E-Recruiting Technology Investment for Fixed Recruiting Cost Reduction

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ABSTRACT

In this paper, a mathematics-based economic decision model for e-recruiting technology investment is introduced to evaluate the economic impact of various e-recruiting technologies. A classical economic order quantity (EOQ) model was extended to include costs uniquely associated with recruiting activities such as staffing and coordination costs. We derive a minimum employment level for an optimal investment in e-recruiting technologies. The model suggests that the optimal investment cost increases rapidly near the minimum number of employees to be recruited, but the growth of the optimal e-recruiting technology investment cost slows down as the total number of employees to be recruited becomes greater than the minimum number of employees to be recruited.

1. INTRODUCTION

To capture the ever-increasing job seekers in the online labor market, a variety of business-to-labor market (B2L) e-recruiting sources have been introduced since mid-1990s. Some of the widely applied B2L e-recruiting sources include general-purpose job board (e.g., Monster.com; HotJobs.com), niche job board (e.g., JournalismJobs.com; MarketingJobs.com), e-recruiting application service provider (e.g., Recruitsoft; Brassring), hybrid (on-line and off-line) recruiting service provider (e.g., New York Times; Wall Street; Chronicle of Higher Education), e-recruiting consortium (e.g., DirectEmployers.com; NACElink), and corporate career web site (e.g., Cisco; IBM).

Since the introduction of e-recruiting sources in the mid-1990s, a large body of literature has provided anecdotal and descriptive evidence of the effectiveness and efficiency of e-recruiting systems. However, a great risk lies in the over-investment in e-recruiting technologies misled by industry hype as we have witnessed in the dot.com boom and bust. As most large companies have come to view e-recruiting technology as a resource critical to the success of their recruiting strategy, what is needed urgently is the development of a sound decision model of e-recruiting technology investment. In practice, in order for HR managers to secure budgets for investment in e-recruiting technologies, they must justify the return-on-investment in e-recruiting investment to the senior management who place much emphasis on the corporate bottom line. A decision model of e-recruiting technology investment can help them to rigorously evaluate various e-recruiting alternatives and to gain insights into the economic tradeoffs associated with e-recruiting investment.

This paper complements the body of literature on IT evaluation methodologies by presenting an economic e-recruiting investment model. The base for our analytical model is the classic economic order quantity (EOQ) model widely used in manufacturing and inventory management. Since critical differences exist in cost components and cost functions between the classic EOQ model and the recruiting decision model, we expanded the EOQ model to take into consideration cost components that are unique to the recruiting decision-making. The expanded model allows us to determine the optimal number of employees to be recruited per recruiting cycle and the timing of recruiting. Section 3 presents an economic decision model for e-recruiting technology investment and analyzes the relationships between various model parameters and cost performances. Finally, Section 4 concludes with managerial implications.

2. AN ECONOMIC RECRUITING DECISION MODEL

In this section, we introduce an economic recruiting decision model and examine relationships between the model parameters and the optimal number of employees to be recruited. The economic recruiting decision model presented here is based on the cost minimization in staffing model of Dyl and Keaveny (1983). Dyl and Keaveny (1983) presented an analytical model for staffing decisions made by human resources professionals. Their model provided a framework for estimating the optimal size of employment during an employment-planning horizon. Their model explicitly considers overstaffing and understaffing costs and a tradeoff between them. Overstaffing reduces overtime cost at the expense of underutilized labor forces. On the other hand, understaffing incurs overtime cost by overly utilized labor forces. While Dyl and Keaveny assumed that an instantaneous employment of the entire batch of employees takes place at the beginning of the recruiting cycle, we incorporated an on-demand recruiting factor that narrows the timing gap between actual employment and employment needs. The on-demand recruiting factor reflects more reasonably the typical hiring practices of recruiters.

The economic recruiting decision model expands the classic EOQ model. The problem structure of the economic recruiting decision is similar to that of inventory management. While the objectives of these two models are the minimization of total cost, their cost functions and cost components are different from each other. The classic EOQ model

Table 1 Categories of Recruitment Related Costs

<table>
<thead>
<tr>
<th>Categories of Staffing Cost</th>
<th>Fixed Recruiting Costs</th>
<th>Coordination Costs</th>
<th>Overstaffing Costs</th>
<th>Understaffing Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of job specifications</td>
<td>Development of hiring criteria</td>
<td>Checking references</td>
<td>Identification and processing of hiring needs</td>
<td>Excess training expense</td>
</tr>
<tr>
<td>Development of hiring criteria</td>
<td>Advertising expense</td>
<td>Identification and processing of hiring needs</td>
<td>Collecting and processing of job applications</td>
<td>Excess compensation</td>
</tr>
<tr>
<td>Advertising expense</td>
<td>Management of recruiting activities</td>
<td>Collecting and processing of job applications</td>
<td>Prescreening</td>
<td>Overtime compensation</td>
</tr>
<tr>
<td>Management of recruiting activities</td>
<td>Recruiter compensation and travel expense</td>
<td>Prescreening</td>
<td>Contacts of candidates</td>
<td>Excess compensation</td>
</tr>
<tr>
<td>Recruiter compensation and travel expense</td>
<td>Sorting candidates</td>
<td>Interviews coordination (phone calls)</td>
<td>Candidate Visits</td>
<td>Overtime compensation</td>
</tr>
<tr>
<td>Sorting candidates</td>
<td>Planning interviews</td>
<td>Candidate Visits</td>
<td>Candidate Feedback</td>
<td>Excess compensation</td>
</tr>
<tr>
<td>Planning interviews</td>
<td>Applicant tracking</td>
<td>Contracting</td>
<td>Contracting</td>
<td>Overtime compensation</td>
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<tr>
<td>Applicant tracking</td>
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<td>Excess compensation</td>
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identifies the optimal order quantity that minimizes the total inventory management cost. Similarly, the recruiting decision model seeks the optimal number of employees to be recruited per recruiting cycle that minimizes total recruiting cost. While the fixed recruiting cost in the economic recruiting decision model is comparable to the setup cost in the EOQ model, the economic recruiting decision model has several unique cost components: overstafing and understaffing cost, coordination cost, and on-demand recruiting factor. Table 1 lists categories of the recruiting related costs.

The economic recruiting decision model consists of four major recruiting costs: fixed recruiting, overstaffing, understaffing, and coordination costs. The fixed recruiting cost is typically dependent on the recruiting sources. For example, the fixed recruiting cost incurred by traditional newspaper advertising and recruiting agencies are generally more expensive than that of job boards and corporate career web sites. The coordination cost is dependent on the business process. Overstaffing and understaffing costs per employee are relatively constant due to the requirement of the labor contract.

The economic recruiting decision model is based on a number of assumptions. It is assumed that the initiation of each recruiting cycle incurs a certain fixed recruiting cost. The overstaffing occurs when the number of hired employees is higher than that of employees needed for business operations. The overstaffing cost is derived from the underutilized labor portion of the total salaries paid to employees. The understaffing occurs when the number of hired employees is lower than that of employees needed for business operations. The understaffing cost is derived from the overtime costs of the employees who were assigned to the overtime work. Due to inflexibility in the labor market and constant changes in the business environment, a company is typically in either an overstaffing or understaffing situation during most of the time. The total overstaffing and understaffing costs are linearly related to the average number of overstaffed and understaffed employees during the planning period, respectively.

The economic recruiting decision model also assumes that the total number of new employees to be hired is known and constant. While certain groups of employees hired by a company do not have a regular employment pattern, the majority of employees generally follows a standard recruiting process and accounts for most of the recruiting related costs. For the majority of employees, the annual turnover rate, growth of labor forces, and related labor costs can be estimated in advance and reflected in the annual budget and recruitment plan. Next we introduce a nomenclature used throughout this paper and discuss a model formulation.

**Nomenclature**

- $C_o$: annual cost of overstaffing per new employee ($/employee/period)$
- $C_u$: annual cost of understaffing per new employee ($/employee/period)$
- $t_e$: time period of excessive employment stated as a fraction of a planning period T
- $t_s$: time period of labor shortage stated as a fraction of a planning period T
- $N_e^*$: the optimal number of employees per recruiting cycle
- $N_e^*$: the optimal number of excessive employees (overstaffing) per recruiting cycle
- $N_e^*$: the average number of excessive employees (understaffing) in a recruiting cycle
- $N_e^*$: the average number of employees in a recruiting cycle
- $C_r$: fixed recruiting cost per recruiting cycle
- $E$: the number of annual new employees
- $\theta$: daily turnover rate
- $\theta$: daily recruiting rate
- $\theta$: on-demand recruiting factor

**Model Formulation**

Mathematically, the recruiting cost per recruiting cycle is defined as follows:

$$RC = C_o t_e \left( \frac{N_e}{2} \right) \theta + C_u t_s \left( \frac{N - N_e}{2} \right) \theta + C_a + C_e N_e$$

(1)

Then, the total recruiting cost of new employees during a planning period is derived by:

$$\min \ TRC = \frac{C_o N_e^2 t_e}{2N} + \frac{C_u (N - N_e)^2 t_s}{2N} + \frac{C_a}{N_e} + C_e N_e$$

(2)

If the first derivative of Equation (2) is taken with respect to $N_e$, set it equal to zero, and solved, we have an optimal $N_e^*$:

$$N_e^* = \frac{N C_o}{C_o + C_u}$$

(3)

By substituting $N_e^*$ in TRC, taking the first derivative of Equation (4) with respect to $N$, setting it equal to zero, and solving, we have an optimal number of employees $N_e^*$ to be recruited per recruiting cycle.

$$\min \ TRC = \frac{C_o N_e^2}{2N} + \frac{C_u (N - N_e)^2}{2N} + \frac{C_a}{N_e} + C_e N_e$$

(4)

$$N_e^* = \frac{2C_o E (C_o + C_u)}{C_o E}$$

(5)

Figure 1 depicts overstaffing and understaffing of employees and the impact of an on-demand recruiting factor $\theta$ on the number of overstaffing and understaffing of employees. When all the employees to be hired per recruiting cycle are employed at the same time (i.e., instantaneous employment), the on-demand recruiting factor $\theta$ is equal to one. As employees are employed at a time close to the time when they are actually needed, the on-demand recruiting factor $\theta$ approaches to zero. When the on-demand recruiting factor $\theta$ reaches zero, the timing of actual employments matches exactly that of the hiring needs and the overstaffing and understaffing costs are equal to zero.

**Example**

Consider the following recruiting situation. Based on a historical turnover rate and growth plan, a company predicts that the number of new employees to be hired annually is 500. No matter how many employees are recruited, a fixed recruiting cost is incurred per recruiting cycle.

Figure 1 Staffing of Employees and On-Demand Recruiting Factor
cycle. There is a tradeoff between the frequency of recruiting cycles and staffing costs. As the number of recruiting cycles during a planning period increases, the fixed recruiting cost increases linearly and staffing cost decreases.

The recruitment lead-time and the timing of the recruiting initiation determine the overstaffing and understaffing costs. The overstaffing cost is incurred when the hired employees are not fully utilized due to excessive labor forces. The understaffing incurs a certain overtime cost when a labor shortage forces existing employees to work overtime to meet production schedules. When overtime is not used, the understaffing cost may be estimated from the lost sales opportunities. The coordination cost is variable and dependent on the total number of new employees to be hired. The company needs to find the optimal number of employees to be recruited per recruiting cycle during a planning period that minimizes the total recruiting cost. The following parameters are assumed for this example:

**Model Parameters**

- \( C_a = 5,000/\text{employee to be hired/planning period} \)
- \( C_{ac} = 6,000/\text{employee to be hired/planning period} \)
- \( C_a = 1,000/\text{recruiting cycle} \)
- \( \varepsilon = 1.0 \)
- \( C = 1,500/\text{employee to be hired/planning period} \)
- \( E: 500/\text{planning period} \)

The straightforward applications of Equations (3), (4) and (5) lead to the following optimal solutions:

\[
N^* = 10 \\
N^*_e = 10 \\
TRC^* = \$802,224.88
\]

Figure 2 (a) and (b) show the relationships between the optimal number of employees to be hired per recruiting cycle and on-demand factor and fixed recruiting cost. As can be seen from Figure 2 (a) and (b), on-demand factor and fixed recruiting cost affect the optimal number of employees per recruiting cycle in the opposite direction in minimizing the total recruiting costs, respectively. The decrease of on-demand factor has an effect of reducing the average number of employees to be hired during the planning period and reducing total overstaffing and understaffing cost. On the other hand, the reduction of the fixed recruiting cost makes the decrease in the number of employees to be hired per recruiting cycle more attractive.

The reduction of the fixed recruiting cost and on-demand recruiting factor, ceteris paribus, decreases the total recruiting cost, respectively. While the economic recruiting decision model is a useful tool as a human resource planning and recruiting, it does not address the investment decisions that can affect the change of parameter values of fixed recruiting cost and on-demand recruiting factor in the decision model. We address these questions in the following section.

**3. AN ECONOMIC DECISION MODEL FOR E-RECRUITING TECHNOLOGY INVESTMENT**

In this paper, we define e-recruiting as a company-wide recruiting activities and practices that utilize a variety of electronic means throughout the entire recruiting process. In the past decade, companies have invested heavily in e-recruiting technologies to reduce the recruiting cost and improve the recruiting process. While a body of literature has shown the cost-effectiveness and efficiency of the e-recruiting technologies, these studies presented descriptive results at best, and the tradeoff between investment costs and benefits has not been formally investigated. Studies of corporate IT investment show that most business organizations overspend in IT technologies, but rarely achieve superior financial returns (Carr [2003]). To complement the deficiency of the existing body of literature, we present an economic decision model for e-recruiting technology investment and analyze the relationship between an investment in the e-recruiting technologies and the total recruiting cost. The economic decision model for e-recruiting technology investment allows us to identify the condition under which a company would be better off with the e-recruiting investment and to gain insights into the reasons individual companies make different investment decisions in the e-recruiting systems.

**Investment in Recruiting Fixed Cost Reduction**

In the previous economic recruiting decision model, the fixed recruiting cost \( C_a \) was assumed to be constant. In this section, we assume that the \( C_a \) is an exponential function with a base \( e \) where an e-recruiting investment cost of \( S \) reduces the fixed recruiting cost. Billington (1987) suggested a similar exponential function with base \( e \) to determine the optimal investment cost for the reduction of setup costs in the classic EOQ model. Porteus (1985) suggested an EOQ model to study optimal investment in setup cost reduction for the cases of both a logarithmic and a power setup cost function. In this paper, Equation (2) is extended to include investment cost of \( S \), resulting in Equation (6).

\[
\text{Min } TRC = \frac{C_a N}{2} \left( \frac{C_a}{C_a + C_{ac}} \right) \theta + \frac{C_a N}{2} \left( \frac{C_a}{C_a + C_{ac}} \right)^2 \theta + C_a E \frac{E}{N} + C_{ac} E + S
\]  

An exponential investment function for the reduction of \( C_a \) is defined in Equation (7).

\[
C_a = L + (H - L)e^{-\lambda S}, \quad S \geq 0
\]

where \( H \) is the highest fixed recruiting cost incurred when there is no investment in e-recruiting technology and \( L \) is the lowest fixed recruiting cost achievable by the investment of \( S \).

To derive the optimal solution for the technology investment, the first derivative of Equation (6) is taken with regard to \( S \) and set to zero, and solved. The result is given by

\[
\frac{\partial TRC}{\partial S} = \frac{C_a E}{N} + 1
\]

\[
\frac{\partial C_a}{\partial S} = \frac{N}{E}
\]
The first derivative of Equation (7) is taken with regard to $S$. The result is given by

$$\frac{\partial C_a}{\partial S} = -\lambda(H-L)e^{-\lambda S} = -\lambda(C_a - L) < 0 \quad (10)$$

Setting Equation (9) equal to Equation (10) and substituting Equation (5) for $N$ in Equation (11) yields Equation (12). Then, by solving Equation (12), we derive the optimal fixed cost $C_a^*$ from Equation (13).

$$N^* = \frac{\lambda E(C_a - L)}{E} \quad (11)$$

$$\lambda E(C_a - L) = \frac{2C_aE(C_a + C_e)}{C_aC_e \theta^2 E} \quad (12)$$

where

$$d = L + \frac{(C_e + C_a)}{C_a \theta \lambda^2 E} \quad (14)$$

Given the optimal fixed recruiting cost $C_a^*$, then optimal investment $S^*$ and $N^*$ are derived from Equations (15) and (16), respectively.

$$S^* = \frac{\ln \left( \frac{C_a^* - L}{H - L} \right)}{-\lambda} \quad (15)$$

$$N^* = \lambda E(C_a^* - L) \quad (16)$$

To identify the minimum number of employees to be recruited during a planning period for the optimal investment, Equation (13) is set less than or equal to $H$ and solved, resulting in Equation (17). Note that the minimum employees to be recruited can be derived from Equation (17) without the optimal solutions. Therefore, $\frac{2(C_e + C_a)H}{C_a C_e \theta^2 (H - L)^2}$ can serve as a threshold value for investment decision-making.

$$E \geq \frac{2(C_e + C_a)H}{C_a C_e \theta^2 (H - L)^2} \quad (17)$$

### Analysis of E-Recruiting Investment: Example

**Base Parameters**

- $C_e$=$5,000$/planning period
- $C_a$=$6,000$/planning period
- $H$=$1,000$
- $L$=$200$
- $F$=$1.0$
- $G$=$0.1$
- $W$=$1,500$
- $Z$=$1,000$
- $\varepsilon$=$0.0001$
- $\delta$=$0.0001$

- Base $C_e$=$1,000$
- Base $\varepsilon$=$1.0$
- Base $C_a$=$1,500$

Total recruiting cost with no investment in recruiting technology: $802,224.88$

### REFERENCES


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