Establish and Optimize the Enterprise Downsizing Model

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Downsizing is a process of reducing staff in order to improve a firm's efficiency, which is widely used by enterprises when their profitability is declining. This paper discusses and probes a relatively perfect index system for downsizing through investigation. Based on the index system discussed, a downsizing model is proposed to maximize the average core value of the enterprise. A new and efficient evolutionary algorithm is presented and applied to determine the downsizing objective. The outcome of demonstrating simulation indicates that the solution can improve the validity and rationality of decisions and then offer enterprises a valuable solution of downsizing management.

INTRODUCTION

Downsizing is one of the effective ways to maintain core competence when enterprises face economic difficulties (Zhao, Xu, Liang, and Liu, 2009). Scholars notice that each time when the global economy was in the bottom of the economic cycle, the storm of downsizing would hit the world (Wang, 2008; Wen, 2009). For instance, based on the statistics from Layoff Tracker, in the year of 2008 when the worldwide financial crisis occurred, the downsizing numbers of Citigroup, AT&T, Sony, Rio Tinto and Bank of America are about 70,000, 12,000, 16,000, 14,000 and 30,000 respectively. Restructuring is another factor that leads to large-scale layoffs. For example, GM dismissed 47,000 employees when restructuring recently. However, while legally and fairly lay off the staff, it is very important for enterprises to figure out how to pull through and maintain the strongest competence and match the strategic objectives.

Downsizing can bring obvious profits through reducing labor cost and operation cost while improving competence. However, downsizing can also generate certain negative outcomes, business owners have to consider the downsizing cost and the shaking morale of remaining employees. Some scholars argue that layoffs can lead to enormous economic lost if enterprises lay off employees who have scarce technology or skills, by mistake. In addition, some recessive impacts will be generated in lay off. Abraham Morrall once investigated the large-scale layoffs of U.S. military Airlines in 1990s; they found out that the remaining employees' sense of safety, efficiency, loyalty and stamina obviously declined after firms implemented large-scale layoffs (Abraham Morrall, 1996). Therefore, we argue that layoff is a doubleedged sword; accordingly, we suggest that in order to improve the expected profitability and to reduce the negative impact enterprises should lay off staffs accurately and effectively when they have to downsize.

In order to reduce the negative effects and to ensure constant development and increasing the profitability, enterprises must form a relatively standard and effective procedure to lay off their employees, which is the correct approach that firms should adopt to realize their expected outcomes for downsizing. However, most current studies on layoffs focus on the establishment of index and process, the management strategy and its impacts (Wang, 2010; Lu, et al., 2009; Zhou and Xiao, 2009; Wang, 2007; Feng, 2005; Si, 2005; Niu and Shi, 2002). Although these studies provide certain effective guidelines to the enterprises macroscopically, they are less effective at microscopic operations in terms of maximizing target value, minimizing risk, improving enterprise's core competence, and managing risk. Evolutionary computation is an intelligent computing model based on natural selection and gene inheritance, which can be effectively used to solve some complex problems that are hard or even cannot be solved by traditional mathematics, especially the optimization problems. Some scholars attained ideal results by applying optimal methods of evolutionary algorithms to study the process of enterprise downsizing (Feng, Liu, and Zhou, 2010; Lei and Pu, 2006).

By following aforementioned scholastic work, this paper is aimed at building a downsizing model to maximize the average core value with a relatively perfect index system. We also present an effective evolutionary algorithm to solve the downsizing problem. The authors expect that this model can provide enterprises an accurate number of layoffs and a list of retrenched staffs that can maximize the whole enterprises' profit. By so doing the firms will be able to make more specific and accurate decisions on layoffs. After this brief introduction, we will present the index and downsizing model in section 2; we will then present the novel evolutionary algorithm in section 3; in section 4 we will discuss the empirical simulation for downsizing model; and finally we will summarize our findings and discussions with a conclusion statement.

DOWNSIZING MODEL

Establish the Index

Based on the studies on the standard of layoffs and the specific standard proposed by Crandall et al. (2001), Paul Roman (2005), Si (2005), Lu (2009), Wang (2010), Feng(2010) among others, as well as the outcome of interviews with experts of human resources (HR) management, we designed a questionnaire with 18 questions. We then selected 80 HR managers who work at large and medium-size enterprises; we delivered questionnaires to those selected HR managers by emails. Finally, we received 68 feedbacks and 62 met the requirements, representing a response rate of 77.5% percent. By applying SPSS statistics software, we eliminated three items because CITC values were below 0.5. Cronbach′s α was 0.863 and split-half reliability was 0.824 in the final report. As a result, fifteen items responded from 62 questionnaires were included in the sample. In order to classify the downsizing index, we test the Kaisex-Meyer-Olkin score, the outcomes indicate that the KMO score was 0.821 and the result of Bartlett's test of sphericity is significant 0.000. These results provided convincing rationale for processing factor analysis, from the rotated component, matrix rotation method is varimax with Kaiser Normalization, and we got six factors for further analysis. Based on these six factors we developed six downsizing index (see table 1 below). The balanced HR structure is an index that inflects the characteristics of HR structure in the organization, including "the diversity of age structure of the remaining employees", "the work seniority", "the education background of employees" and "the diversity of employees' knowledge" (Wang, 2010; Wang, 2007; Lu, Ge, and Zhang, 2009). According to the organization, strategy theory, the demand for personnel capacity must be based on the company's strategy and business development. It includes the compatibility between employees' capacity and organization's strategy development, as well as the compatibility between employee composition and the adjustment of organization structure (caused by process optimization, business transformation, etc.) (Wang, 2007; Lu, Ge, and Zhang, 2009; Feng, Liu, and Zhou, 2010). The importance of the post refers to the priority of the job and the mastery degree of technology and confidential information (Feng, Liu, and Zhou, 2010). The characteristics of employees' capacity include the ability to learn and innovate, the ability to establish and maintain the relationship with customers, and the compatibility between employees' capacity and the job (Wang, 2010; Wang, 2007). The employees' performance includes the stability of the performance, the execution of the company's objective and action plan, and the contribution to the company (Wang, 2010; Wang, 2007; Feng, Liu, and Zhou, 2010). The employees' quality includes working attitude, responsibility, dedication and moral quality (Wang, 2010). The 62 human resource department personnel scored these six criteria on a five point Likert scale. Then the weight of each criterion is determined according to the average score of each criterion (See Table 1).

TABLE 1
CRITERION AND WIGHT OF LAYOFFS

Core criterion	Average score	Weight
Balance of HR structure	3.6	0.157
Organization strategy	2.8	0.122
Importance of the jobs	4.2	0.183
Characteristics of capacity	4.0	0.175
Performance	4.5	0.197
Quality	3.8	0.166

Downsizing Model

In the process of downsizing, it is necessary to establish an optimization model for downsizing and apply intelligent computing to solve the problem. Two steps need to be performed before the construction of the downsizing model. Firstly, the enterprise should set up a specifically designed ad hoc committee to lead the downsizing process. Top managers, HR managers and leaders from every department have to negotiate the total number of layoffs and the specific numbers to be allocated to each department. Secondly, HR department should evaluate each employee by the 6 criterion stated above and then give them a score. Moreover, after model is set up, the ad hoc committee should implement the reduction plan and assure the handover procedure is peaceful and smooth. In addition, dismissal procedure and other rehabilitation works could be performed.

The optimization model makes the best downsizing proposal. Here we suggest an effective downsizing model. Assume that a company consists of *m* departments and the number of employees in each department is s_1, s_2, …, s_m., then the average core value of all the employees can be described by the following model:

$$\frac{\sum_{i}^{m} \alpha_i (\sum_{j}^{s_i} x_{i,j} \cdot (\sum_{k}^{6} A_{i,j,k} \omega_k))}{\sum_{i,j} x_{i,j}}.$$

Where, *i* represents the number of department and *j* represents the number of employee in *i* department. And α_i is the weight of department *i*, it would be adjusted according to its importance to the layoff target. The core department will receive greater weight in the model. A_{ijk} represents the score of the *k* criterion of the *j* employee in *i* department, $k = 1, 2, \cdots, 6$. ω_k is the weight of the *k* criterion which is showed in table 1.

x_{ij} is the stay-behind intensity for *j* employee in *i* department and it also can be understood as the contribution that the *j* employee contributes to the company's core value, where $i \in \{1, 2, \cdots, m\}$,and $j \in \{1, 2, \cdots, s_i\}$. The stronger intensity represents the bigger contribution. The value of x_{ij} represents "dismiss" or "not dismiss". When x_{ij} is 0, the intensity is 0 and so is the contribution. In this situation, the j employee in i department will be dismissed. While when x_{ij} is 1, the intensity is 1 so is the contribution. For all i and j, when $x_{ij} = 1$, the maximum of $\sum_{i,j} x_{i,j}$ is 25, which practical meaning is that every employee will stay-behind. When $x_{ij} = 0$, the minimum of $\sum_{i,j} x_{i,j}$ is 0, which means all employees will be dismissed.

$\sum_{k}^{6} A_{i,j,k}\omega_k$ is the core value of the j employee in i department. When $x_{ij} = 1$, the value of employees will be added to the total value of the enterprise. Otherwise, $x_{ij} = 0$, the employee, who make no contribution to the total value of the enterprise, will be laid off in the downsizing.

$\sum_{i}^{m} \alpha_i (\sum_{j}^{s_i} x_{i,j} \cdot (\sum_{k}^{6} A_{i,j,k}\omega_k))$ is the core value of all the remain employees. If the total intensity of remain employees was divided by $\sum_{i,j} x_{i,j}$, the average core value of enterprise after downsizing could be figured out.

$$\begin{cases} \max \left(\dfrac{\sum_{i}^{m} \alpha_i (\sum_{j}^{s_i} x_{i,j} \cdot (\sum_{k}^{6} A_{i,j,k}\omega_k))}{\sum_{i,j} x_{i,j}} \right) \\ T_i \min \le \sum_{j}^{s_i} \psi(x_{i,j}) \le T_i \max \\ T \min \le \sum_{i,j} \psi(x_{i,j}) \le T \max \\ i \in \{1, 2, \cdots, m\}, j \in \{1, 2, \cdots, s_i\}, s_i \in \{s_1, s_2, \cdots, s_m\} \end{cases}$$

$T_i \min$ is the predetermined minimum number of the remain employees in i department. $T_i \max$ is the predetermined maximum number of the remain employees. Generally, $0 \le T_i \min \le T_i \max \le s_i$。 $T \min$ and $T \max$ represent the total minimum and maximum number of the enterprise after downsizing, where $0 \le T \min \le T \max \le \sum_{i}^{m} s_i$.

In the downsizing model, the intensity to stay-behind decides whether to cut one or not. Because there are many departments in one enterprise and different departments have different situations; we cannot lay off the employees without considering the differences among departments. Here, a threshold, represented as σ, is used to present the critical intensity in different departments. When $x_{ij} < \sigma_i$, the j employee in i department will be cut. Otherwise, the j employee is stay-behind. Therefore, function ψ mentioned above is described as the follows：

$$\psi(x_{ij}) = \begin{cases} 1, & if \quad x_{ij} \le \sigma_i; \\ 0, & else. \end{cases}$$

Through calculating, enterprises can configure how to lay off staff to achieve the maximum total profits within all constraints, and to determine the object of the layoffs. However, it is difficult to use traditional computing to solve such a complex problem with strong constraints. In order to reduce the cost and improve the accuracy and efficiency for downsizing, a novel and effective evolutionary algorithm based on Differential Evolution (DE), DE based on constraint treatment (DECT) is presented to solve the downsizing problem.

DIFFERENTIAL EVOLUTION BASED ON CONSTRAINT TREATMENT

DE, proposed by Storn and Price, is comparatively a newer addition to the class of evolutionary algorithms (Storn, Price, 1995). As a reliable and effective global optimizer algorithm, DE has been successfully applied in diverse fields. Actually, it has been said that DE is one of the most competitive EAs for continuous optimization (Qin, Suganthan, 2005).

Like other evolutionary algorithms (Jiang, Lin, 2010), DE starts with an initial population vector randomly generated in the solution space. Let assume N is a constant number which presents the size of population, and D is the dimension of parameter vectors. So, the population is expressed as $X_i(t)$, where $i = 1, 2, \cdots, N$, t is the generation. The main difference between DE and other evolutionary algorithms, such as Genetic Algorithm and Particle Swarm Optimization algorithm (Kennedy, Eberhart, 1995), is its new generation vectors generating method. In order to generate a new population vectors, three vectors in population are randomly selected, and weighted difference of two of them is added to the third one. After crossover, the new vector is compared with the predetermined vector in population. If the new vector is better than predetermined one, replace it; else, the predetermined vector saved in the next generation's population. For DE based on constraint treatment, the procedure is illustrated as following:

Mutation: For each vector i from generation t, a mutant vector $X_i(t+1)$ is defined by

$$X_i(t+1) = X_{r_1}(t) + F(X_{r_2}(t) - X_{r_3}(t)) ,$$

where $i \in \{1, 2, \cdots, N\}$ and $r_1, r_2, r_3 \in [0, N]$, i , r_1 , r_2 and r_3 are different. The differential mutation parameter F, known as scale factor, is a positive real normally between 0 and 1, but it also can take values greater than 1. Simply, larger values for F result in higher diversity in the generated population and the lower values in faster convergence.

Crossover: Crossover also plays an important role in DE algorithm which increases the diversity of the population. A crossover vector $X_i'(t+1)$ is defined as following:

$$X_i'(t+1) = (X_{i,j}'(t+1), X_{i,j}'(t+1), \ldots, X_{i,j}'(t+1))$$

where $j \in \{1, 2, \cdots, D\}$ and

$$X_{i,j}'(t+1) = \begin{cases} X_{i,j}(t+1), \text{ } if \text{ } rand(j) \le C_r, \\ X_{i,j}(t), \quad else. \end{cases}$$

Selection: A greedy selection mechanism is used as follows:

$$X_{i,j}(t+1) = \begin{cases} X_{i,j}'(t+1), \text{ } if \text{ } f(X_{i,j}'(t+1)) \text{ } better \text{ } than \text{ } f(X_{i,j}(t)), \\ X_{i,j}(t), \quad else. \end{cases}$$

Without loss of generality, this paper only considers minimization problems. If, and only if, the trail vector $X_i'(t+1)$ is better than $X_i(t)$ (for minimize problems, better than means smaller than; for maximize problem, means bigger than), then $X_i(t)$ is set to $X_i'(t+1)$; otherwise, the $X_i(t)$ go into the next generation without changed.

Constraint Treatment: For a function optimization problem with constraint conditions, the constraint treatment operators are required to ensure the legitimacy of the candidates generated by genetic operators. For a problem with q constraint function $g_i(X)$ ($i = 1,\cdots,q$), if $g_i(X) \le 0$, the constraint is satisfied, otherwise the constraint is unsatisfied, Function $h_i(X)$ is expressed as the degree of constraint violation in $g_i(X)$ for vector *X*. Furthermore, $H(X)$ is expressed as degree of constraint violation in the whole constraint functions for vector *X*. $H(X) = 0$,which means that *X* is a feasible solutions which meets all the constraints. So, $h_i(X)$ and $H(X)$ could be described as follows:

$$h_i(X) = \begin{cases} 0, & \text{if } g_i(X) \le 0, i = 1,2,\cdots q \\ g_i(X), & \text{else.} \end{cases}$$

$$H(X) = \sum_{i=1}^{q} h_i(X)$$

Hereby, the better function used in DECT could constructed as follows:

$$Better(X_1, X_2) = \begin{cases} true, & \text{if } H(X_1) < H(X_2), \\ false, & \text{if } H(X_1) > H(X_2), \\ true, & \text{if } (H(X_1) = H(X_2)) \wedge (f(X_1) \le f(X_2)), \\ false, & \text{if } (H(X_1) = H(X_2)) \wedge (f(X_1) > f(X_2)). \end{cases}$$

where, *f* is the objective. For individuals $X_1$and X_2 , $Better(X_1, X_2)$ = true means that X_1 is better than X_2, otherwise $X_2$is better than X_1.

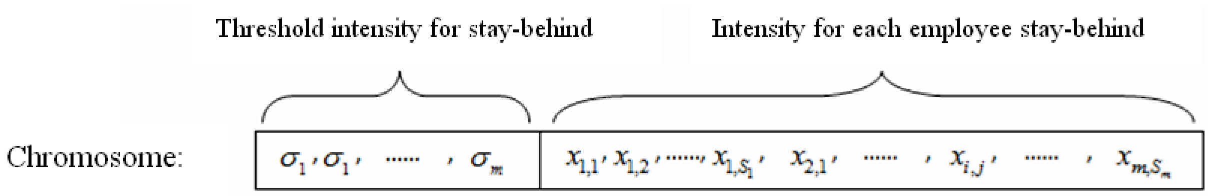
The *Better* function shows that, when two individuals are compared, our preference focus on the satisfaction of the constraints. Suppose two individuals $X_1$and X_2, if $f(X_1) > f(X_2)$ for minimize problem, but $H(X_1) < H(X_2)$, we hold that the X_1 is better than X_2. This mechanism makes the population quickly move toward to the feasible region in the search space *S*, which improves the efficiency for optimal solution searching.

With the operators mentioned above, the general evolving framework of DECT could be constructed as follows.

```
Initialize population of N vectors at random, t = 0
Calculate the fitness of all vectors with Constraint Treatment.
while stop criterion not met do
    for all vectors X_i(t) in the population do
    Pick at random three distinct vectors from the current population X_r1(t), X_r2(t) and X_r3(t),
        where, r1 ≠ r2 ≠ r3.
    Create intermediate vector X_i(t+1) with Mutation operator.
    Do the Crossover and Selection operators for vector X_i(t+1).
    Calculate the fitness of X_i(t+1) with Constraint Treatment.
    End for
End while
```

Based on the needs of downsizing model, a gene fragment, which represents the threshold intensity for stay-behind, is developed and inserted into the chromosome of evolutionary algorithm. The length of the gene fragment equals to the number of departments in a company. Thus, the chromosome for DECT downsizing model could be described as follows (See Figure 1).

FIGURE 1
THE EXPRESSION OF CHROMOSOME IN DECT



After real encoding, $X_i(t)$ could be expressed as follows:

$$X_i(t) = (\sigma_1, \sigma_2, \cdots, \sigma_m, x_{11}, x_{12}, \cdots, x_{ms_m})$$

x_{ij} and σ_i are real values which generated from [0, 1]. When x_{ij} closes to 1, which means that the *j* employee in *i* department strongly contributes to the core value, and achieves a high intensity for stay-behind. When x_{ij} closes to 0, which means that the *j* employee in *i* department has the weakest contribution to the core value, and achieves a high intensity for dismissed.

In the process of problem solving, the evolution of chromosome focuses on two points. One is the optimization of threshold intensity for left-behind. The other one is the optimization of intensity for each employee stay-behind. After generations, an optimal solution will be founded to satisfy the objective model.

DEMONSTRATING SIMULATION

Assume there are three departments (*A*, *B* and *C*) in an enterprise. Furthermore, there are 6 employees in department *A*, 10 employees in department *B* and 14 employees in department *C*. Based on the layoff target, the weight of three departments are 0.3, 0.3 and 0.4 respectively. In step1, management leaders decided to dismiss 3 to 12 employees totally in the whole enterprise. After negotiation, department *A* has to dismiss 0 to 1 employee, department *B* dismiss 0 to 4 employees and department *C* 3 to 7. In step2, HR department evaluate every employee in those three departments following the six criterions in Table 1. The results after evaluated are listed in Table 2. In step3, use DECT to solve the problem, where $\omega_1 = 0.157$, $\omega_2 = 0.122$, $\omega_3 = 0.183$, $\omega_4 = 0.175$, $\omega_5 = 0.197$, $\omega_6 = 0.166$, $\alpha_1 = 0.3$, $\alpha_2 = 0.3$, $\alpha_3 = 0.4$, *N*=100 and C_r=0.9. To evaluate the performance of convergence accurately, the maximum number of function calls (*MAX_NFC*) was employed as the stop criterion. For each trail, the *MAX_NFC* is set to 9000. In order to ensure the accuracy as well as to show the scientific and fairness for employees, the algorithm runs 50 times independently.

According to the situation described above, the constraints of the problem can be illustrated as the following：

$$\begin{cases} h_1 : 5 \le \sum_{j}^{6} \psi(x_{1,j}) \le 6 \\ h_2 : 6 \le \sum_{j}^{10} \psi(x_{2,j}) \le 10 \\ h_3 : 7 \le \sum_{j}^{14} \psi(x_{3,j}) \le 11 \\ h_4 : 18 \le \sum_{i}^{3} \sum_{j}^{s_i} \psi(x_{i,j}) \le 27 \end{cases}$$

The length of individuals in evolutionary population is 33(3+30), the top three genes is the threshold intensity for stay-behind in the relevant department. The residual genes expressed as the intensity of each employee stay behind. The data in Table 3 is the average results of those 50 independent trials.

TABLE 2
SCORE OF EMPLOYEES

Employee	Balance of HR Structure	Organization Strategy	Importance of the Post	Characteristics of Capacity	Performance	Quality
A_1	4	3	1	2	1	4
A_2	2	1	3	2	1	2
A_3	2	5	2	1	4	1
A_4	2	2	2	2	2	2
A_5	3	3	4	4	4	3
A_6	1	2	1	2	1	2
B_1	2	4	2	2	3	2
B_2	3	4	3	2	3	3
B_3	3	4	2	2	3	4
B_4	4	3	2	4	2	2
B_5	4	3	3	4	2	3
B_6	1	1	1	1	1	1
B_7	3	4	4	4	4	5
B_8	2	1	3	2	1	2
B_9	4	3	2	4	2	2
B_{10}	5	5	5	5	5	5
C_1	1	4	4	3	4	1
C_2	2	4	5	4	1	4
C_3	2	4	3	1	2	2
C_4	4	5	4	2	4	5
C_5	1	1	3	1	2	3
C_6	4	4	1	2	3	3
C_7	4	3	3	4	3	1
C_8	2	1	3	2	1	2
C_9	2	5	4	2	2	4
C_{10}	3	3	3	4	2	4
C_{11}	2	1	3	3	2	5
C_{12}	4	3	3	3	2	3
C_{13}	2	4	3	4	1	4
C_{14}	2	5	3	2	2	4

For the downsizing model with the maximum average core value, DECT algorithm generated same results within 50 independent trials. According to the results showed in Table 3, the enterprise needs to dismiss 7 employees in total, they are A_6, B_1, B_6, B_8, C_3, C_5 and C_8. For different departments respectively, department A, B and C dismiss 1, 3 and 3 employees separately. The results satisfied the constraints predetermined. The average threshold for 50 trials are following: $\sigma_A = 0.0$, $\sigma_B = 0.023$ and $\sigma_C = 0.005$.

The score value of A_2, B_8 and C_8 are the same in the table 2. However, A_2 could stay behind while B_8 and C_8 are dismissed. This result is caused by two reasons: (1)These employees are in different departments whose downsizing conditions are not the same; (2)Consider scores obtained by different employees of the same department, their disparity is obvious in department *B* and *C*, while relatively small in department *A*.

TABLE 3
RESULTS OF CALCULATION

Employee	A_1	A_2	A_3	A_4	A_5	A_6	B_1	B_2	B_3	B_4
Intensity	1.0	1.0	1.0	1.0	1.0	0	0	1.0	1.0	0.0
Employee	B_5	B_6	B_7	B_8	B_9	B_{10}	C_1	C_2	C_3	C_4
Intensity	1.0	0	1.0	0	1.0	1.0	1.0	1.0	0	1.0
Employee	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
Intensity	0	1.0	1.0	0	1.0	1.0	1.0	1.0	1.0	1.0

SUMMARIES AND CONCLUSION

This paper establishes a downsizing model based on a general criterion system and uses novel and effective evolutionary algorithms to solve the problem. The result can optimize the average core value of the enterprise as well as dismiss employees efficiently and fairly. Therefore, it can help enterprises to make decisions objectively and scientifically to achieve scientific management and improve enterprise's core competence. To improve the applicability of the model, our next work will focus on the selection of parameters because the computing is sensitive to the value of parameters. In addition, different enterprises in different industries have different strategies. That is why we should make some adjustment of the index and their weight in practice. Only when we ensure the rationality of the parameters, can we make scientific decision.

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