Development and Applicability of NCS-based Job Matching Algorithm: Korean Youth Labor Market

Jaehyung Cho, Yeoungil Lee, Jungpo Kim, Seungbum Lee

Abstract Background/Objectives: Youth unemployment has been such a serious matter in Korea for years and, to respond to this matter, several initiatives have been developed and implemented. Notably, job mismatching as a form of unemployment or underemployment for graduates of colleges and universities is continuously happening.

Methods/Statistical analysis: To address job mismatch as a social problem, colleges and universities are asked to focus on competency-based learning; as a result, the National Competency Standards (NCS) was developed so that higher education can strategically strengthen and implement more career-focused curriculum and practical experiences in order to solve the youth unemployment problem. The purpose of this study is to develop a strategic plan that can solve youth unemployment problem in a Korean labor market.

Findings: To do so, this study develops an algorithm that presents the most optimal job match between competencies of a job seeker (n) and competencies of an employer (m). In addition, this study will discuss a job matching system based on the algorithm for practical usage. This study standardized NCS-based competencies and proved that this system can be practically utilized to identify multiple job seekers for the company.

Improvements/Applications: Calculating and producing weights through the MADM algorithm is particularly helpful in identifying a pool of job seekers for the companies, which will increase the probability of successful hiring/finding a job in the labor market.

Keywords:Youth unemployment, Job matching system, Multi-attribute decision making(MADM), National Competency Standards(NCS)

I. INTRODUCTION

Due to the prolonged recession that affects the global economy, youth unemployment has recently been a serious economic and social problem in Korea. According to Statistics Korea [1], the unemployment rate for youth between the ages of 15 and 29 is 11.6%, which hit a record high in 2017, and the unemployment rate for youth between the ages of 25 and 29 stood at 10.5%.So much analysis has been done to understand the causes and determinants of youth unemployment by considering a supply and demand model. It can be argued that the slow economic climate and, thus, slow recovery lead to low job creation in the market. As a result, overeducation of young job seekers, which is a by-product of the long recession, created a situation where graduates of colleges and universities avoid a certain job category known as 3D (difficult, dirty, dangerous). Therefore, overeducated young job seeks face a doubly challenging job market situation where they not only seek a job but also, very selectively, consider good paying jobs for their careers. According to previous studies, this is the naturally anticipated situation where people with higher educational and, thus occupational skills demand high compensation matched with their knowledgebase and skill sets [2].

Given challenges stemming from youth unemployment, higher education in Korea has been trying to develop strategic ways to better respond to the challenges for years. Specifically, as Korean government requires reform of thecurrent higher education system to be more training-oriented and competency-based [3,4]the national standard of competencies (NCS) was developed so that duties and tasks as well as knowledge-base required by industrial sectors to understand work function are systematically presented to job seekers [4]

Accordingly, the purpose of this study is, broadly speaking, to discuss whether or not NCS-based learning could address youth unemployment in the Korean youth labor market. This study suggests NCS-based job matching between a job seeker (n) and company (m). To be specific, this study considers it as a standard assignment problem where it solves the job matching problem by assigning m jobs to n individual job seekers in a way that can minimize job hiring/ findingcosts and maximize values of job matching [5,6]. This study uses soft matching criterion as opposed to hard matching which considers only perfect match; that way, assignment problem can be better addressed with relaxation of hard matching between n and m.

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II. REASONS FOR JOB MISMATCH IN KOREA

In the academic field of the labor force, job mismatching as a form of either underemployment or unemployment has been an important subject matter, especially during economic hardship. Clogg et. al(1984), for instance, identified reasons for job mismatch and noted an increased influx of college students trying to enter into a labor market when the market was not ready or capable of absorbing them as a reason for prevalence of job mismatch in society [9]. Job mismatching is commonly witnessed for young job seekers, especially, when college and university graduates try to enter into the labor market in a situation where no more newly created jobs are added in a market structure and/or system[9,10]. Partially because of that, previous research has focused on overeducation[11,12,13,14]. as a reason for job mismatching. While overedcuation does play a role in job mismatch in a Korean youth labor market, additional unique considerations stemming from traditional social values have to be also considered.

As job mismatching is becoming increasingly noticeable, understanding a structural problem in youth unemployment is much needed so that strategic planning can be developed. While previous researchshowed that job mismatching was a common social problembetween the 1960s and 1970s in the U.S due to demographic and technological changes in society and, additionally labor market structural changes [15], still, job mismatching is observed globally in many different industry sectors in today's society [16,17]. The problem of job mismatching in the Korean labor market that negatively affects youth unemployment is not an exception from that trend[7].

According to Korean Educational Development Institute(2015)[8], there are very strong preferences exhibited to certain jobs by college and university graduates. [Table 1] shows the result of data analysis from the KRIVET. For instance, males who graduated from a 4-year university only prefer full-time jobs (70.2%), do not prefer certain jobs with irregular work schedule (62%), and only prefer jobs with convenient commute (60.6%). Females who have a degree from a 4-year university do not prefer certain jobs with an irregular work schedule (79.4%), only prefer jobs with convenient commute (76.3%), and only prefer jobs with five working days (Monday to Friday) (71.5%).

Table 1. Job preference by gender/ types of higher education graduates(KEDI, 2015)

Items	2-year college graduates		4 year-university graduates		Total	
	Male	Female	Male	Female	Male	Female
Prefer job nearby Seoul	23.7	39.1	23.5	35.2	23.6	36.8
Prefer job in Gangnam District*	4	2.1	1.2	3.1	2.5	2.7
Prefer job in city	26.7	40.7	33.3	45.8	30.3	43.7
Prefer job with job security	17.6	27.6	30.7	40.6	24.7	35.3
Prefer job with SMFs*	8.8	8.2	19.6	16.8	14.7	13.3
Prefer chaebol* or transnational company	6.9	4.6	13.9	9.2	10.7	7.3
Prefer job with public institution	6.7	4.2	10.8	11.9	8.9	8.8
Not prefer job with hard labor	25.9	51.3	34.2	55.6	30.4	53.8
Prefer job that matches with education level	26	43.8	44.2	60.2	35.9	53.6
Prefer job that matches with major in college/university	25.4	31	31.4	37.1	28.6	34.6
Prefer full time job	63.3	64.6	70.2	67	67	66
Prefer office job	16.4	26.3	25.7	38.9	21.4	33.8
Prefer job with 5 working days only	45.7	65.7	53.3	71.5	49.8	69.1
Prefer job with easy commute	56	80.3	60.6	76.3	58.5	77.9
Not prefer jobs with irregular working hours	59.6	80.5	62	79.4	60.9	79.8
N	468	634	556	925	1,025	1,558

*Gangnam District is a part of southern region in Seoul where it is known for affluent, luxurious, and glamorous life style.
*SMFs indicates small & medium sized firms.
*Chaebol is a large business conglomerate.

III. JOB MATCHINGALGORITHM

In this study, a single unit of transaction postulates that one company has more than n job seekers applying for thatcompany. In nature, however, a job market is comprised of multiple units where there are multiple companies looking for their favorite employees and multiple job seekers applying for one company almost at the same time. Therefore, like in any labor

market, this study hypothesizes that there is much competition among m companies and among n job seekers.It has to be noted that there is always a set of costs,both tangible and intangible, incurred due to the competition among job seekers (e.g., applying costs) as well as companies (e.g., hiring costs) in the labor market. Thus, this study assumes that the most optional model is to reduce overall costs for both job seekers and companies by minimizing a possible number of transactions.

That is, this study considers assignment problems based on the notion of how to match a n to a m. From a company's standpoint, they have to hire their favorite employee(s) out of n job seekers, and failure to hire on schedule will financially hurt the company both financially and non-financially. In the same vein, the job seekers make an effort to minimize the costs to find a job (e.g., applying for a job, getting ready for interview, spending time for research the companies). These assignment problems are viewed as the n*m situation, and this study is to develop the most optimal algorithm for the n*m situation. The 'most optimal' is developed through the algorithm where nindividual job seeker will be matched with m company in order based on NCS-driven criteria, which are the competencies required by a company to perform the job.Also assuming each company is to hire a given number of employees, this study assumed that one labor market's overall costs for finding a job can be depicted like the following:

$$Min \sum_{i=1}^{s} \sum_{j=1}^{n} \sum_{k=1}^{n_j} (mc_{ijk}^{s} + fc_{ijk}^{s} + tard_{j}^{s} \times T_{ijk}^{s}) x_{ikj} \quad (1)$$

X_{ikj} : if company i take on a new employee k for duty j, it becomes 1, otherwise 0

S : the number of companies

n: the number of duties

n_j : the number of employees for duty j

mc_{ijk}^{s}: company's hiring cost for the duty j

fc_{ijk}^{s} : job seeker's finding a job cost for the duty j

$tard_{j}^{s}$: company's marginal tardiness employment cost for duty j

T_{ijk}^{s}: with regard to company i's employment of the duty j, the interval between its hiring date and the employment completion date

So it is the sum of hiring costs from each company, finding a job cost from each job seeker, and additional costs when hired later than original hiring date. A particularly important

assumption in this algorithm is a competitive structure of a labor market. That is to say, it is natural to see a situation where there are only a few companies simultaneously hiring that many job seekers prefer (e.g., reputation/paying/pension/job security of company). Yet, only a selected few found jobs in the companies that many job seekers prefer in a competitive structure of labor market. In the same vein, only few companies found their favorite employees in a competitive structure of labor market. From a global viewpoint, a company can minimize hiring costs when they open the hiring only with few job seekers whose competencies well match with competencies required for the job. The same logic can be made for the job seekers. If the job seekers are aware of the companies that fit well with his/her competencies, finding job costs can be much reduced by only applying for certain companies. Also companies, in nature, could receive rejections from their favorite potential employees because these employees may have other offers from other competitor companies, thus, the companies have to make an offer to next available potential employee [18].

IV. JOB MATCHING ALGORITHM MODEL DEVELOPMENT

4.1 *Definition of Job matching factors and evaluation*

This study argues that effective job matching is needed to minimize costs for both finding andhiring in a labor market while satisfying both of them for their transactions in the labor market. To do so, a job matching algorithm was developed, and this study will operationally define:

job seekers (*n*) = seniors at one university

companies (*m*) = firms recruiting/hiring seniors from the university

[Table 2] shows job matching factors and evaluation for the algorithm. Job seekers and companies are given an opportunity to rank their own preferences (high(H)/medium(M)/low(L)) during a job search process so that it easily presents a match between two. It has two different categories: NCS competencies and individual preferences. Individual preferences were considered because assignment problems are generally accompanied by several kinds of input such as different decision making factors related to a certain situation [5]. Given that this study adds a range of salary and location of company as measured by commute range, which are two factors that are perceived as important by job seekers in Korea.

Table2. Job matching factors and evaluation

Category	Matching Factors	Matching Evaluation Criteria
NCS Competencies	Major at university	When there is match: - Weight (1.2) * GPA * Preference (H/M/L)
	Extra-curricular activities	When there is match: - Weight (1.0) * Duration (Months) * Preference (H/M/L)

	Competencies	When there is match - Weight (0.7) * NCS-based competency points * Preference (H/M/L)
Individual Preferences	Salary	Difference in desired salary between the job seeker vs company - High: <5,000,000 won* - Medium: <10,000,000 won - Low: <20,000,000 won
	Location of company	Within commute range - High: Commute by public transportation (bus or subway) - Medium: Commute by driving or taxi Not within commute range - Low: Out of commute range

*Won: Currency of Korea. 1,000 won is about $8.95 (USD) as of September 2018.

Given that nature of job finding and hiring requires multi-level and multi-faceted information for job matching, multi-attribute decision making (MADM) is needed [19]. While other multi criteria decision making methods are available such as the Analytic Hierarchy Process [20,21], multi attribute utility theory [22], or goal programming [23,24], this study used MADM as it can provide a way to compare attributes that have different yet conflicting criteria so that the most satisfying decision can be produced through weights [19].

4.2. Developing job matching search system

A framework of the job matching search system is to provide a job seeker with an opportunity to provide and update his/her job matching factors in a digital portfolio that can be accessed and shared with companies that host recruiting/ hiring events at the university. The framework of the job matching search system is illustrated below in [Figure 1]. This framework is comprised of three main functions: a) there is a database where information about job seekers and companies are stored electronically, and b) there is a search system available to companies which allow them to review n job seekers on the database once they host a hiring/recruiting event at the university. In this case, companies are able to show NCS-based required tasks by potential employees and indicate points using a 1-5 Likert scale for matching evaluation criteria. Lastly, c) there is a system via the algorithm based on the logic of MADM which would be utilized as an attribute valuation rule for evaluation.
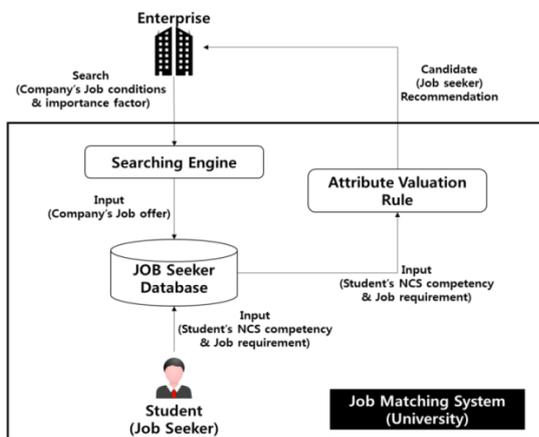

Figure 1. Framework of job matching search system

V. EXPERIMENT

5.1 Experiment data

The purpose of this study is to develop a job matching algorithm and examine the applicability of the job matching search system based on the algorithm. A total of 620 students' portfolios from all 5 different colleges in the university were obtained and 457 students' portfoliosdeemed usable for this experiment. As shown in [Table 3], there are more female students (61.9%) than male students (38.1%), and many more students from academic fields of social science (e.g., Business) than science (e.g., Global IT) in this study.

Table3. College and gender of student portfolios

Colleges	Male	Female	Total
Global IT	15 (75.0%)	5 (25.0%)	20 (4.4%)
Global Business	63 (36.8%)	108 (63.2%)	171 (37.4%)
Global Human Convergence	33 (35.9%)	59 (64.1%)	92 (20.1%)
Glocal Creativity & Convergence	16 (69.6%)	7 (30.4%)	23 (5.0%)
College of English Language	47 (31.1%)	104 (68.9%)	151 (33.0%)
Total	174 (38.1%)	283 (61.9%)	457

Note. There are 5 colleges in this university.

An original pool of hiring companies is comprised of 102 companies for the experiment; however there are 3 main industry categories: a) management/accounting/ office work, b) mechanical engineering, and c) leisure/recreation/ accommodations/ tourism/ sport. What the companies wanted in terms of an employee's personality, performance, or skills are quite subjective and non-standardized. Put differently, if the company wants their favorite employees to have a 'good personality', 'be confident', or 'be creative', it is not able to standardize for proper measures in the realm of this study. In order to solve this difficulty, this study decided to utilize 10 skills to reflect NCS-based competencies. For instance, if the company wants 'confident', it will be matched to technical skills and networking skills.

5.2. Experimental scenario and results

For an experimental

purpose,two most common scenarios were developed and [Table 4] shows departments from the company, NCS-based required task, and evaluationcriteria scores, for which the companies can provide points for skills. The evaluation criteria scores can be inserted by each company, or the points can be provided based on each company's needs to the university. In fact, it is anticipated that companies would hope to know more about their potential than just their competencies, for instance, desired salary, willingness to relocate, and so forth. That is, as opposed to match ann job seeker to m company, this study recommends a step by step job matching so that n job seekers are first identified from the pool and then another round of matching will occur. Without this step by step matching, there might be a situation where a deserving job seeker who received a very high evaluation criteria scorein all 9 skills and an average score for only one skill will not be recommended for matching as a result of one skill not high enough. To prevent a potential situation like this, step by step job matching is necessary.

Table 4. Job hiring scenarios for company

Category	Scenario (1)	Scenario (2)
Departments	Department of Overseas logistics	Department of Service Support
NCS-based required task	Management/Accounting/Office work/ Production & Logistics Management	Accommodations/Tourism/ Recreation/Sport/ Leisure/ Facility
NCS based competencies	Creativity/ Great at professional presentations	Great personality/ Foreign Language

		skills
Evaluation criteria scores	↓	↓
Communication	4	5
Analytic	-	-
Problem solving	4	-
Personal development	-	4
Resource management	4	-
Networking	4	4
Information literacy	4	-
Technical	5	-
Organizational	-	4
Vocational ethics	-	4

[Table 5] presents an example of normalization, rank, and weights for 14 evaluation criteria. Four more job matching evaluation criteria (previous work experience, certificates, awards/ prizes, and foreign language certificates) were added as these criteria play an influential role in step by step job matching. Weights for each evaluation criteria were calculated after considering points in [Table 4], and rank shows importance of each evaluation criteria. Scenario 1 shows that technical skills, certificates, and foreign language certificates yielded the highest weights (w=0.105263).

Table 5. Rank and weights for scenarios

Evaluation Criteria	Scenario 1			Scenario 2		
	Normalization	Rank	Weights (w)	Normalization	Rank	Weights (w)
Communication	0.114286	4	0.082707	0.16129	1	0.103704
Analytic	0	9	0.045113	0	8	0.051852
Problem solving	0.114286	4	0.082707	0	8	0.051852
Personal development	0	9	0.045113	0.129032	4	0.081481
Resource management	0.114286	4	0.082707	0	8	0.051852
Networking	0.114286	4	0.082707	0.129032	4	0.081481
Information literacy	0.114286	4	0.082707	0	8	0.051852
Technical	0.142857	1	0.105263	0	8	0.051852
Organizational	0	9	0.045113	0.129032	4	0.081481
Vocational Ethics	0	9	0.045113	0.129032	4	0.081481
Previous work experience	0	9	0.045113	0.16129	1	0.103704
Certificates	0.142857	1	0.105263	0	8	0.051852
Awards/Prizes	0	9	0.045113	0	8	0.051852
Foreign language certificates	0.142857	1	0.105263	0.16129	1	0.103704

[Table 6]below shows the result of MADM of the top 10 student portfolios out of all 457. Frist, it shows the top 10 ranks without weights, which means all 14 evaluation criteria were treated equally. Scenario 1 and 2 show the results of MADM after considering weights shown in [Table 5]. [Table

6]presents the MADA results for without considering weight. Scenario 1 and 2 all yielded different weights proving 458 students have a different rank based on weights. Therefore, this study could match n job seekers with an m

company because this isnot a system where a single job seeker is recommended for multiple jobs. Rather, it is a system where the company provides scores for each evaluation criteria based on the NCS-based task for the job.

Table 6. Result of MADM for scenarios

Scenario	Colleges	Majors	Gender	MADM	Rank
Without Weight	Global Business	Management	F	9.0472682	1
	Global Business	International Secretarial Studies	F	7.8642626	2
	Global Human Convergence	Korean Language & Culture	F	7.7923477	3
	Global Human Convergence	Portuguese	M	7.708043	4
	Global Business	Accounting	M	7.6772504	5
	Global Human Convergence	Paideia for Creative Leadership	M	7.6080901	6
	Global Business	Data Science	F	7.1889501	7
	Global Business	Accounting	M	7.0296492	8
	English Language	English	M	7.0149145	9
	Global Business	International Secretarial Studies	F	6.929453	10
Scenario 1	Global Human Convergence	Spanish	F	9.598134	1
	Global Human Convergence	Russian Language & Business	M	9.453785	2
	Global Human Convergence	Diplomacy & Commerce	F	8.905762	3
	Glocal Creativity & Convergence	Digital Media	F	8.814768	4
	Global IT	Embedded IT	F	8.7624	5
	Global Business	International Secretarial Studies	F	8.641176	6
	English Language	English	F	8.533826	7
	Global Business	Accounting	F	8.386774	8
	Global Business	e-Business	F	7.974724	9
	Global Business	Management	M	7.759147	10
Scenario 2	Global Business	International Secretarial Studies	F	7.388916752	1
	Global Human Convergence	Korean Language & Culture	F	7.333090185	2
	Global Human Convergence	Paideia for Creative Leadership	M	7.291307979	3
	Global Business	Accounting	M	7.186245691	4
	Global Human Convergence	Portuguese	M	7.182232097	5
	Global Business	Data Science	F	6.847456776	6
	English Language	English	M	6.564372133	7
	Global Business	Accounting	M	6.519601286	8
	Global IT	Embedded Software	M	6.386863841	9
	English Language	Indonesia/ Malaysia	F	6.371781285	10

VI. CONCLUSION

With the advent of NCS, companies are able to clearly convey the messages about competencies required by

employees, and job seekers, too, are able to develop and demonstrate their qualifications through their portfolio based on the competencies required by the company. Essentially, this study adapts an agent role that

connects seniors in a 4-year university (job seekers) to companies. The job matching presented in this study will be particularly helpful to job seekers in that they can minimize overall costs for find a job by focusing on competencies required for the job they are interested in and, thus, they can experience a high level of job satisfaction. Meanwhile, the companies can witness better performance from those who are newly hired as these employees come already aware of competencies required for the task and skills needed for the job, therefore reducing a learning curve by the employees and time/ resources necessary for training by the company.

This study standardized NCS-based competencies and proved that this system can be practically utilized to identify multiple job seekers for the company. Calculating and producing weights through the MADM algorithm is particularly helpful in identifying a pool of job seekers for the companies, which will increase the probability of successful hiring/finding a job in the labor market. For future research, it is recommended to develop the ways that can further consider wants and needs of n and m for job matching and its satisfaction and usage level. That way, future research can contribute to the body of research in youth unemployment. Overall, labor force policies that seek to reduce job mismatch is necessary, and this study suggested the way that can practically be employed.

ACKNOWLEDGMENT

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