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Applying Stochastic Fractal Search Algorithm (SFSA) in Ranking the Determinants of Undergraduates Employability: Evidence from Vietnam*

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Abstract

Employability has recently become the first target of the national higher education. Its model has been updated to catch the new trend of Industry 4.0. This paper aims at analyzing and ranking the determinants of undergraduate employability, focusing on business and economics majors in Ho Chi Minh City, Vietnam. In-depth interviews with content analysis have been primarily conducted to reach an agreement on a key group of factors: human capital, social capital, and identity. The Stochastic Fractal Search Algorithm (SFSA) is then applied to rank the sub-factors. Human capital is composed of three major elements: attitude, skill, and knowledge. Social capital is approached at both structural and cognitive aspects with three typical types: bonding, bridging, and linking. The analysis has confirmed the change of priority in employability determinants. Human capital is still a driver but the priority of attitude has been confirmed in the contemporary context. Then, social capital with the important order of linking, bridging, and bonding is emphasized. Skill, knowledge, and identity share the least weight in the model. It is noted that identity is newly proposed in the model but a certain role has been found. The findings are crucial for education strategies to enhance university graduate employability.

Keywords: Employability, Human Resource, Social Capital, Stochastic Fractal Search (SFS), Vietnam

JEL Classification Code: J24, E24, M12, Z13

1. Introduction

Labor and employment statistics of the Vietnamese Ministry of Labor, Invalids, and Social Affairs in 2019 show that employees with college and university degrees are in the top unemployment groups. In the third quarter of 2019, the number of unemployed people with university degrees was 186,800, higher than the total unemployment in the remaining 3 groups of qualifications: unskilled, vocational education, and college. An increase of 26.4 thousand people as compared to the previous quarter (2nd quarter of 2019) and an increase of 35 thousand people compared to the same period of last year (3rd quarter of 2018) was recorded. The unemployment rate for the undergraduate, college, vocational, and unskilled groups was 3.09%, 3.91%, 1.89%, and 0.99% respectively (Tran & Nørlund, 2015). One of the reasons for the above situation is explained by the undergraduates' employability.

Higher education plays an important role in economic development, especially the knowledge economy in the digital age (Jones & Vedlitz, 1988). Three educational functions: knowledge-creating knowledge, transmitting, and transferring are emphasized in the current context.

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The training of human resources to meet the needs of the labor market is an issue of primary concern for universities. Industry 4.0 has shifted the demand for labor in the market in the direction of undertaking "mental" or "attitude" jobs. Aedo, Hentschel, Luque, and Moreno (2013) have studied 30 countries around the world, including high-income and low-income countries. The findings reveal the need for doing "process" jobs, including both white collars (e.g. accounting) and blue collars (e.g assembling) tends to decrease. In contrast, the "non-process" jobs, which require high skills such as analysis, communication, which are associated with emotional intelligence (EQ), are increasing and accounting for a large proportion in the labor market. Another opportunity is also open to workers in the "process" workgroup, which does not require high skills, but a sensitive perception, such as customer service staff. This workgroup opens up opportunities for university graduates majoring in economics and business, in the context of fierce competition in the labor market. The World Bank showed that the biggest pressure is the lack of skilled laborers (Pham & Talavera, 2018). This is also a disadvantage of Vietnamese higher education. The Communist Party of Vietnam emphasized the requirement "to strongly shift the higher educational process to building capacity and employability of the learners from mainly equipping knowledge in its resolution".

The Vietnamese Ministry of Education and Training has realized this resolution by launching a project to improve the quality of higher education in the 2019-2025 period, according to which the quality of "training products", especially the learners capacity and employability, has been prioritized. It can be said that the working capacity of university graduates is the top target of universities in the world (Clarke, 2018). Therefore, many pieces of research in the world have been conducted to investigate this problem. In the context of Vietnam, given the resources constraint, this study aims at applying the Stochastic Fractal Search Algorithm (SFSA) in ranking the employability determinants of undergraduates majoring in Economics and Business. This technique is expected to prioritize the role of each employability determinants for an efficient and effective education policy.

2. Literature Review

Undergraduate employability is defined as the knowledge, skills, and attributes that have been trained at the university level, which are expected to be applied to the job after graduation with the expectation to increase the chances of career success in the labor market (Boden & Nedeva, 2010; Hillage & Pollard, 1998; Yorke, 2006). Research in Vietnam is based on competency models, with three core elements: attitude, skills, and knowledge (ASK) when exploring the learners' capacity (Duong, Nguyen, & Nguyen, 2020; Tran & Lewis, 2012). The capacity model is an effective measuring tool in human resource management (Lengnick-Hall, Beck, & Lengnick-Hall, 2011). It is the core strategy to link behaviors and skills with the strategic direction of the organization. Sharing this point of view, Nguyen, Nguyen, Nguyen, and Huynh (2019) developed a competency model of the undergraduates in Ho Chi Minh City. Research results indicated that attitude is the foundation for the development of learners' skills and knowledge. A student's attitude and motivation determines the results and effectiveness of his or her educational activities. Learning to get good grades, passing other exams is different from "learning to know, learning to work, learning to live together, and learning to be" (Jung Wan, 2020; Reeves, 2006). Empirical studies in Vietnam show that many factors influence the attitudes, which in turn determine the student's capacity (see table 1).

The summary in Table 1 indicates that university-related factors play a decisive role in learning attitudes and motivation, which forms learners' competencies. However, the studies have not analyzed the employability as well as ranking as its determinants so that efficient remedies for capacity shortage in the labor market can be recommended. Holmes (2013) summarizes three groups of factors explaining the employability, including (i) human capital, (ii) social capital, and (iii) identity (see figure 1).

The theories of human capital have contributed to explaining students' employability through competence. It is a multidisciplinary and multi-dimensional concept involving capacity building and development (Kachalov et al., 2015). Competence is an important tool in the human resource management efforts of all organizations. Competence is not only applied to private organizations but also widely used in the public sector and non-governmental organizations (Hondeghem & Vandermeulen, 2000).

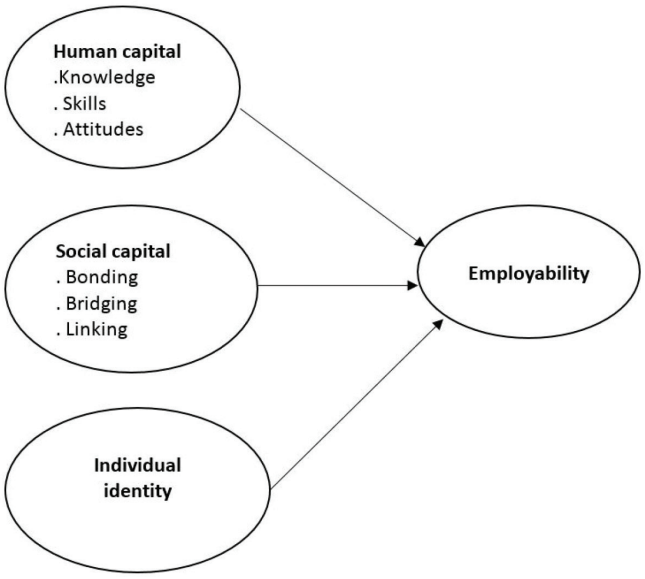

Figure 1: Drivers of employability

Table 1: Variables description in the model

Author(s)	Methodology	Results
Do, Lam, and Nguyen (2016)	Multiple regression, using a survey data set of 190 students at Lac Hong University, Vietnam	The external and internal motivation have an equal role, with the coefficients of 0.594 and 0.588 respectively. The learning environment (0.692) is the most important factor, determining external learning motivation, besides other factors such as family and friends (0.620), social factor (0.522). As for internal motivation, self-will (0.546) comes in the first position, followed by self-awareness (0.529) and life view (0.462)
Nguyen and Du (2014)	Qualitative and quantitative research, using a survey data set of 358 students majoring in Economics, social, and engineering disciplines	Research results show that "learning to have practical skills", "learning to acquire knowledge" and "learning for a university degree" strongly influence the learning motivation of students
C. B. Nguyen (2018)	Quantitative research using a data set of 300 second-year students, faculties of Economics, Business Administration, Social Sciences and Natural Sciences, Hong Duc University, Vietnam	Research results show that there are two groups of factors that affect students' learning motivation. For the last group of factors, self-consciousness (82.1%) plays the most important role, followed by confidence in the selected major (80.8%) and learning interest (60.1%). For the group of objective factors, the requirement of the labor market (71.3%) ranks first, followed by lecturers' qualifications and professionals (61%) and ethic, reputation, and style (57.3%)
Phan (2016)	Using qualitative and quantitative methods, based on survey data of 456 students in the first and second year at faculties: Commerce, Tourism, Engineering, Environmental Management, Electronics at the Ho Chi Minh City Industrial University	Both subjective and objective factors were investigated. Subjectively, factors such as the personal selection of the discipline, self-awareness, and responsibility of students are considered to be important. Regarding the objective factors, students highly appreciate the following elements: disciplines that meet the social needs, qualifications and teaching methods of lecturers, family expectations
Pham (2016)	Using survey data of 160 students from the University of Economics – Hanoi National University with the application of EFA and multiple regression analysis	The findings with a priority ranking of the factors as follows: training program (0.346), facilities (0.330), services (0.244).

Competence is not limited to only perceptual factors but also includes ethical, functional, and relationship-building aspects. The factors constituting capacity are constantly developing in the context of a volatile labor market. The concept of competency first appeared in 1973 in a study explaining personal success (McClelland, 1973). To be able to reach to a scientific and accurate assessment of competencies, researchers have proposed the model with a combination of knowledge, skills, and attitudes to fulfill a job well. This model is widely used in training activities in universities as well as in the current human resource management process, based on three factors: (i) Attitude (affective or emotional features); Skills (manual or physical aspects); and (iii) Knowledge (cognitive requirements).

Besides human capital, the undergraduates' employability is also explained by the theory of social capital. Since 1980s, scholars and researchers from many different fields have recognized the importance of social capital, considering it as the fourth source of capital alongside other traditional capital sources such as natural capital, physical capital, and human capital (Ngo, Nguyen, & Nguyen, 2020; Nguyen, Nguyen, Nguyen, & Huynh, 2016). Social capital contributes to the justification of an individual's occupational status, given similar qualifications and skills. Thus, in addition to human capital, social capital also plays a certain role in the capacity building and development of individuals in the labor market. Social capital is a concept that includes two dimensions: (i) structure and (ii) cognition. The structural aspect of social capital refers to the networks and institutions that connect people. The cognitive social capital implies the values such as norms, beliefs, responsibilities, and expectations of each person, in which trust is often considered as the main element (Huynh, Nguyen, Nguyen, & Nguyen, 2018; Nguyen & Ngo, 2020). Social capital is also categorized by function, including three types: (i) bonding, (ii) bridging, and (iii) linking. According to Stone, Gray, and Hughes (2003), bonding social capital focuses on understanding the composition and function of the homogeneous network, mainly at the individual (micro) level. It refers to a strong relationship among people with close relationships such

as family members, neighbors, friends, and co-workers. Bridging social capital expresses the relationships between people who are do not have quite the same anthropological traits but have similar financial status and power. This network encompasses community relationships such as associations, social groups, and clubs (sports, culture, arts, entertainment, etc). Linking social is a concept that implies hierarchical links with vertical direction, which is the resource lever.

The third factor that explains university graduates' employability is identity. Personal processes, especially career preparation, career self-management, and self-regulation are considered individual attributes where emotional adjustment is seen as the core (De Vos & Soens, 2008; Sturges, Guest, Conway, & Davey, 2002; van der Heijde, 2014; Vo, Nguyen, & Le-Hoai, 2019). Career preparation increases career understanding, which can be improved through career guidance. In addition, career self-management and self-regulation help increase working capacity through overcoming barriers in the achievement of career goals.

3. Research Methodology

The Stochastic Fractal Search algorithm (SFS) is implemented by two main processes: the diffusing process and the updating process (Salimi, 2015). In the first process, each particle diffuses around its current position to satisfy intensification (exploitation) property. In the updating process, SFS uses some random methods. In other words, the updating process in SFS leads us to diversification (exploration) properties in metaheuristic algorithms. To create new particles from the diffusion procedure, the statistical methods called Gaussian are investigated. Preliminary studies over taking advantage of Levy and Gaussian distributions separately show, however, that although Levy flight converges faster than Gaussian walk in a few generations; Gaussian walk is more promising than Levy flight in finding global minima.

$$Gaussian(M,\sigma)=\frac{1}{\sigma\sqrt{2\pi}}e^{\frac{-(M-\pi)^2}{2\sigma^2}} \quad (1)$$

Therefore, unlike Fractal Search, which uses the Levy flight distribution, SFA only used Gaussian distribution for the random walk employed in the Diffusion Limited Aggregation (DLA) growth process of SFS. A series of Gaussian walks participating in the diffusion process has been listed in the following equations:

$$X_{new1}=Gaussian(\mu_{X_{best}},\sigma)+(\varepsilon X_{best}-\varepsilon' X_i) \quad (2)$$

$$X_{new2}=Gaussian(\mu_X,\sigma) \quad (3)$$

where

ε and ε' are uniformly distributed random numbers restricted to [0, 1].

X_{best} and X_i are denoted as the position of the best point and the ith point in the group, respectively.

The first two Gaussian parameters are $\mu_{X_{best}}$ and σ where $\mu_{X_{best}}$ is exactly equal to X_{best}. The two the latter parameters are μ_X and σ where μX is equal to X_i. The standard deviation (σ) is computed by equation:

$$\sigma=\left|\frac{\log(g)}{g}\times\left(X_i-X_{best}\right)\right| \quad (4)$$

To encourage a more localized search as individuals and get closer to the solution, the term $\frac{\log(g)}{g}$ is used to decrease the size of Gaussian jumps, as the number of generation increases, it assumes a global optimization problem with dimension D is at hand. Therefore, each denoted individual considered to solve the problem has been built based on a D-dimensional vector. During the initialization process, each point is initialized randomly based on problem constraints by prescribing minimum and maximum bounds. The initialization equation of the jth point, P_j, is addressed as follows:

$$X_j=X_{j\text{üüüüü}}+\varepsilon\times\left(X_j\quad -X_j\quad\right) \quad (5)$$

where $X_{j\min}$ and $X_{j\max}$ are the lower and the upper problem constrained vectors, respectively. As stated in previous equations, ε is a uniformly distributed random number that is restricted to the [0, 1] continuous area. After initializing all points, the fitness function of each point is computed to attain the best point (X_{best}) among all points. According to the exploitation property in the diffusion procedure, all points have roamed around their current position to exploit problem search space. On the other hand, two statistical procedures aimed to improve space exploration are considered due to the exploration property. The first statistical procedure performs on each individual vector index, and the second statistical method is then applied to all points.

a) *The first statistical procedure*:

For the first statistical procedure, at first, all the points are ranked based on the value of the fitness function. Each point i in the group is then given a probability value which obeys a simple uniform distribution as the following equation:

$$X_{a_i} = \frac{rank(X_i)}{N} \quad (6)$$

where *rank(X$_i$)* is considered as the rank of point X_i among the other points in the group, and N is used as the number of all points in the group. Equation (6) wants to state that the better the point, the higher the probability. For each point X_i in a group based on whether or not the condition $X_i < \varepsilon$ is satisfied, and where ε is a uniform random number belonging to [0, 1], the jth component of X_i, is updated according to equation (7), otherwise it remains unchanged.

$$X_i^{'}(j) = X_r(j) - \varepsilon \times \left[X_t(j) - X_i(j)\right] \quad (7)$$

where

X'_i is the new modified position of X_i,

X_r and X_t are randomly selected points in the group,

ε is the random number selected from the uniform distribution in the continuous space [0, 1].

b) *The second statistical procedure*:

Regarding the first statistical procedure that is carried out on the components of the points, the second statistical change is aimed to change the position of a point considering the position of other points in the group. This property improves the quality of exploration, and it satisfies the diversification property. Before starting the second procedure, once again, all points obtained from the first statistical procedure are ranked based on equation (6). If the condition $X_{a_i} < \varepsilon$ is held for a new point X'_i, the current position of X'_i is modified according to equation (8) and (9), otherwise no update occurs. Equation (8) and (9) are presented as follows:

$$X_i^{"} = X_i^{'} - \hat{\varepsilon} \times (X_t^{'} - X_{best}),\ \hat{\varepsilon} \le 0.5 \quad (8)$$

$$X_i^{"} = X_i^{'} + \hat{\varepsilon} \times (X_t^{'} - X_r^{'}),\ \hat{\varepsilon} > 0.5 \quad (9)$$

Where

X'_r and X'_t are randomly selected points obtained from the first procedure, and

$\hat{\varepsilon}$ are random numbers generated by the Gaussian Normal distribution. The new point X'_i is replaced by X'_i if its fitness function value is better than X'_i.

c) Stochastic Fractal Search Algorithm:

The overall procedure of the proposed SFSA for solving the EED problem is addressed as follows:

Step 1: Initialize a population size (N points);

Step 2: Calculate fitness function to find the best point (X_{best});

Step 3: Compare value of G with maximum iteration. If G is less than maximum iteration goes to step 7, otherwise go to step 4;

Step 4: Call Diffusion Process;

Step 5: Call Updating Process;

Step 6: Return step 3;

Step 7: Post-process results and visualization;

d) The overall procedure of the proposed Diffusion Process is addressed as follows:

Step 1: Set maximum Diffusion number (MDN points);

Step 2: Initialize i = 1;

Step 3: Compare i with MDN. If i less than or equal MDN go to step 5. Otherwise, go to step 4.

Step 4. Based on user define select Gaussian walk to create a new position. i increases by 1 and go to step 3.

Step 5: Best point among created Gaussian walk selected, goes to the main function

d) The overall procedure of the proposed Updating Process is addressed as follows:

First updating process:

Step 1: First, all points are ranked based on equation (6);

Step 2: For each point *Xi* in group;

Step 3: For each component j in *XI*;

Step 4: If rank (*Xi*) ≤ rand[0,1] go to step 5. Otherwise, go to step 3.

Step 5: Update jth component of *Xi* based on equation (7)

Second updating process:

Step 1: First, all points are ranked based on equation (6).

Step 2: For each point *Xi* in group

Step 3: If *Rank (Xi)*≤ rand[0,1] go to step 4. Otherwise, go to step 2.

Step 4: Update position of *Xi* based on equation (8) and (9)

4. Results and Discussion

The survey of 10 experts and 200 undergraduates in Ho Chi Minh City relating to seven factors to the employability. All tests and calculations were implemented using MATLAB 2016b and executed on a computer with a Core i5 - 1.33GHz, 4 GB RAM, and a Windows 10 -64-bit operating system. Based on the survey data and the application of Lagrange and Spline functions, the selection tendency of each factor has been found. $CI_i = f(r_i)$, i = 1,7 is adopted in combination with sine function for the simplicity.

$$CI_i = f(r_i) = a_i + b_i r_i + c_i r_i^2 + \left| e_i \sin\left[f_i (r_{\min}^i + r_i) \right] \right|$$

$$\sum_{i=1}^{7} r_i = 100$$

The Stochastic Fractal Search algorithm (SFSA) is used to find r_i, given the minimum function: $CI = \sum_{i=1}^{7} CI_i$. Table 3 presents the results of r_i:

Table 2: Parameters results

Unit	1	2	3	4	5	6	7
r_i^{min}(%)	0	0	0	0	0	0	0
r_i^{max}(%)	100	100	100	100	100	100	100
a_i	1856.7988	451.3251	1149.9977	856.7988	1958.5696	1356.6592	2858.5696
b_i	38.53973	46.15916	40.39655	38.53973	36.32782	38.27041	47.39582
c_i	0.16247	0.10587	0.09038	0.09247	0.18111	0.06799	0.08171
e_i	100	100	100	100	140	120	120
f_i	0.064	0.084	0.084	0.064	0.056	0.048	0.078

Table 3: Parameters results

Unit	1	2	3	4	5	6	7
r_i	5.3223	10.0022	14.0077	8.0825	15.1794	28.3931	19.0124

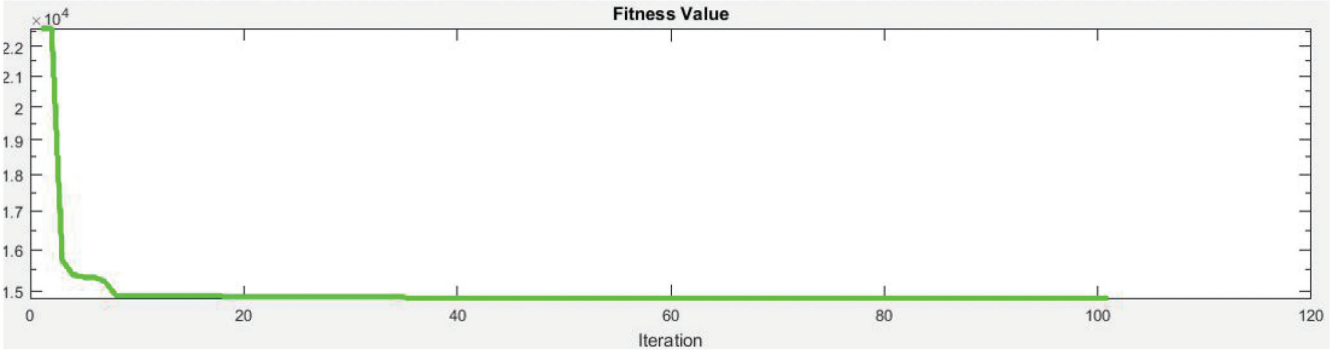

Figure 3: Convergence and value of CI

Table 4: Ranking employability determinants

Components	Rank	r_i
Attitudes	1	28.3931
Linking social capital	2	19.0124
Bridging social capital	3	15.1794
Bonding social capital	4	14.0077
Skills	5	10.0022
Knowledge	6	8.0825
Individual identity	7	5.3223

The arrangement of r_i from maximum to minimum to illustrate the important level is shown in Table 4.

Research results show that attitude is the most important factor determining the employability. According to Cross (2001), personal attitudes include the following abilities: (i) the ability to gather information appropriately to solve problems, (ii) ability to gain experience because career ability is highly dependent on accumulated experience, (iii) attitude to dealing with problems, and (iv) solution approach in problem solving and ability to negotiate with others, including customers as well as colleagues. Career attitudes summarized by Lewis and Bonollo (2002) include the following categories: (i) negotiating with the client, including clarifying with the client what to do; (ii) solving the problem, which is a career skill, as well as an attitude toward work, (iii) taking responsibility for work results, (iv) social communication skills, demonstrated through teamwork, and (v) project management: the ability to organize work to meet schedule and expected results. The changing trend of the demand for human resources in the labor market is indispensable, especially in the context of the rapidly changing technology of Industry 4.0. The trend of automation leads to the status that machines replace humans in doing repetitive, "process" jobs (Botha, 2019; Luong, Tran, & Nguyen, 2018; Nguyen, 2020; Pham, Dao, Cho, Nguyen, & Pham-Hang,

2019). Therefore, education should aim to equip students with a positive attitude which motivates a lifelong learning, the core factor which determines each individual's success or failure because no one can master and teach everything (Jocic et al., 2020; Nguyen, Nguyen, Huynh, & Nguyen, 2020).

Each individual must observe and acquire knowledge in his or her field of interest. This is also the foundation for the development of creativity and the ability to adapt to changes. In addition, various types of social capital also contribute significantly to the process of building and developing the undergraduates employability. Linking shares the biggest role among the three type of social capital, followed by bridging and bonding . Individuals can gain influence and better resources through connecting with people of higher status. Individuals with linking social capital can get benefit in getting a better job, or a better social status (Wuthnow, 2002). Kim (2009) shows that the network of relationships with people in higher position has contributed to increasing the employability and income of lawyers. Ducharme and Martin (2000) classified social capital resources into four types of assistance: (i) tools, (ii) sentiment, (iii) information, and (iv) companionship. These tools all contribute to improving working capacity. Bridging social capital covers the relationships that make up a wide network with structural flaws with the characteristic "thin trust" or "general trust" (Dubos, 2017). A broad social network is a social network that contains structural holes.

Structural gaps are gaps in the network that provide opportunities to mediate the flow of information between people or groups, thus giving an advantage to individuals with interconnected relationships between individuals or groups. According to Burt (2000), positions near structural gaps in a network structure are more likely to have "good ideas": people with connections between different groups often encounter different ways of thinking and give them more choices. Structural hole theory is concerned with the pattern of the relationship between network members and social capital described as a function of intermediate opportunities. Structural holes in the network occur when there are intermediaries in the network. The structural network offers three benefits: (i) unique and timely access to information, (ii) great bargaining power, and (iii) career opportunities through the social system (Dubos, 2017).

Indeed, in imperfect markets, the benefits will be attributed to the owner of many structural holes. Research by Baldwin, Bedell, and Johnson (1997) shows that the individual who is the center in the network has the advantage in accumulating knowledge, skills for employability. This is a resource that not only helps individuals to handle their work well, but also helps to connect with colleagues in the future through consulting activities, sharing experiences and thus have the opportunity to progress in their career. Bonding has the advantage of being close, highly reliable, and information is shared quickly within the network. However, this network has the limitation of old information because strong relationships are often closed in nature, confined to a narrow cluster of people. Meanwhile, the network of weak ties is a source of new information, useful for individuals in the process of building and developing working capacity.

In addition, skills, knowledge and identity are the factors that need to be considered in building and developing work capacity. Skill-led education system is the goal of contemporary education (Leitch, 2006). Skill is the ability to perform tasks, turn knowledge into action. Usually skills are divided into main levels such as: imitation (observation and stereotyped behavior), application (doing some actions by following instructions), manipulation (more accurate with each circumstances), creativity (become a natural reflection). Lewis and Bonollo (2002) argued that skills are a very broad category, depending on the major, which can be generalized as follows: (i) the skills to clarify the tasks to be done; (ii) the skills to define the job; (iii) job evaluation and adjustment skills; (iv) job detailing skills, (v) job performance communication skills; and (vi) general skills shown in the job performance. Depending on the requirements of the job, the respective skills should be focused on building and developing. However, the skill-based approach cannot cover the complexity of employability requirements. Knowledge, expressed through the capacity to collect data, understand problems, application capacity, analytical capacity, aggregate capacity, and assessment capacity still has an important role. These are the basic competencies that an individual needs to converge when entering the labor market. Lastly, idenity – a broad combination of skills, knowledge, conduct, culture, social networks can boost the employability. The identity can be prepared by students during their university lives via engaging in various community activities.

5. Conclusions

Each nation and institution is continuously chasing for the goal of human development and employability, is the most suitable aim of higher education. The Stochastic Fractal Search algorithm provides the ranking results of various determinants in understanding the employability factors. Human capital and social capital always share a large proportion but the components have been changed. Attitude is superior to skill and knowledge, linking and bridging are more important than bonding. Therefore, the findings from this research are efficient and effective for employability enhancement in the contemporary context.

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