features indirectly provided via frontend applications and systems.	
10	Frontend Developer	Computer Science
	Frontend Developers optimize interfaces and UI for easy usage. They decide structure as well as design, and further balance function and aesthetic design. They also adjust design for the best provision via smartphones. They control the maximum speed and scalability and develop UI with various markup languages.	
11	Blockchain Developer	Computer Science
	Blockchain Developers plan and develop blockchain technology-based services. They design and develop software through the application of blockchain technology to various information systems, including finance, payment and transportation. They establish the structure and framework of blockchain systems and design the necessary protocols.	
12	Business Intelligence Expert	Statistics, Business
	Business Intelligence Experts work on the task of collecting, integrating and analyzing complex data of customer information within the company and supporting the decision-making process. They customize Business Intelligence (BI) solutions like Tableau for a company's needs, simplify and visualize data as a form of dashboard. They also provide consulting services utilizing BI solutions.	
13	Application Software Developer	Computer Science
	Application Software Developers design software to be utilized in specific fields of computer systems. Application software varies depending on the needs of companies or individuals, which is heavily based on business and services. For this reason, they require having knowledge of functions as well as usability at the same time. They are responsible for the entire process of developing and managing application software, such as market research, design, implementation, evaluation, customer feedback and maintenance.	
14	AI Developer (engineer)	Computer Science
	AI Developers develop technology implementing AI algorithms or programs to make computers, robots or any other devices think and make decisions like human beings. Researchers develop algorithms or methodology for better performance. They perform	

	tasks such as creating AI integrated solutions, identifying key areas of business, setting priorities and analyzing AI and machine learning (ML) solutions.	
15	AI Ethics Inspector	Business, Computer Science
	AI Ethics Inspectors verify, inspect and certify the ethics and safety aspects of AI for the entire process of planning, designing, developing, launching and operating AI integrated products and services. They review and inspect the technical application of AI ethics and safety for AI products and services. They also evaluate whether AI ethics guidelines are well applied in the services and provide consulting for operation and monitoring. They write inspection results, improve lacking areas and provide certification. They provide education in need for product and service managers.	
16	Embedded System Developer	Computer Science
	Embedded System Developers develop embedded systems functioning tasks in specific products as added solutions or systems. They plan and analyze necessary software and develop device environments, design drivers and modules for communication among hardware components, develop modules for operating systems and perform maintenance through troubleshooting throughout the entire development process.	

With the understanding of AI jobs, it is important to consider the definition of AI and its application. According to (Coursera, 2023), the definition of AI is to use computer science and data, so the machine itself can solve problems. Within the boundaries of AI, machine learning exists. Machine learning is a study of computer systems which learn and adapt automatically based on experience, without explicit programming. Within the categories of machine learning, there is deep learning, which is a machine learning technique that layers the algorithms and computing units - or neurons - into artificial neural networks mimicking the human brain.
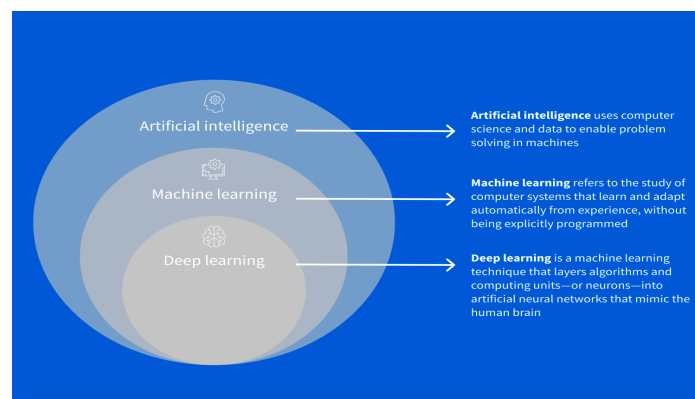
Figure 5. AI and its Sub-categories (Coursera, 2023)

Representative application in the field of machine learning is Siri. Machine learning incorporates different applications in diverse domains, but frequently used in image or voice recognition, email filtering or stock market trading. Compared to deep learning, machine learning is a heavily rule-based approach and it is pertinent to be applied with static data. Siri starts as an AI assistant to help users to find information or install relevant applications via conversation. First, it is developed as a rule-based approach, such as if certain speech is categorized as "weather request," it provides information or connects to related functions based on the recognized category.

Open AI's Chat GPT represents deep learning technology. Deep learning is used for understanding unstructured data and providing answers based on its judgment through probabilities calculation. Instead of finding answers based on the categorization of users' intent, it creates answers from the scratch. For this reason, this technique is well suited for language and image generation, chatbot or content recommendation. Chat GPT is based on deep learning, specifically based on the generative language model. GPT is the acronym for Generative Pre-trained Transformer. This model has the characteristics of its base model pre-trained with numerous data, and understands users' intent and generates answers based on its accumulated knowledge through pre-training. Therefore, deep learning is more similar to human's way of thinking by creating responses considering diverse external factors.

Autonomous driving incorporates machine learning and deep learning in diverse domains. For safe driving, censors should instantly understand external factors, such as cars passing nearby, proper speeds or right pathways to the designated points. For this reason, it must understand language, vision and sounds simultaneously with high accuracy to provide proper information to automobiles, so it can make the right decision instead of drivers. However, further development in autonomous driving is expected due to its heavy relation to safety and potential accidents caused by malfunctioning.

1.3. Research Question

This research aims for the analysis of the effect of AI in terms of changes in Korean human resources. Specifically, from a research background, AI, like many other technologies, will change the kinds of job and the number of employees with different needs. Due to the huge impact and wide application of AI, society will require more workers who can fit in for the new emerging fields. Based on this, this study will focus on finding changes in the number of employees for existing job classification in Korea from 2009 to 2019. And then, by re-arranging jobs to fit the classification of AI industries, it will analyze the changes in employment by answering the following research questions.

A. What kinds of jobs will be increased in terms of the number of employees in Korea?

B. If more people become employed, which AI industry will increase in terms of the number of employees?

C. Is there any relation between the number of AI companies and the number of employees?

Chapter Two. Research Methodology

2.1. Available Resources

According to (Korea Ministry of Employment and Labor, 2020), from 2012 to 2019, the kinds of jobs in Korea increased by 5,236. Out of this, 270 are newly created jobs. This is mainly contributed by the development of technologies, population changes as well as improvement of professionalism of previously existing jobs. Among the job categories, the number of jobs in research and engineering is 2nd which is right after the construction and production category. Considering the facts that construction and production categories can also be related to technology development, the impact on the human resource market can be more than expected.

In alignment with this, (Kim and Choi, 2021) provided 55 new jobs related to the Korean Digital New Deal in the field of AI, Big Data, 5G and IoT as indicated in table 1. Korean Digital New Deal is the government initiative for technological development and based on this, the list of jobs was selected based on five criteria.

1) When executing jobs, do people directly utilize digital skills or related knowledge? (More than 51% of their work)
2) Is there any specialization different from any other jobs?
3) Isn't this job temporary? Isn't the work range too small?
4) Do people need special training for the jobs?
5) Is an increase in the number of human resources expected in the field?

Next, domestic statistics from (Korea Statistical Information Service, 2023) about Job, Gender, Wage and Working Condition will be used to find the trend and changes of the number of Korean employment according to job categories. These statistics follow the 6th edition of Korean Standard

Classification of Occupation (KSCO) and provides the number of employees in each detailed occupation. By defining the periods for the analysis, this data will be the basis for analysis of Korean employment changes specifically due to AI.

Finally, (Software Policy and Research Institute, 2021) provides an AI status report based on survey data from AI companies in Korea. From this, categories of AI industry as well as the number of companies included in each industry will be utilized to find the relation with the number of employment in each occupation from the above. In this way, this research aims to find the impact of AI in terms of human resources in Korea.

2.2. Research Methodology

With the available resources, this research will take two different methodologies to find out first, the number of employed changes from 2009 to 2019 and second, whether this change actually relates to the AI development in Korea, focusing on designated AI industries.

First of all, this research will utilize the data and analyze whether there is any change in the number of employees in each occupation from 2009 to 2019. To define the period of analysis, the categories as well as the history of AI should be considered. Starting from 2009, deep learning flourished with the launch of ImageNet, a database of 14 million images of labelled for training neural nets, exclusively deep learning. From this period, various firms started to implement AI, specifically deep learning, in their business model. Therefore, this research will focus on the time period from 2009 to 2019, when deep learning started to flourish, and to 2019, when we can estimate what kind of AI industries as well as estimated numbers of companies existing in Korea.

This study will first find whether there is any trend in terms of the number of people employed during the period of introduction and the spread of AI. Second, after finding whether there are changes in the

number of people employed from 2009 to 2019, quantitative methodology will be taken. In terms of employment increases in Korea between 2009 and 2019, this research will estimate the number of people working in AI designated industries as of 2019 and find relations based on the regression analysis with AI industries especially focusing on the number of AI companies.

Chapter Three. Key Findings and Results

3.1. Key Findings

According to (Korea Statistical Information Service, 2023), the number of employed has been increasing since 2009. In 2009, it was 7,377,241, but as of 2019, 10,846,459. During ten years, 3,469,218 more people became employed and this is a 47% increase from 2009 to 2019. 2009 is the critical point in terms of AI due to the introduction and spread of deep learning technology, which makes AI become more capable of processing big data. From this, along with the population increase in Korea, recent technological development has contributed to the increase in the number of people employed. Figure 6 provides a trend in terms of the number of employed labors from 2009 to 2019, which supports the view that technological developments including AI contributed to the increase in terms of the number of people employed. From a literature review, we found that first, the Korean government investment in research and development has been consistently increasing and second, the unemployment rate stayed below 5% during this period, which means full employment. Therefore, a steady increase in the number of employed labors substantiates that technological development has a positive relation with the number of employees by creating more jobs or numerous job opportunities.
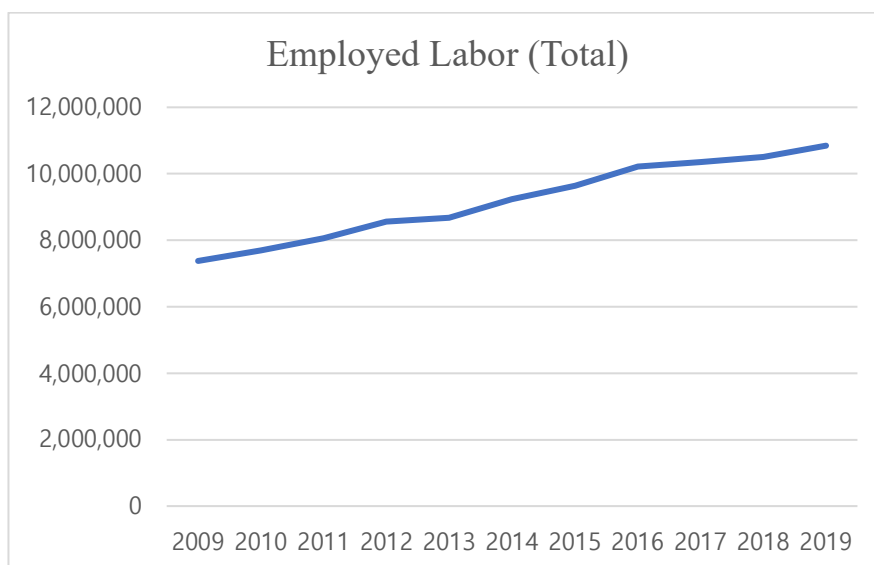
Figure 6. The Number of Employed from 2009 to 2019 in Korea

According to the 6th Korean Standard Classification of Occupations (KSCO), there are nine different job categories. The first category is people employed as manager roles. The second category is professionals and related workers, who require special training to do jobs in charge. Third is the clerks in different fields of industry. Next is the group of people employed as service workers. Followed by, people working as sales workers is the next. Skilled agricultural, forestry and fishery workers are indicated as the sixth category. Craft and related trades workers are the next. As the eighth category, a group of people employed as equipment, machine operating and assembly workers are followed. Finally, elementary workers are the last category who work without special training or education. Below figure provides a general trend of 9 different job categories from 2009 to 2019. Except Mangers (1), other 8 categories have shown an increasing pattern in terms of the number of employments.
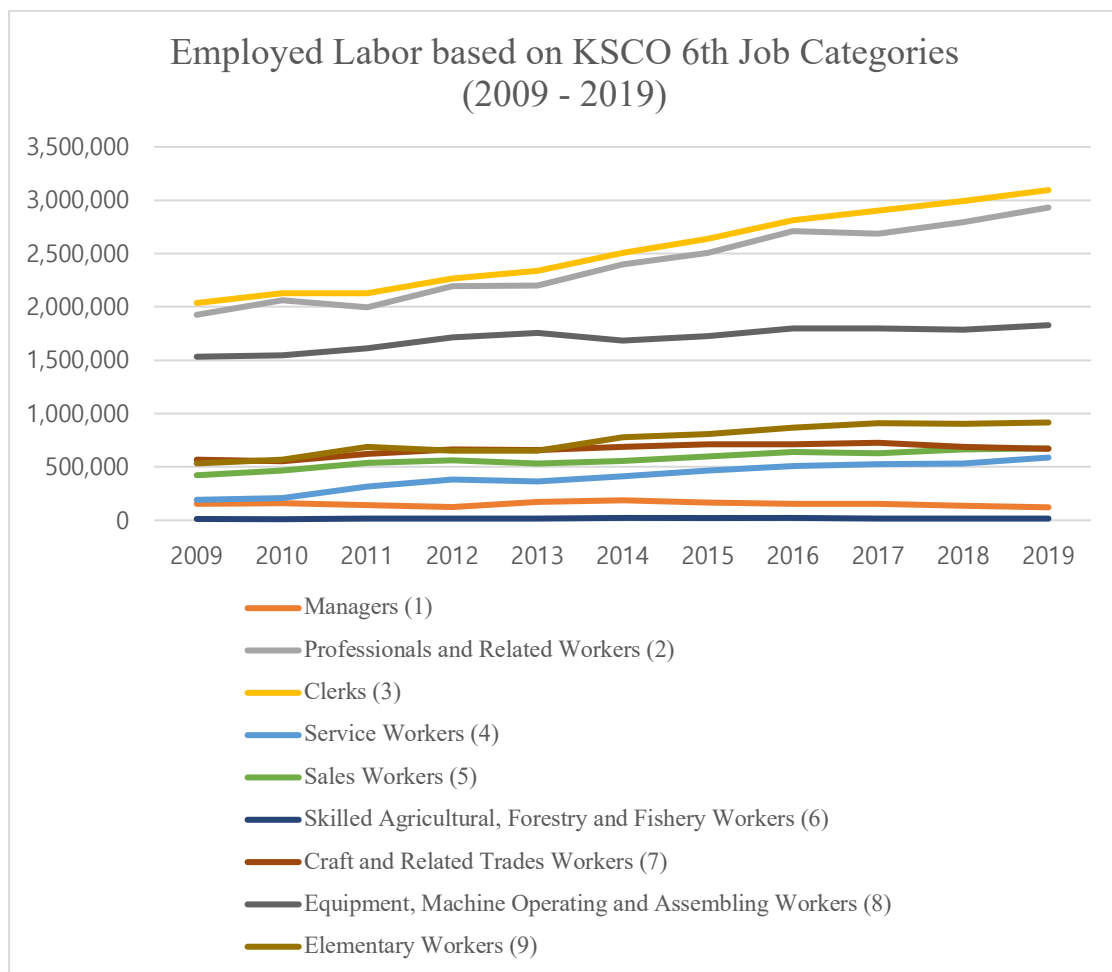
Figure 7. The Number of Employed based on KSCO 6th (2009 to 2019)

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Out of these nine categories, (4) Service Workers have been increased the most in terms of %. From 2009 to 2019, the number has been increased from 192,217 to 588,451 and this is a 206% increase. On the other hand, (1) Managers have been decreased the most in terms of %. The number has decreased from 151,921 to 121,887 from 2009 to 2019 and this is a 20% decrease. From this finding, we can estimate that recent technological development does not require a management role as much as before, while the service role, which has relatively more interaction with the customers, is much more required than previously.

Table 3. The Number of Employed based on Job Categories (2009 and 2019)

Korean Standard Classification of Occupations (KSCO 6th)	2009	2019	% Increase (2009 − 2019)
Total	7,377,241	10,846,459	+47%
Managers (1)	151,921	121,887	-20%
Professionals and Related Workers (2)	1,926,005	2,931,512	+52%
Clerks (3)	2,036,609	3,095,170	+52%
Service Workers (4)	192,217	588,451	+206%
Sales Workers (5)	422,399	674,223	+60%
Skilled Agricultural, Forestry and Fishery Workers (6)	12,601	18,395	+46%
Craft and Related Trades Workers (7)	568,562	670,844	+18%
Equipment, Machine Operating and Assembling Workers (8)	1,533,254	1,828,998	+19%
Elementary Workers (9)	533,672	916,979	+72%

In particular, it is important to focus on the reason behind that, even though all other job categories increase in the number of employees, the managers category shows a different pattern with a decreased number of employees. According to (Watkins, 2012), the global trends of fostering more

leaders instead of managers can explain this situation. Previously, management roles were required to organize, proceed and monitor required tasks, since the major goal of companies was to get work done, instead of heavy focus on innovation. Especially in Korea, rapid industrialization even up to the early 2000s expected employees to work designated tasks and follow the path of economic development of developed countries like the US as soon as possible. For this reason, numerous manager roles were required during the process to fully execute tasks and reach the goal within a short period of time.

However, with its membership in the OECD as well as classification as a developed country by UNCTAD, Korea is no longer a developing country. The transformation from a developing country to a developed country influenced numerous sectors, including employment. Now, with its recent technological development and firm economic standing on the globe, Korea requires more leaders who can provide visionary goals and lead innovation. At the same time, the development of different management solutions replaces the job of manager, especially those based on ensuring quality of production, such as scheduling tasks, designating deadlines or assigning work to relevant people. Based on the study from (Dixon, 2019), investment in robotics is associated with decreased number of managers. Introduction of robots with its AI technology contributes to the reduction of variance or human errors during production processes, by pertinently executing supervising roles. For this reason, firms are now in need of leaders who can think and make future decisions instead of managers who supervise and monitor the production process.

Based on the previous job categories, table 4 shows detailed jobs under each category as well as the number of people employed in 2009 and 2019. For some of the job categories, 2-digit codes of KSCO data were only available, while other categories included 3-digit codes of KSCO data with more detailed job description and the number of people. Along with this, a % difference in terms of the number of people employed between 2009 and 2019 is also indicated to overview changes during ten years.

Table 4. The Number of Employed on Detailed Job Categories (2009 and 2019)

Korean Standard Classification of Occupations (KSCO 6th)	2009	2019	% Increase (2009 − 2019)
Public and Corporate Senior Officials (11)	5,811	1,389	-76%
Administration Clerks (311)	17,073	3,957	-77%
Construction Structure Related Workers (771)	8,529	2,602	-69%
Factory Automation and Industrial Robot Operators (853)	16,346	5,079	-69%
Hairdressing, Wedding and Medical Assistance Service (42)	45,421	253,181	+457%
Door to Door, Street and Telecommunications Sales Related Workers (530)	31,994	126,490	+295%
Beverage Processing Machine Operators (812)	5,227	18,846	+261%
Domestic Chores and Infant Rearing Helpers (951)	2,521	29,516	+1071%

From this table, the job that increased the most in terms of % is (951) Domestic Chores and Infant Rearing Helpers. It has been increased from 2,521 to 29,516 between 2009 and 2019, which is a 1,071% increase. In line with this, other jobs related to service workers in general also show an increasing pattern. On the other hand, the job that decreased the most in % is (311) Administration Clerks. It has decreased from 17,073 to 3,957 between 2009 and 2019, and this is a 77% decrease. In alignment with this, other jobs related to managers in general also show a decreasing pattern. If we compare the jobs with the increase in % and the jobs with the decrease in %, the jobs with the decrease in % are more focused on specific jobs, while the jobs with the increase in % are more spread out across different fields. This is mainly due to not only the total number of people employed has been increasing from 2009 to 2019 but also technological development is applied in wide range of industries with certain industries replacing existing occupations. The full list of the number of employees in each job and the % changes from 2009 to 2019 is provided in appendix 2.

In specific, the jobs with the increase in % followed by (951) Domestic Chores and Infant Rearing Helpers are (42) Hairdressing, Wedding and Medical Assistance Service (+457%), (530) Door to Door, Street and Telecommunications Sales Related Workers (+295%) and (812) Beverage Processing Machine Operators (+261%). The jobs with the decrease in % followed by (311) Administration Clerks are (11) Public and Corporate Senior Officials (-76%), (771) Construction Structure Related Workers (-69%) and (853) Factory Automation and Industrial Robot Operators (-69%). From this finding, we can conclude that the service-related occupations as well as occupations related to the newly introduced technology have been increased the most. While the positions in terms of management and traditional fields of technology have decreased the most. In alignment with our previous findings, technological developments in recent years require more people related to services with higher levels of human interaction and new technology, and fewer people related to management and occupations, which can be easily replaced by automation, including administrative workers, operators and makers across different fields. Next, in-depth analysis of whether there is any relation with AI in terms of human resources change will be implemented.

According to (Software Policy and Research Institute, 2021), this is the list of 14 industries of 496 AI companies in Korea as of 2019 and 2020. This result is based on a survey of companies which are creating profits or expected future values based on their AI software, service or hardware. Multiple selections of industries were allowed and the table below shows what % and the number of AI companies are included in each industry. Furthermore, for better understanding, 100% total conversion was implemented. From this table, 1) Information and Communication, 2) Manufacturing, 3) Health Care and Social Welfare Services and 4) Finance and Insurance are where AI specific jobs are mostly concentrated, which consists of 63.6%. From this, the top 4 industries are where Korean AI companies concentrate on. This is due to the industry characteristics which specifically require AI and its application to process relevant data, since not every industry requires AI considering initial cost and return benefit. Application of AI is specifically beneficial to firms that possess large amounts of data and are in need of analysis to create further innovations.

Table 5. Industry Categories of AI Companies in Korea (2019-2020)

No	AI Industry Categories (2019 - 2020)	% (The number of Companies)	% Conversion (Total 100%)
1	Information and Communication	38.1 (188)	26.1
2	Manufacturing	23.8 (118)	16.3
3	Health Care and Social Welfare Services	16.1 (80)	11.1
4	Finance and Insurance	14.7 (73)	10.1
5	Agriculture, Forestry and Fisheries	13.3 (66)	9.1
6	Public Administration, Defense and Social Security Administration	12.5 (62)	8.6
7	Wholesale and Retail Industry	6.7 (33)	4.6
8	Education Services	6.3 (31)	4.3
9	Professional, Scientific and Technical Services	4.6 (23)	3.2
10	Transportation and Warehousing	4.0 (20)	2.7
11	Arts, Sports, and Leisure-related Services	1.6 (8)	1.1
12	Real Estate	1.2 (6)	0.8
13	Construction	0.6 (3)	0.4
14	Others	2.2 (11)	1.5
15	Total	145.7 (722)	100

Specifically, Information and Communication, and Manufacturing are two main industries that AI companies included. Considering the characteristics of industries, Information and Communication is heavily based on data processing through AI to provide accurate and pertinent information to service users. For example, SK telecom, which is the biggest telecommunication company in Korea, utilizes user's profile data upon the users' agreement including cell phone usage to provide personalized options through AI for call plans. In terms of the manufacturing industry, for example, Samsung, one

of the biggest manufacturers in the world for its cell phone and various home appliances, takes advantage of the application of AI within their hardware to provide customized options based on usage patterns. From this, there are specific industries which require the application of AI within their business model and consequently, skewed balance of the number of AI companies in each industry as above follows. In next session, in depth analysis to find whether there is a relation between the number of AI companies as well as the number of human resources based on the AI industry categories designated in table 5. This will provide further overview of how AI influences the human resources from the perspectives of industry.

Before that, according to previous analysis on job categories and AI industries, this table re-grouped occupations based on KSCO into designated AI industries in table 3. Re-grouping was undertaken based on the detailed job description indicated in KSCO 6th edition provided by Statistics Korea. Based on this grouping, the number of people employed as well as the proportion of % from the total in terms of number of employees in each group as of 2009 and 2019 are calculated. For the job categories possibly included in multiple groups, which are (312) Administration Related Clerks and (314) Secretaries and Assistant Clerks, the number of employees is not taken into account for calculation in this analysis. The full list of re-grouping with what kinds of occupations included in each AI industry category is provided in appendix 3.

Table 6. AI Industries and Detailed Job Categories (2009 and 2019)

No	AI Industry Categories	Employed 2009 (proportion %)	Employed 2019 (proportion %)	Employed Changes (%)	Proportion Changes (%)
1	Information and Communication	202,346 (3.3%)	338,230 (3.9%)	135,884 (67%)	+0.6
2	Manufacturing	1,464,539 (24.0%)	1,846,460 (21.2%)	381,921 (26%)	-2.8
3	Health Care and Social Welfare Services	641,892 (10.5%)	1,174,335 (13.5%)	532,443 (83%)	+3.0

4	Finance and Insurance	499,457 (8.2%)	532,597 (6.1%)	33,140 (7%)	-2.1
5	Agriculture, Forestry and Fisheries	14,640 (0.2%)	21,976 (0.3%)	7,336 (50%)	+0.0
6	Public Administration, Defense and Social Security Administration	135,892 (2.2%)	155,222 (1.8%)	19,330 (14%)	-0.5
7	Wholesale and Retail Industry	455,388 (7.5%)	695,445 (8.0%)	240,057 (53%)	+0.5
8	Education Services	205,460 (3.4%)	267,931 (3.1%)	62,471 (30%)	-0.3
9	Professional, Scientific and Technical Services	734,531 (12.0%)	1,004,702 (11.5%)	270,171 (37%)	-0.5
10	Transportation and Warehousing	584,673 (9.6%)	698,320 (8.0%)	113,647 (19%)	-1.6
11	Arts, Sports, and Leisure-related Services	245,199 (4.0%)	545,340 (6.2%)	300,141 (122%)	+2.2
12	Real Estate	483,692 (7.9%)	678,218 (7.8%)	194,526 (40%)	-0.1
13	Construction	220,445 (3.6%)	265,104 (3.0%)	44,659 (20%)	-0.6
14	Others	218,322 (3.6%)	501,779 (5.8%)	283,457 (130%)	+2.2
15	Total	6,106,476 (100%)	8,725,659 (100%)	2,619,183 (43%)	0.0

Along with the re-grouping of jobs within 14 AI industries, this table also indicates the number of employed changes in % at the last column as well as each industry's employees' proportion from total industry changes in % from 2009 to 2019. For both of the employed changes and proportion changes, 3) Health Care and Social Welfare Services, 11) Arts, Sports, and Leisure-related Services and 14) Others have been increased the most. This means that the number of employees as well as the proportions of employees in industry to the total number of employed are affected in a similar pattern.

For example, if the number of employees in 3) Health Care and Social Welfare Services increased by 83% from 2009 to 2019, the industry's proportion of the number of employees increased from 10.5% to 13.5%, which is a 3.0% increase. On the other hand, 2) Manufacturing, 4) Finance and Insurance and 10) Transportation and Warehousing have decreased the most.

Based on this analysis of the re-grouping of jobs and % changes in employment of each AI industry, the industries which are influenced the most share the characteristics of requirement of further human resources or replacement of human resources due to technological development. For example, 11) Arts, Sports, and Leisure-related Services requires a greater number of human employees to process responsible tasks in the job description. On the other hand, 2) Manufacturing requires fewer human resources to proceed designated jobs, potentially due to productivity increases from technological development or replacement of certain duties by automation based on AI. From this, the industry group of 3) Health Care and Social Welfare Services, 11) Arts, Sports, and Leisure-related Services and 14) Others need more human resources from 2009 and 2019 along with the technological development, while 2) Manufacturing, 4) Finance and Insurance and 10) Transportation and Warehousing need fewer human resources. Considering the characteristics of industry, the first group is heavily based on human interaction with the service customers, but the second group is based on routine tasks or automation, with productivity and efficiency increases as key factors when doing jobs.

In particular, 2) Manufacturing decreased the most in terms of industry's employees' proportion from total industry from 2009 to 2019. From table 5, we found that 2) Manufacturing is the industry category where many AI companies concentrate. However, interestingly, the industry's presence in terms of the employment has decreased during this period. We can conclude that 2) manufacturing is the industry which requires broad application of AI, so many AI companies are established in this field. However, in terms of human resources, it requires less compared to other industries. Therefore, in manufacturing, development and application of AI results in the decreasing demand of human

resources, and potentially, replacement of human resources by AI is the reason behind it. Referring to our previous analysis that the introduction of robotics equipped with AI actually replaces the manager roles of monitoring and ensuring product quality via human error decreases, manufacturing, which requires high maintenance in terms of product quality, can be affected the most in this employment transformation.

3.2. Results

From the previous analysis on AI companies and the employed changes in % between 2009 and 2019, this table organized data to show whether there is any influence on human resources due to AI as of 2019 and the regression analysis is implemented with (B) AI Companies (Number) as independent variables and (C) Employed 2019 (Number) as dependent variables. This is a hypothesis for this regression analysis.

(Hypothesis) The number of AI companies in 2019 has a positive relation with the number of employed in the same year, which means, if the number of AI companies is greater in certain industries, the number of employed is also greater than other industries.

Table 7. The Number of AI Companies and the Number of Employed (2019)

	(A)	(B)	(C)
No	Industry Categories	AI Companies (Number)	Employed 2019 (Number)
1	Information and Communication	188	338,230
2	Manufacturing	118	1,846,460
3	Health Care and Social Welfare Services	80	1,174,335
4	Finance and Insurance	73	532,597
5	Agriculture, Forestry and Fisheries	66	21,976
6	Public Administration, Defense and Social Security Administration	62	155,222
7	Wholesale and Retail Industry	33	695,445

8	Education Services	31	267,931
9	Professional, Scientific and Technical Services	23	1,004,702
10	Transportation and Warehousing	20	698,320
11	Arts, Sports, and Leisure-related Services	8	545,340
12	Real Estate	6	678,218
13	Construction	3	265,104
14	Others	11	501,779
15	Total	722	8,725,659

```
. reg C B

    Source |      SS           df       MS        Number of obs   =        15
-----------+----------------------------------    F(1, 13)        =    117.13
     Model | 5.7563e+13          1  5.7563e+13    Prob > F        =    0.0000
  Residual | 6.3886e+12         13  4.9143e+11    R-squared       =    0.9001
-----------+----------------------------------    Adj R-squared   =    0.8924
     Total | 6.3951e+13         14  4.5679e+12    Root MSE        =    7.0e+05

-----------------------------------------------------------------------------
         C | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-----------+-----------------------------------------------------------------
         B |   11251.66   1039.631     10.82   0.000     9005.675    13497.65
     _cons |   78035.25     206830      0.38   0.712    -368793.8    524864.3
-----------------------------------------------------------------------------
```

Figure 8. Regression Analysis based on **Table 7.**

As a result, regression analysis of (B) AI Companies (Number) as an independent variable and (C) Employed 2019 (Number) as a dependent variable is significant with a 0.90 R-squared value. So, the previous hypothesis that the number of AI companies in 2019 has a positive relation with the number of employed in the same year, is true, with 90% of the variance of the dependent variable explained by the variance of the independent variable. Also, from this regression, we can gain the regression equation of C = 11251.66 B + 78035.25 with a p-value of 0.000, which means that the result is significant. Therefore, we can conclude that if the number of AI companies is greater in a certain industry, the number of employed in that industry is also expected to be greater than other industries for the same year.

This finding is crucial to support the proposed idea that AI and its associated technology actually do disrupt the labor market, but across the various fields, there are more jobs created than lost. Previous

regression concluded that the greater number of AI companies in certain industry leads the greater number of human resources. At the same time, according to (Software Policy and Research Insitute, 2022), the average number of employees in Korean AI companies has increased from 229.6 people in 2020 to 253.7 people in 2022. This means that if we assume that the same number of AI companies exist in Korea, the number of employed labors in each AI company is increasing, which consequently result that the total number of employment increase. Considering these implications, the next section will be policy recommendation to pertinently address employment transformation due to AI.

Chapter Four. Policy Recommendation

4.1. Policy Recommendation

In regard to AI and employment, it is crucial to consider what is the right direction of government policies. There are three different directions in terms of policy development. First is research and development. For this, policies to support research and development in AI technologies, especially focusing on long-term investment can be recommended. Second, policies on AI education can be developed to address current needs of human resources in the AI sector. This is based on the provision of relevant education especially in elementary schools to foster younger generation equipped with relevant AI skills. Lastly, policies on employment can be considered. For this, re-skilling of workers to meet the requirements for jobs on AI as well as support AI companies which can accommodate human resources on AI and ensure good quality employment.

Korea has been implementing related policies since the previous term of Moon Jae-In government. In this period, however, various policies were suggested to focus on regulation of AI, for example, registration of laws, establishment of guidelines for AI use and data governance. Although it needs further analysis about the effect of related policies' impact on AI technologies, due to the periodic specificity of initiation of AI services provided by different firms, establishment of a foundation to properly incorporate AI within society was foremost expected. The current government of president Yoon Suk-yeol, however, has started to implement policies to promote further development of AI and broad application within different sectors in Korean society. In terms of research and development, it actively supports the expansion of strategic technology investment, including AI, to secure economic growth as well as national security. In terms of education, polices to incorporate AI within the existing curriculum to respond to digital transformation have become implemented. For example, development of the AI curriculum as well as the designation of special-purpose high schools to foster talent in AI are included as educational reform. Finally, fostering industry-driven talent development

is policy in regard to AI in terms of employment. Through this, the Korean government promotes the expansion of on-site AI education and re-skilling of employees in various industries, so they can do AI jobs with relevant skills.

Based on this study, still as the number of AI companies increases, the number of employees is also expected to increase. In this regard, governments can support the foundation of AI companies or transformation of existing companies to accommodate AI within their business model. However, according to (Smith, 1776), government intervention in the process of economic development is not recommended; instead of this, a self-regulating free market is more healthy form to fully incorporate self-interest and freedom of production and consumption, and achieve best interests with given conditions. Aligning with this, the Korean government should provide programs to educate entrepreneurs or employees for AI sectors, instead of monetary support, such as subsidies. Through this, more people can take advantage of equal opportunities to properly learn and equip their skills in executing AI jobs. In this regard, industry-led on-the-job training can be an efficient way to immediately address the issues of training required human resources within firms. In this way, more division of labor can be expected to increase efficiency and productivity by assigning the right human resources experienced in relevant training.

Adam Smith also believed that individuals possess a natural inclination to improve one's skills and enhance productivity. The group of people in this mind builds a collective drive for progress and contributes to the growth of a nation's output. At the same time, the number of productive workers increases with the efficiency enhancement through the utilization of improved tools, in this case, AI. He also suggested that capital investments in productive labors lead to greater presence of industry and this will result in a higher number of productive labor and increase the country's annual produce. The Korean government supports application of AI in various fields and this is a pertinent direction in this regard. This policy converges that the introduction of AI will increase the number of productive workers with efficiency enhancement.

In conclusion, first, the government should focus its investment in education on fostering entrepreneurs who can establish AI companies. Additionally, it should promote public and private collaboration to create a more market-oriented AI industry that operates within a free economy while ensuring access for everyone. Second, the introduction of AI in the market enhances productivity and leads to an increase in the number of productive employees and the growth of related industries. In such a scenario, the government should provide additional support to industries implementing on-site education programs for training and re-skilling employees. This approach will enable them to promptly address the challenges related to human resource requirements.

4.2. Limitation and Further Research

According to (Software Policy and Research Insitute, 2021), the total number of people who work in the field of AI in 2020 is 205,350. Furthermore, this report executed the survey of 933 companies and found out of a total 14,737 people with AI jobs and their job categories in 6 different groups based on their job responsibilities. The 6 groups are 1) AI Project Manager, who execute the jobs of managing AI projects including development, infrastructure establishment and service provision based on AI technology; 2) AI Consultant, who is in charge of business consulting to companies which are planning to incorporate AI technology within the business models; 3) AI Developer, who is in charge of engineering and coding of relevant programs to implement AI within the system for service provision; 4) AI System Operator, who makes sure AI system operation is executing without issues as well as develops programs for system operation; 5) Data Processing Manager, who labels required data for SI training and ensure data quality; 6) AI Data Analyst, who analyze AI based on the big data and based on the findings, devise data for proper training of AI.

With the grouping of AI jobs into 6 categories, this survey also provided the number of people for each group. From the total number of people participating in this survey, AI developer consists of 58%. So, about 60% of people who answered that they are working on AI jobs are AI developers, who

are in charge of development of AI programs, based on explicit programming to establish AI systems. Following this, Data Processing Manager consists of 13.4%. This is mainly due to the fact that for the development of an AI program, numerous data are required for pre-training as well as fine-tuning of the AI system, so the AI program can work well without less human intervention. Thirdly, AI Project Manager consists of 12.1%, since people managing AI projects are required to properly monitor AI program development.

<p align="center">Table 8. AI Jobs Group and AI Jobs based on Job Description</p>

No	Group	Job Categories	Number of People (%)
1	AI Project Manager	Data Transaction Expert	1,785 (12.1%)
		AI Ethics Inspector	
2	AI Consultant	Data Consultant	593 (4.0%)
		Business Intelligence Expert	
3	AI Developer	Backend Developer	8,544 (58.0%)
		Frontend Developer	
		Blockchain Developer	
		AI Developer (engineer)	
4	AI System Operation Manager	Database Engineer	854 (5.8%)
		Embedded System Developer	
		Application Software Developer	
5	Data Processing Manager	Data Labeler	1980 (13.4%)
		Bigdata Quality Manager	
6	AI Data Analyst	Data Scientist	981 (6.7%)
		Data Analyst	
		Data Engineer	
	Total		14,737 (100%)

Table 8 also included 16 AI jobs categorized in table 2. Based on 16 jobs' job description, this table indicates which specific AI jobs are included in which group. Furthermore, considering 14 AI Industry characteristics, additional research can be implemented by re-categorizing which industries encompass which group of AI jobs. However, the categorization of AI job groups within 14 industries requires active discussion among experts to agree on which jobs should be grouped under which category. In addition, the total number of people is very limited, so data collection through surveys should also be required. So, for further research, it is recommended that a targeted survey on AI jobs,

including their industries, job descriptions and the number of people currently working on a large scale, so it can represent the Korean human resource and employment specifically on AI.

In addition, up-to-date analysis on the period after 2020 can provide different results from this study. Due to the active application of AI and invention of new AI technology, which is the generative model represented by Chat GPT, different results can be found by disrupting higher degree in terms of human labor via technology. However, for this, data collection is further required to properly oversee the status of AI as well as its impact on the human resource market, considering international and global trends according to the expansion of new technology.

4.3. Conclusion

Since 2009, employment in Korea has increased significantly. This can be contributed not only by population increases but also by various factors including technological development. This research focuses on AI. One of the critical periods of AI is the spread of deep learning. As of 2009, diverse firms started to introduce AI within their business models and as a result, AI human resources were further required, including engineers, analysts and system operators. In this term, this research analyzed the period from 2009 to 2019 and found the occupation category of manager has decreased with its number of employments. This is due to the fact that AI can replace the roles of monitoring and ensuring product or service quality, which are commonly required by managers, with its strength on automation. Furthermore, the industries of 3) Health Care and Social Welfare Services and 11) Arts, Sports, and Leisure-related Services, the proportions from a total of 14 AI industries have been increased the most in employment. On the other hand, 2) Manufacturing and 4) Finance and Insurance have decreased the most. As the development of AI, the first group requires hands-on labor by humans, while the last group is possibly replaced by AI for automation or increased in terms of efficiency due to AI, which requires a lower proportion of human resources than previously.

Lastly, from regression analysis, we found out that as the number of AI companies increases in certain industries, the number of employees also increased as of 2019. This surely means that still, with the foundation of new AI companies, more human resources are required accordingly. Based on this, policy recommendations for fostering public and private cooperation to give learning opportunities to everyone is suggested. In our upcoming generation with AI as an indispensable technology, diverse changes in human resources are expected, such as creating and replacing existing occupations as well as industries. Therefore, further research on up-to-date data of AI and human resources should be analyzed to accurately expect the outcome of AI from a human resource perspective.

Appendix 1 − The Number of Employed based on KSCO 6th Categories (2009 to 2019)

KSCO 6th	2009	2010	2011	2012	2013
Total	7,377,241	7,698,676	8,067,180	8,569,535	8,683,949
Managers (1)	151,921	158,068	144,229	125,189	174,214
Professionals and Related Workers (2)	1,926,005	2,059,853	1,996,919	2,194,188	2,198,012
Clerks (3)	2,036,609	2,131,350	2,130,070	2,263,478	2,335,870
Service Workers (4)	192,217	207,495	317,881	380,751	362,592
Sales Workers (5)	422,399	463,531	536,379	560,490	529,769
Skilled Agricultural, Forestry and Fishery Workers (6)	12,601	12,930	14,784	14,468	14,996
Craft and Related Trades Workers (7)	568,562	553,640	620,686	662,797	657,487
Equipment, Machine Operating and Assembling Workers (8)	1,533,254	1,544,619	1,615,416	1,716,848	1,758,128
Elementary Workers (9)	533,672	567,189	690,816	651,326	652,881

2014	2015	2016	2017	2018	2019
9,227,229	9,643,688	10,221,341	10,353,783	10,510,220	10,846,459
187,604	168,928	154,903	157,284	134,314	121,887
2,395,666	2,505,970	2,708,528	2,685,896	2,794,873	2,931,512
2,507,705	2,637,204	2,812,925	2,900,568	2,991,450	3,095,170
410,083	466,281	506,965	527,626	533,283	588,451
554,484	598,207	639,769	630,791	664,783	674,223
20,354	21,458	19,985	16,734	16,473	18,395
690,334	711,721	710,310	726,753	685,561	670,844
1,682,734	1,726,432	1,797,204	1,797,780	1,787,236	1,828,998
778,264	807,488	870,752	910,351	902,247	916,979

Appendix 2 – The Number of Employed in Detailed Job Categories (2009 and 2019)

KSCO (6th)	2009	2019	% Difference (2009 – 2019)
Total	7,377,241	10,846,459	+47%
Managers (1)	151,921	121,887	-20%
Public and Corporate Senior Officials (11)	5,811	1,389	-76%
Administrative and Business Support Management Occupations (12)	43,771	37,488	-14%
Professional Service Management Occupations (13)	28,097	25,879	-8%
Construction, Electricity and Production Related Managers (14)	41,253	35,909	-13%
Sales and Customer Service Managers (15)	32,989	21,222	-36%
Professionals and Related Workers (2)	1,926,005	2,931,512	+52%
Science Professionals and Related Occupations (21)	32,511	48,144	+48%
Information and Communication Professionals and Technical Occupations (22)	202,346	338,230	+67%
Engineering Professionals and Technical Occupations (23)	626,863	873,058	+39%
Healthcare, Social Welfare, and Religious Related Occupations (24)	462,989	898,935	+94%
Education Professionals and Related Occupations (25)	205,460	267,931	+30%
Legal and Administration Professional. Occupations (26)	8,120	8,782	+8%
Business and Finance Professionals and Related Occupations (27)	265,635	297,645	+12%
Culture, Arts and Sports and Related Occupations (28)	122,082	198,786	+63%
Clerks (3)	2,036,609	3,095,170	+52%
Administration and Accounting Related Occupations (31)	1,590,020	2,522,247	+59%
Administration Clerks (311)	17,073	3,957	-77%
Administration Related Clerks (312)	1,174,984	2,028,482	+73%
Accounting Related Clerks (313)	309,865	389,087	+26%
Secretaries and Assistant Clerks (314)	88,098	100,722	+14%
Finance and Insurance Clerks (32)	233,822	234,952	0%
Finance and Insurance Related Clerks (320)	233,822	234,952	0%
Legal and Auditing Clerical Positions (33)	38,940	48,839	+25%
Legal and Inspection Clerks (330)	38,940	48,839	+25%
Consulting, Statistical and Information Clerks and Other Clerks (39)	173,827	289,131	+66%

Statistics Related Clerks (391)	1,361	968	-29%
Travel, Information and Reception. Clerks (392)	53,190	103,540	+95%
Customer Service and Workers n.e.c. (399)	119,276	184,624	+55%
Service Workers (4)	192,217	588,451	+206%
Police, Fire Fights and Security Related. Service Occupations (41)	17,521	36,622	+109%
Hairdressing, Wedding and Medical Assistance Service (42)	45,421	253,181	+457%
Transport and Leisure Services Occupations (43)	23,538	35,070	+49%
Cooking and Food Service Occupations (44)	105,736	263,579	+149%
Sales Workers (5)	422,399	674,223	+60%
Sales Occupations (51)	243,982	339,290	+39%
Sales Workers (510)	243,982	339,290	+39%
Store Sales Occupations (52)	146,423	208,443	+42%
Door to Door, Street and Telecommunication Sales Related Occupations (53)	31,994	126,490	+295%
Door to Door, Street and Telecommunications Sales Related Workers (530)	31,994	126,490	+295%
Skilled Agricultural, Forestry and Fishery Workers(6)	12,601	18,395	+46%
Agricultural, Livestock Related Skilled Occupations (61)	9,984	15,944	+60%
Skilled Forestry Occupations (62)	2,180	1,554	-29%
Forestry Related Workers (620)	2,180	1,554	-29%
Skilled Fishery Occupations (63)	437	897	+105%
Fishery Related Workers (630)	437	897	+105%
Craft and Related Trades Workers (7)	568,562	670,844	+18%
Food Processing Related Trades Occupations (71)	44,738	57,830	+29%
Food Processing Related Trades Workers (710)	44,738	57,830	+29%
Textile, Clothing and Leather Related Trade Occupations (72)	42,406	31,994	-25%
Textile and Leather Related Workers (721)	38,672	29,070	-25%
Garment Related Workers (722)	3,734	2,924	-22%
Wood and Furniture, Musical Instrument and Signboard Related Trade Occupations (73)	13,526	17,217	+27%
Wood and Furniture, Musical. Instrument and Signboard Related Trade Occupations (730)	13,526	17,217	+27%
Metal Coremakers Related Trade Occupations (74)	97,073	93,439	-4%

Die and Mold Makers, Metal Casting. Workers and Forge Hammersmiths (741)	43,048	31,800	-26%
Pipe and Sheet Metal Makers (742)	9,291	4,921	-47%
Welders (743)	44,734	56,718	+27%
Transport and Machine Related Trade Occupations (75)	141,417	177,031	+25%
Automobile Mechanics (751)	45,252	49,060	+8%
Transport Equipment Mechanics (752)	12,343	29,068	+136%
Machinery Equipment Fitters and Mechanics (753)	83,823	98,902	+18%
Electric and Electronic Related Trade Occupations (76)	75,287	101,451	+35%
Electric and Electronic Machine Fitters and Repairers (761)	32,197	42,963	+33%
Electrician (762)	43,090	58,488	+36%
Construction and Mining Related Trade Occupation (77)	71,750	93,918	+31%
Construction Structure Related Workers (771)	8,529	2,602	-69%
Construction Related Technical Workers (772)	23,330	31,286	+34%
Construction Finishing Related Technical Workers (773)	32,705	55,200	+69%
Mining and Civil Engineering Related Technical Workers (774)	7,186	4,829	-33%
Video and Telecommunications Equipment Related Occupations (78)	54,158	58,303	+8%
Video and Telecommunications. Equipment Related Fitters and Repairers (780)	54,158	58,303	+8%
Other Technical Occupations (79)	28,208	39,662	+41%
Handcraft Workers and Precious. Metalsmiths (791)	1,720	3,097	+80%
Plumbers (792)	17,100	24,201	+42%
Other Technical Workers (799)	9,388	12,364	+32%
Equipment, Machine Operating and Assembling Workers (8)	1,533,254	1,828,998	+19%
Food Processing Related Operating Occupations (81)	43,004	74,890	+74%
Food Processing Related Machine Operating Occupations (811)	29,807	39,546	+33%
Beverage Processing Machine Operators (812)	5,227	18,846	+261%
Other Food Processing Related Machine Operators (819)	7,970	16,498	+107%
Textile and Shoes Related Machine Operating Occupations (82)	54,361	47,257	-13%
Textile Production and Processing Machine Operators (821)	33,961	19,422	-43%

Textile and Shoe Related Machine Operators and Assemblers (822)	16,884	22,920	+36%
Laundry Related Machine Operators (823)	3,516	4,915	+40%
Chemical Related Machine Operating Occupations (83)	134,187	184,954	+38%
Petroleum and Chemical Material Processing Machine Operators (831)	21,584	33,269	+54%
Chemical, Rubber and Plastic Production Machine Operators (832)	112,603	151,685	+35%
Metal and Nonmetal Related Operator Occupations (84)	167,283	171,184	+2%
Metal Casting and Metal Processing Related Operators (841)	94,214	99,511	+6%
Painting and Coating Machine Operators (842)	38,184	30,616	-20%
Nonmetal Products Production Machine Operators (843)	34,885	41,057	+18%
Machinery Production and Related Machine Operators (85)	317,288	393,376	+24%
Machine Tool Operators (851)	117,247	179,034	+53%
Cooling and Heating Related Equipment Operators (852)	30,840	28,329	-8%
Factory Automation and Industrial Robot Operators (853)	16,346	5,079	-69%
Transport Vehicle and Machine Related Assemblers (854)	132,092	158,152	+20%
Metal Machinery Parts Assemblers (855)	20,763	22,781	+10%
Electrical and Electronic Related Machine Occupations (86)	329,419	382,537	+16%
Power Generation and Distribution Equipment Operators (861)	23,341	14,033	-40%
Electrical and Electronic Equipment Operators (862)	95,220	86,725	-9%
Electrical, Electronic Parts and Products Production Equipment Operators (863)	101,782	137,830	+35%
Electrical, Electronic Parts and Products Assembler (864)	109,076	143,949	+32%
Driving and Transport Related Occupations (87)	400,311	456,864	+14%
Locomotive Drivers (871)	7,633	14,226	+86%
Freight Train Director and Related Workers (872)	4,614	1,775	-62%
Automobile Drivers (873)	339,331	362,190	+7%
Handling Equipment Operators (874)	28,769	56,939	+98%
Construction and Mining Machines Operators (875)	14,184	16,260	+15%
Ship Deck Workers and Related Workers (876)	5,780	5,475	-5%

Water Treatment and Recycling Related Operating Occupation (88)	10,266	19,662	+92%
Water Treatment Plant Operators (881)	6,744	14,165	+110%
Recycling Machine and Incinerator Operators (882)	3,522	5,497	+56%
Wood, Printing and Other Machine Operating Occupations (89)	77,135	98,274	+27%
Wood and Paper Related Operators (891)	34,229	46,505	+36%
Print and Photo Development Related Machine Operators (892)	21,834	22,451	+3%
Other Production Related Machine Operators (899)	21,071	29,318	+39%
Water Treatment Plant Operators (881)	6,744	14,165	+110%
Elementary Workers (9)	533,672	916,979	+72%
Construction and Mining Related Elementary Occupations (91)	17,971	17,567	-2%
Transport Related Elementary Occupations (92)	57,127	80,685	+41%
Loading and Lifting Elementary Workers (921)	38,138	52,297	+37%
Deliverers (922)	18,990	28,388	+49%
Production Related Elementary Occupations (93)	105,646	234,185	+122%
Production Related Elementary. Workers (930)	105,646	234,185	+122%
Clean and Guard Related Elementary Occupations (94)	226,866	318,952	+41%
Cleaner and Sanitation Workers (941)	114,306	201,740	+76%
Guards and Ticket Examiners (942)	112,560	117,211	+4%
Household Chores and Cooking Attendants and Sales Related Elementary Workers (95)	94,184	212,155	+125%
Domestic Chores and Infant Rearing Helpers (951)	2,521	29,516	+1071%
Food Related Elementary Workers (952)	54,499	105,949	+94%
Sales Related Elementary Workers (953)	37,164	76,689	+106%
Agriculture, Forestry, Fishing and Other Service Elementary Occupations (99)	31,879	53,435	+68%
Agriculture, Forestry and Fishing Related Elementary Workers (991)	2,039	3,581	+76%
Meter Reading, Money Collecting and Parking Controlling Related Workers (992)	20,826	36,172	+74%
Other Service-Related Elementary Workers (999)	9,014	13,682	+52%

Appendix 3 – The Number of Employed in AI Industries based on Detailed Job Categories (2009 and 2019)

No	AI Industry	Detailed Jobs Categories	Employed in 2009 (%)	Employed in 2019 (%)
1	Information and Communication	Information and Communication Professionals and Technical Occupations (22)	202,346	338,230
		Total	202,346 (3.3%)	338,230 (3.9%)
2	Manufacturing	Food Processing Related Trades Workers (710)	44,738	57,830
		Textile and Leather Related Workers (721)	38,672	29,070
		Garment Related Workers (722)	3,734	2,924
		Wood and Furniture, Musical Instrument and Signboard Related Trade Occupations (730)	13,526	17,217
		Die and Mold Makers, Metal Casting Workers and Forge Hammersmiths (741)	43,048	31,800
		Pipe and Sheet Metal Makers (742)	9,291	4,921
		Welders (743)	44,734	56,718
		Handcraft Workers and Precious. Metalsmiths (791)	1,720	3,097
		Plumbers (792)	17,100	24,201
		Other Technical Workers (799)	9,388	12,364
		Food Processing Related Machine Operating Occupations (811)	29,807	39,546
		Beverage Processing Machine Operators (812)	5,227	18,846
		Other Food Processing Related Machine Operators (819)	7,970	16,498
		Textile Production and Processing Machine Operators (821)	33,961	19,422
		Textile and Shoe Related Machine Operators and Assemblers (822)	16,884	22,920
		Laundry Related Machine Operators (823)	3,516	4,915
		Petroleum and Chemical Material Processing Machine Operators (831)	21,584	33,269
		Chemical, Rubber and Plastic Production Machine Operators (832)	112,603	151,685
		Metal Casting and Metal Processing Related Operators (841)	94,214	99,511

		Painting and Coating Machine Operators (842)	38,184	30,616
		Nonmetal Products Production Machine Operators (843)	34,885	41,057
		Machine Tool Operators (851)	117,247	179,034
		Cooling and Heating Related Equipment Operators (852)	30,840	28,329
		Factory Automation and Industrial Robot Operators (853)	16,346	5,079
		Transport Vehicle and Machine Related Assemblers (854)	132,092	158,152
		Metal Machinery Parts Assemblers (855)	20,763	22,781
		Power Generation and Distribution Equipment Operators (861)	23,341	14,033
		Electrical and Electronic Equipment Operators (862)	95,220	86,725
		Electrical, Electronic Parts and Products Production Equipment Operators (863)	101,782	137,830
		Electrical, Electronic Parts and Products Assembler (864)	109,076	143,949
		Water Treatment Plant Operators (881)	6,744	14,165
		Recycling Machine and Incinerator Operators (882)	3,522	5,497
		Wood and Paper Related Operators (891)	34,229	46,505
		Print and Photo Development Related Machine Operators (892)	21,834	22,451
		Other Production Related Machine Operators (899)	21,071	29,318
		Production Related Elementary Workers (930)	105,646	234,185
		Total	1,464,539 (24.0%)	1,846,460 (21.2%)
3	Health Care and Social Welfare Services	Administrative and Business Support Management Occupations (12)	43,771	37,488
		Healthcare, Social Welfare, and Religious Related Occupations (24)	462,989	898,935
		Cleaner and Sanitation Workers (941)	114,306	201,740

		Meter Reading, Money Collecting and Parking Controlling Related Workers (992)	20,826	36,172
		Total	641,892 (10.5%)	1,174,335 (13.5%)
4	Finance and Insurance	Business and Finance Professionals and Related Occupations (27)	265,635	297,645
		Finance and Insurance Related Clerks (320)	233,822	234,952
		Total	499,457 (8.2%)	532,597 (6.1%)
5	Agriculture, Forestry and Fisheries	Agricultural, Livestock Related Skilled Occupations (61)	9,984	15,944
		Forestry Related Workers (620)	2,180	1,554
		Fishery Related Workers (630)	437	897
		Agriculture, Forestry and Fishing Related Elementary Workers (991)	2,039	3,581
		Total	14,640 (0.2%)	21,976 (0.3%)
6	Public Administration, Defense and Social Security Administration	Public and Corporate Senior Officials (11)	5,811	1,389
		Police, Fire Fights and Security Related Service Occupations (41)	17,521	36,622
		Guards and Ticket Examiners (942)	112,560	117,211
		Total	135,892 (2.2%)	155,222 (1.8%)
7	Wholesale and Retail Industry	Sales and Customer Service Managers (15)	32,989	21,222
		Sales Workers (510)	243,982	339,290
		Store Sales Occupations (52)	146,423	208,443
		Door to Door, Street and Telecommunications Sales Related Workers (530)	31,994	126,490
		Total	455,388 (7.5%)	695,445 (8.0%)
8	Education Services	Education Professionals and Related Occupations (25)	205,460	267,931
		Total	205,460 (3.4%)	267,931 (3.1%)
9	Professional, Scientific and Technical Services	Professional Service Management Occupations (13)	28,097	25,879
		Science Professionals and Related Occupations (21)	32,511	48,144
		Engineering Professionals and Technical Occupations (23)	626,863	873,058
		Legal and Administration Professional Occupations (26)	8,120	8,782

		Legal and Inspection Clerks (330)	38,940	48,839
		Total	734,531 (12.0%)	1,004,702 (11.5%)
10	Transportation and Warehousing	Automobile Mechanics (751)	45,252	49,060
		Transport Equipment Mechanics (752)	12,343	29,068
		Machinery Equipment Fitters and Mechanics (753)	83,823	98,902
		Locomotive Drivers (871)	7,633	14,226
		Freight Train Director and Related Workers (872)	4,614	1,775
		Automobile Drivers (873)	339,331	362,190
		Handling Equipment Operators (874)	28,769	56,939
		Ship Deck Workers and Related Workers (876)	5,780	5,475
		Loading and Lifting Elementary Workers (921)	38,138	52,297
		Deliverers (922)	18,990	28,388
		Total	584,673 (9.6%)	698,320 (8.0%)
11	Arts, Sports, and Leisure-related Services	Culture, Arts and Sports and Related Occupations (28)	122,082	198,786
		Hairdressing, Wedding and Medical Assistance Service (42)	45,421	253,181
		Transport and Leisure Services Occupations (43)	23,538	35,070
		Video and Telecommunications Equipment Related Fitters and Repairers (780)	54,158	58,303
		Total	245,199 (4.0%)	545,340 (6.2%)
12	Real Estate	Accounting Related Clerks (313)	309,865	389,087
		Consulting, Statistical and Information Clerks and Other Clerks (39)	173,827	289,131
		Total	483,692 (7.9%)	678,218 (7.8%)
13	Construction	Construction, Electricity and Production Related Managers (14)	41,253	35,909
		Electric and Electronic Machine Fitters and Repairers (761)	32,197	42,963
		Electrician (762)	43,090	58,488
		Construction Structure Related Workers (771)	8,529	2,602
		Construction Related Technical Workers (772)	23,330	31,286
		Construction Finishing Related Technical Workers (773)	32,705	55,200
		Mining and Civil Engineering Related Technical Workers (774)	7,186	4,829

		Construction and Mining Machines Operators (875)	14,184	16,260
		Construction and Mining Related Elementary Occupations (91)	17,971	17,567
		Total	220,445 (3.6%)	265,104 (3.0%)
14	Others	Cooking and Food Service Occupations (44)	105,736	263,579
		Other Technical Workers (799)	9,388	12,364
		Domestic Chores and Infant Rearing Helpers (951)	2,521	29,516
		Food Related Elementary Workers (952)	54,499	105,949
		Sales Related Elementary Workers (953)	37,164	76,689
		Other Service-Related Elementary Workers (999)	9,014	13,682
		Total	218,322 (3.6%)	501,779 (5.8%)
15	Total		6,106,476 (100%)	8,725,659 (100%)

References

Adam Smith (1776). "An Inquiry into the Nature and Causes of the Wealth of Nations"

Choi and Kim. (2021). "Digital New Deal Jobs and Future Skills." Korea Employment Information Service.

Coursera (2023). "Deep Learning vs. Machine Learning: Beginner's Guide." Coursera Data: https://www.coursera.org/articles/ai-vs-deep-learning-vs-machine-learning-beginners-guide

David Autor, David Mindell, Elisabeth Reynolds. (2020). "The Work of the Future: Building Better Jobs in an Age of Intelligent Machines." MIT Work of the Future.

Gaskell Adi. (2022). "AI Create Job Disruption But Not Job Destruction." Forbes Careers.

Jay DixonHong, Lynn WuBryan. (2019). The Robot Revolution: Managerial and Employment Consequences for Firms. (pg 10-11). SSRN.

John Hawksworth, BerrimanRichard. (2018). "Will Robots Really Steal our Jobs?" pwc Economics.

Korea Employment Information Service. (2021). "Digital New Deal Jobs and Future Skill."

Korea Ministry of Employment and Labor. (2020). "Korean Dictionary of Occupation." Korea Employment Information Service.

Korean Statistical Information Service (2023). "Job, Gender, Wage and Working Condition." Domestic Statistics: https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1ES3A07S&vw_cd=MT_ZTITLE&list_id=B19_EQ13_1&scrId=&seqNo=&lang_mode=ko&obj_var_id=&itm_id=&conn_path=MT_ZTITLE&path=%252FstatisticsList%252FstatisticsListIndex.do

Koseet al.M.Ayhan,. (2020). "Statistics and Projections, Unemployment Rate, Selected Countries and Regions, 1960 -2020." OECD Economic Outlook.

Software Policy and Research Insitute, (2021, 2022). "AI Status Report."

Tania Banina, Anastassia Fedyk, Alex Xi He, James Hodson. (2022). Artificial Intelligence, Firm Growth and Product Innovation.

Watkins D.Michael. (2012). How Managers Become Leaders. "Harvard Business Review",

https://hbr.org/2012/06/how-managers-become-leaders.

World Bank. "High-technology Exports (Current $), Republic of Korea". World Bank Indicator:

https://data.worldbank.org/indicator/TX.VAL.TECH.CD?locations=KR

World Bank. "R&D Expenditure in Science and Technology (% of GDP), Republic of Korea". World

Bank Indicator: https://data.worldbank.org/topic/science-and-technology?locations=KR-AD

World Bank. "Unemployment Total (% of Total Labor Force), Republic of Korea". World Bank

Indicator: https://data.worldbank.org/indicator/SL.UEM.TOTL.NE.ZS?locations=KR

World Economic Forum (2020). "The Future of Jobs Report."