Integrated Management Model for Human Capital

Contents

1 Introduction

Considering the shortage of the talent, it's essential for companys to retain good people and make them well-trained. However, current situation is not satisfactory while many talents always tend to get a good job via job-hopping, causing orgnizational churn in employees who are closely connected to them.

ICM is facing such an issue that the churn rate reachs 18%. The churn rate of middle managers even reaches twice as much as others. At present, the company only has 85% of its positions occupied while HR is recruiting only 8%-10% of the vacancies due to limited resources. In addition, HR department hopes to place employees to suitable positions to maximize their talent. In order to simulate this situation and help to improve it, we build a human capital model based on Social Network Analysis and Markov process.

There are several tasks we need to accomplish:

- Build a Human Capital network model of ICM's personnel situation.
- Identify dynamic processes within the Human Capital network, which includes organizatinal churn and direct and indirect effects on the organization's productivity.
- Analyze the organization's budget requirements over the next 2 years.
- Judge if ICM could sustain its 80% full status for positions if the annual churn rate for all positions goes to 25% and 35% respectively. Calculate the costs of these higher turnover rates and describe the indirect effects of these high churn rates.
- Assumes that there is no external recruiting and ICM promotes only qualified employees for the next two years. Simulate the impact of 30% churn rate in both junior managers and experienced supervisors, if other churn values remain 18%.
- Connect our Human Capital network to other organizational network layers such as information flow, trust, influence, and friendship that the other offices of ICM are considering building.

2 Variables and Descriptions

Definitions of symbols employed in this section are listed in **Table 1**, where all the subscripts with t represent the t-th month and all the subscripts with i represent the employee indexed by i:

3 Human Capital Model

3.1 Assumptions and Justifications

- **Assumption 1** If an employee has an opportunity to be promoted, he won't leave the company.

Variable	Description
i	Index of an employee
$L_{i,t}$	The level of i
$A_{ac_i,t}$	The work achievement of i
$A_{ab_i,t}$	The work ability of i
$A_{at_i,t}$	The work attitude of i
$A_{po_i,t}$	The potential of i
$A_{i,t}$	The grade of i
$s_{ij,t}$	The relation strength from i to j
$a_{ij,t}$	The influence caused by leader-member relation between i and j
$f_{ij,t}$	The influence caused by friendship between i and j
$c_{i,t}$	The Clustering Coefficient of i
$p_{i,t}$	Promotion probability of i
$l_{i,t}$	Churn probability of i
$prod_{i,t}$	Productivity of i
$salary_{i,t}$	Salary of i
$d_{i,t}$	The work experience of i
m_{ij}	The variable to reflect whether employee indexed by i is suitable for position indexed by j
B_{ac_j}	The suitable work achievement of position indexed by j
B_{ab_j}	The suitable work ability of position indexed by j
B_{at_j}	The suitable work attitude of position indexed by j
B_{po_j}	The suitable potential of position indexed by j
N	The number of employees over the next two years
p	The average productivity over the next two years
r	The percentage of recruiting positions in ICM positions
c	The current churn rate
ra	The ratio of the churn rate between middle managers and the rest employees

Table 1: Variables and Descriptions

The possibility of the unforeseen accidents, which could force an employee to leave his position, is neglected. Based on human nature, an employee will stay at his position to chase for higher level.

- **Assumption 2** For each vacancy, if there exists an employee satisfying its requirement, ICM won't recruit for it.

  Since recruiting good people is difficult, time consuming and expensive, it is wasteful to recruit for a position if an employee satisfies the requirement.

- **Assumption 3** Demotion won't occur.

- **Assumption 4** Administrative clerk won't be promoted or be reassigned.

- **Assumption 5** Each division or office has at least one middle manager or senior manager.

3.2 Model Overview

Most researches on human capital can be classified as either microscopic or macroscopic. Since both macroscopic and microscopic methods alone can not solve the problem perfectly, we approach the problem with the combination of macroscopic and microscopic methods.

To measure the ability of each person, we use Quantitative Management Performance. Via this measurement, we can classify different kinds of employees which will influence the promotion process.

To build the employee network and analyze its properties, we employ the social network analysis (SNA) technique. In our model, employees are viewed as nodes and relationships are viewed as links among employees. With this network, we can simulate the complex relationship.

3.3 Employee Performance Model

In this part, we build an Employee Performance model to evaluate an employee in four aspects, in terms of Quantitative Management Performance — work achievement, work ability, work attitude and potential[3]. These four aspects are supposed to be quantized according to the annual evaluation based on performance judged by the supervisor and we take these independent variables as $A_{ac_i,t}$, $A_{ab_i,t}$, $A_{at_i,t}$ and $A_{po_i,t}$ for each employee indexed by i. Each of these four parameters ranges from 0 to 1. They are used to calculate the promotion probability for each employee. Meanwhile, they influence the leaving probability and team cohesiveness.

It is obvious that these parameters are of different importance. So in an effort to make our model more accurate and reliable, we introduce a weighted index of deviation $A_{i,t}$, with

$$A_{i,t} = w_{ac} \cdot A_{ac_i,t} + w_{ab} \cdot A_{ab_i,t} + w_{at} \cdot A_{at_i,t} + w_{po} \cdot A_{po_i,t} \tag{1}$$

We determine weights via the Analytical Hierarchy Process(AHP) [Saaty 1982]. We build a 4×4 reciprocal matrix by pair comparison:

	A_{ac}	A_{ab}	A_{at}	A_{po}
A_{ac}	1	5	2	1
A_{ab}	$\frac{1}{5}$	1	$\frac{1}{3}$	$\frac{1}{4}$
A_{at}	$\frac{1}{2}$	3	1	1
A_{po}	1	4	1	1

The meaning of the number in each cell is explained in **Figure 2**[11]. The numbers themselves are based on our own subjective decisions.

Intensity of Importance	Definition
1	Equal Importance
2	Weak or slight
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong or demonstrated importance
8	Very, Very strong
9	Extreme importance

Table 2: The fundamental scale of absolute numbers

We then get the weight of each parameter by calculating the bigest eigenvalue and it's corresponding eigenvector, as given in **Table 3**.

We test the consistency of the preferences for this instance of the AHP. For good consistency [4]:

- The principal eigenvalue λ_{max} of the matrix should be close to the number n of alternatives, here 4; we get $\lambda_{max} = 4.047$.
- The consistency index $CI = (\lambda_{max} - n)/(n-1)$ should be close to 0; we get $CI = 0.0157$.
- The consistency ratio $CR = CI/RI$ (where RI is the average value of CI for random matrices) should be less than 0.1; we get $CR = 0.0182$.

Hence, our decision method displays perfectly acceptable consistency and the weights are reasonable.

Factor	A_{ac}	A_{ab}	A_{at}	A_{po}
Weight	0.3805	0.0709	0.2371	0.3030

Table 3: Weight for factors

3.4 Social Network Model

The social network model contains a directed weighted graph $G(V, E)$ in which V denotes the employees and E denotes the connection between employees. Since there are personnel changes, $G(V, E)$ will change with time goes by. In order to simulate this situation, we use $G_t(V_t, E_t)$ instead of $G(V, E)$ where t is a discrete variable. So $G_t(V_t, E_t)$ denote the social network in the t-th month.

Firstly, we explain the way we build edges of $G_t(V_t, E_t)$.

When $t = 0$, there are about $370 \times 85\%$ nodes (employees) in G_t. We build edges between employees in the same division or office, since employees in the same division or office certainly know each other. So each division or office form a complete graph. To establish inter-division or inter-office relations, we build 10 edges for each employee with employees in other divisions with equal probability. Then we build the other edges between employee indexed by i and employee indexed by j with the probability $p = \frac{|N_{i,t} \cap N_{j,t}|}{|N_{i,t} \cup N_{j,t}|}$ which is called Jaccard similarity coefficient[Jaccard 1901].

When $t > 0$, there will be employees leaving or joining the company. If an employee leaves, all his relations with other employees will be deleted. If an employee newly joins the company, he will follow steps which employees at $t = 0$ take.

Let $s_{ij,t} \in E_t$ denotes the weight from i to j in t-th month. We have these properties of $G_t(V_t, E_t)$:

- $s_{ij,t} \neq s_{ij,t}$

  We made this graph directed and weighted because one person may consider another person his best friend while that person doesn't consider him a good friend. This situation may appear in leader-member relations and the relations between person with more friend and person with less friend. In general, $s_{ij,t} \neq s_{ij,t}$ for the reason above.

- $s_{ij,t} = \dfrac{a_{ij,t} + f_{ij,t}}{2}$

  $a_{ij,t}$ denotes the influence caused by leader-member relation between the employee indexed by i and the employee indexed by j, $f_{ij,t}$ denotes the influence calculated by the amount of friends of the employee indexed by i and the employee indexed by j. We define

$$a_{ij,t} = \begin{cases} \frac{1}{2+|L_{i,t}-L_{j,t}|}, & L_{i,t} \geq L_{j,t} \\ 1 - \frac{1}{2+|L_{i,t}-L_{j,t}|}, & L_{i,t} < L_{j,t} \end{cases} \tag{2}$$

  , where $L_{i,t}$ denotes the level of i in t-th month, and

$$f_{ij,t} = \frac{|N_{i,t} \cap N_{j,t}|}{|N_{i,t}|} \tag{3}$$

3.5 Promote and Churn Model

Firstly, we explain the model of promotion designed to predict the promotion probability. The promotion rate of the employee indexed by i is defined as p_i to

evaluate the probability of promotion. If there is a vacancy, judging if an employee is qualified for the position depends on his work experience and ability. First of all, it is essential to evaluate whether he has the special work experience. If he matches the condition of work experience, his ability will be evaluated subsequently. In Human Performance Model, each employee's ability is evaluated by a parameter A_{D_i}. Each level of position has its own ability standard. The ability of an employee is supposed to reach the four standard parameters respectively, otherwise its p_i is set to 0. For those who reach the standard, the promotion probability can be calculated by the equation: $p_i = \frac{A_{D_i}}{\sum_\alpha A_{D_\alpha}}$ where α represents employee who has probability to be promoted.

According to **Assumption 1** and **Assumption 2**, the model updates monthly (from t to $t+1$) obeying the following rules:

step 1 Promotion: If there's a superior vacancy and the employee indexed by i satisfies the requirement of the position, let $L_{i+1,t} = L_{i,t} + 1$ with the probability mentioned above and build edges between i and his new colleagues.

step 2 Churn: If the employee indexed by i isn't promoted, he will have the probability to churn with a churn rate $l_{i,t}$.

step 3 Stay: If the employee indexed by i hasn't been promoted or churned, he will be kept on his original position.

4 The Improved Model

4.1 Assumptions and Justifications

- **Assumption 6** Except the promotion probability and organization change, the other factors effects the churn probability are invariable.

  Though churn probability is influenced by varieties of factors, we do not have enough information about these factors. Therefore, we have to regard most of them as constants in our model.

- **Assumption 7** Productivity of the company is the sum of the productivity of all employees.

4.2 Organizational Churn

The network of the company we've built changes from time to time due to organizational churn and promotion. Considering various of factors in reality, we build an organizational churn and promotion model to predict the dynamic process.

The first part of the model is churn model. We define the churn rate of the employee indexed by i as $l_{i,t}$. We divides $l_{i,t}$ into three parts: $l_{i1,t}$, $l_{i2,t}$ and $l_{i3,t}$. $l_{i1,t}$ represents the churn rate resulting from the lack of promotion opportunity. $l_{i2,t}$ represents the churn rate resulting from the personnel alterations of other employees who share an edge with employee indexed by i. To simplify our model, we presume that $l_{i1,t}$, $l_{i2,t}$ is linear correlated with $(1 - p_{i,t})$ and $s_{ij,t}$, which means

$$l_{i1,t} = \lambda_1(1 - p_{i,t}), l_{i2,t} = \lambda_2 \sum_j s_{ij,t} \tag{4}$$

λ_1 and λ_2 could be determined in later calculation.

$l_{i3,t}$ represents the other factors we regard as constants, about which we can't get enough information from the known conditons. Thus

$$l_{i,t} = \lambda_1(1 - p_{i,t}) + \lambda_2 \sum_j s_{ij,t} + l_{i3,t} \tag{5}$$

After analyzing a great deal of churn rate reports, we define the coefficients of the three parts to 10.9%, 2.2% and 75.4% respectively[1][2]. With these percentages and the general churn rate 18%, we can calculate λ_1, λ_2 and $l_{i3,t}$. As an original condition, it satisfies

$$\begin{cases} \lambda_1 \sum_{i=1}^{370}(1 - p_{i,t}) & = 10.9\% \times 370 \times 1.5\% \\ \lambda_2 \sum_{i=1}^{370} \sum_j s_{ij,t} & = 2.2\% \times 370 \times 1.5\% \\ l_{i3} & = 1.5\% \times 75.4\% \end{cases} \tag{6}$$

Thus we can use **Equation 6** to calculate the churn rate l_i.

To analyze the consequence of this phenomenon, we used our program to simulate this process. As a result, we observed an organizational churn in our simulation as shown in **Figure 1**.

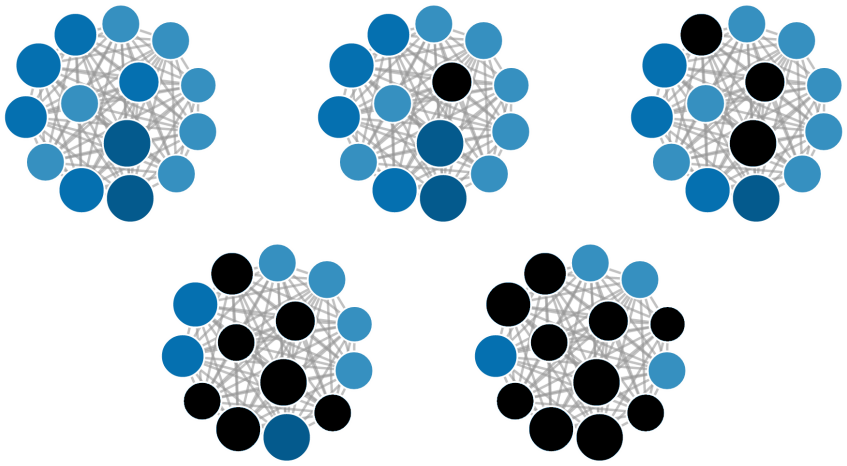

Figure 1: Organizational Churn

The black spots in the graph denote employees who have leaved during the past year. Each graph represents the status of 3 months after the privious graph. In the first 3 months, there is only one employee leaving the company. In the second 3 months, there are two employees leaving the company, while 4 more employees leave during the next 3 months. As a conclusion, there's a phenomenon of organizational churn according to our model.

4.3 Productivity

Firstly, we explain the concept of clustering coefficient [Duncan J. Watts and Steven Strogatz 1998] of employee indexed by i denoted as $c_{i,t}$, which is a measure

of the degree to which nodes in a graph tend to cluster together. $c_{i,t}$ is defined as:

$$c_{i,t} = \frac{|\{s_{jk,t} : v_j, v_k \in M_i, s_{jk,t} \in E\}|}{k_{i,t}(k_{i,t} - 1)} \tag{7}$$

where $M_{i,t} = \{v_j : s_{ij,t} \in Es_{ji,t} \in E\}$ and $k_{i,t} = |N_{i,t}|$.

In order to get the definition of productivity, we give some factors that will influence productivity:

- The first factor is churn rate which will reduce the productivity if churn rate is at a high level.
- The second factor is the clustering coefficient $c_{i,t}$, which determines team cohesiveness. We consider that the higher $c_{i,t}$ is, the higher the productivity is.
- The third factor is the ability of employee indexed by i mentioned in **Section 3.3**. It is obvious that a higher ability brings a higher productivity.
- The fourth factor is the time duration that i stays in his position, denoted as $d_{i,t}$. Productivity will increase as the employee get familiar with his job.
- The last factor is the salary of employee indexed by i, denoed as $salary_{i,t}$. It is obvious that salary will influence the productivity.

According to the factors described above, we have the formula for calculating productivity:

$$prod_{i,t} = salary_{i,t} \cdot c_{i,t} \cdot A_{i,t} \cdot d_{i,t} \cdot (1 - l_{i,t}) \tag{8}$$

Finally, we introduce the direct and indirect effects on the organization's productivity. With the relation updates, edges in our employee network update, which causes the clustering coefficient changes. Meanwhile, the salary and work experience will change over time, which results in the changing of productivity. These factors effect the productivity collectively.

5 Further Improved Model

As the HR manager faces many problems such as identifying employees that are likely to churn and maximizing employees' knowledge and abilities, we propose our further improved model to help the HR managers.

5.1 Incentive Mechanism

An employee is more likely to churn if he or she was connected to other former employees who have churned. So there are two kinds of people who should be highly paid attention to and incented.

Firstly, we should pay attention to those who have more friends than others. Because of their wide connection with other employees, the consequence of their churn may be destructive, which can cause many friends' churn.

Secondly, we focus on those having more friends who have churned during the past year. This kind of people have a great probability to churn because of the influence of others.

We choose one sample in our simulations to explain our incentive mechanism. **Figure 2** shows only 50 people in the sample.

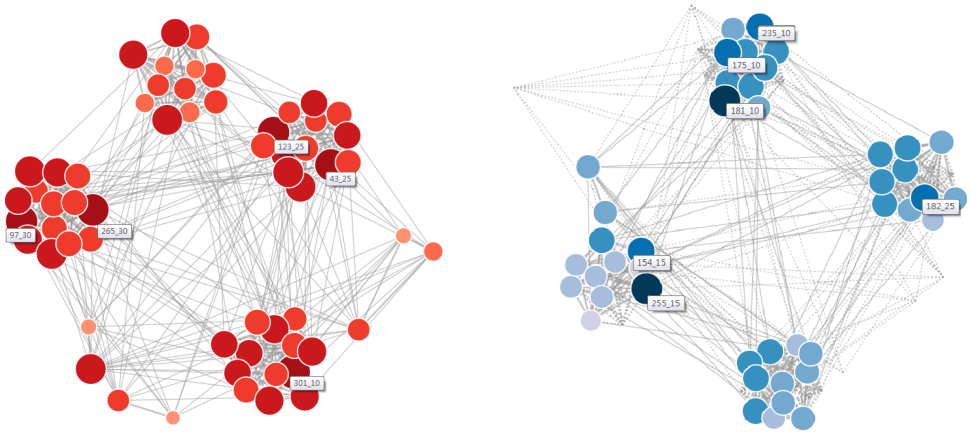

Figure 2: Employees should be pay attention to

In **Figure2**, as we can see, each vertex represents an employee, each solid line represents a relation between two employees, each dotted line represents an relation between a person who is on the job and a person who have churned. There are 5 employees in left graph we should pay attention to which are employees indexed by 43, 97, 123, 265 and 301 because they have more solid lines than others. There are 6 employees in the right graph we should pay attention to which are employees indexed by 154, 175, 181, 182, 235 and 255 because they have more dotted lines than others.

We should provide incentives to these employees which will decrease their probabilities to churn.

At t-th month, we choose top 10% of the employees which have the properties above and reduce their churn rate by 50%. As shown in **Table 4**, the churn rate decreases rapidly in one year.

t	1	2	3	4	5	6	7	8	9	10	11	12
without incentive mechanism	6	5	7	7	6	6	7	4	5	5	6	6
with incentive mechanism	5	3	4	4	4	5	3	3	4	2	4	3

Table 4: The amount of people leaving

5.2 Matching Employees to the Right Positions

We assume that different employees have different abilities. As we have an annual evaluation based on performance for each employee and each division or office has it's necessarily needed abilities, we can match employees with their most suitable positions.

Because the evaluation is given annually, we reassign employees annually according to their abilities and the formula below:

$$m_{i,j} = (A_{ac_i} - B_{ac_j})^2 + (A_{ab_i} - B_{ab_j})^2 + (A_{at_i} - B_{at_j})^2 + (A_{po_i} - B_{po_j})^2 \tag{9}$$

where B_{ac_j}, B_{ab_j}, B_{at_j}, B_{po_j} represent the abilities needed for position j.

Defining $x_{ij} = \begin{cases} 1, & \text{reassign employee } i \text{ to position } j \\ 0, & \text{otherwise} \end{cases}$, we can describe this problem as a mathematical programming problem:

$$\begin{aligned} &\min \sum_{i=1}^{n}\sum_{j=1}^{m} m_{ij}x_{ij} \\ &s.t. \sum_{j=1}^{m} x_{ij} = 1, i = 1, 2, \ldots, n \\ &\sum_{i=1}^{n} x_{ij} \leq 1, j = 1, 2, \ldots, m \\ &x_{ij} = 0 \text{ or } 1, i = 1, 2, \ldots, n, j = 1, 2, \ldots, m \end{aligned} \tag{10}$$

We can solve this problem via KuhnMunkres algorithm [Harold Kuhn and James Munkres 1957] whose time complexity is $O(n^4)$.

We reassign them annually according to their evaluation. **Figure 3** shows the productivity with reassignment and without reassignment. We can find that the productivity increases rapidly after reassigning employees, which means reassignment truly help with increasing the productivity of the company.

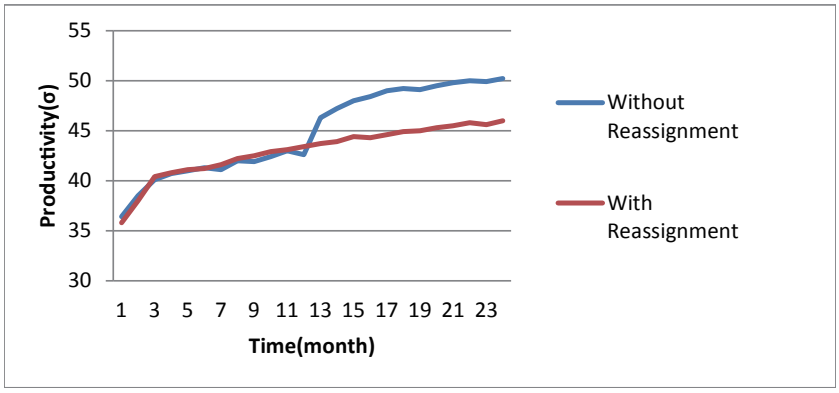

Figure 3: Productivity-Time Curve

6 Performance and Analysis

6.1 Analysis for Task 3

We assume that the company offers training programs for its employees monthly and newly hired employees start to get their salaries next month after they enter

the company. With these two assumptions, results can be drawn according to our model through simulation.

Budget can be divided into threee parts: salary budget, training budget and recruiting budget. The budget requirement predicted for next two years is listed in the **Table 5** below in terms of σ.

Total Budget	Salary Budget	Training Budget	Recruiting Budget
1170.8σ	951.387σ	164.423σ	55.08σ

Table 5: Budget

6.2 Analysis for Task 4

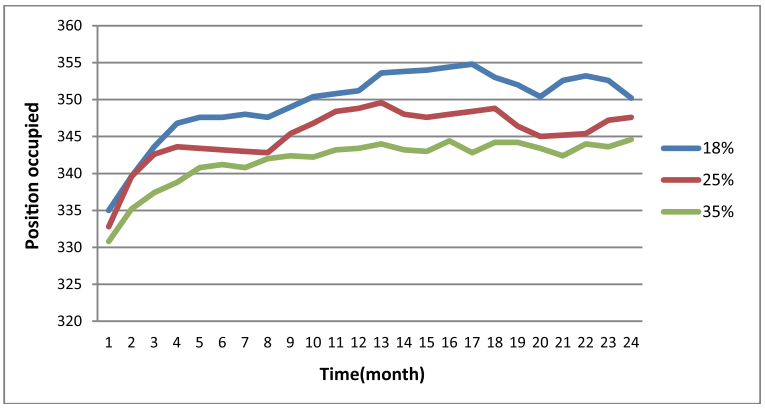

Figure 4: Status of positions

To analyze the status of positions under different churn rate, we use our model to simulate dynamic processes with these churn rate constraints. We execute our program 100 times for each churn rate and average the predicted values. **Figure 4** shows the averaged results our model predicted. Under all of these three conditions, the number of employees in the company keeps rising. The higher the churn rate, the lower the final full rate the company reaches after two years. But ICM can sustain its 80% for positions even if the churn rate goes to 35% according to our model's prediction.

The churn rate effects the budget of the company as well. Three parts of the bugdet behave differently when churn rate increases. The calculated budget is shown in **Figure 5** and **Figure 6**. Each data point in three charts is an averaged result of 10 predictions and a linear trendline is added to each chart. It is clear that recruiting budget showed in **Figure 5** is likely to be proportional to the churn rate while salary budget and training budget showed in **Figure 6** are likely to be inversely proportional to the churn rate.

To maintain enough employees, the company has to spend more on recruiting. So high turnover rate directly increase the recruiting budget. High turnover rate's effect on training budget and salary budget is more complex. On the one hand, when churn rate goes up, vacancies in the middle level keeps rising due to long

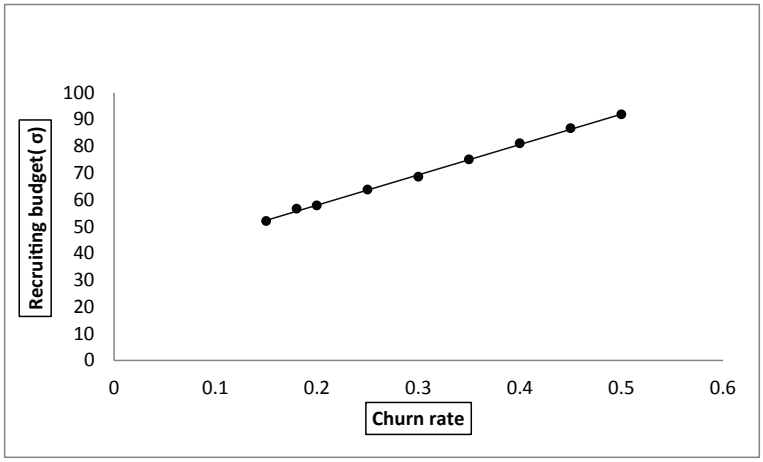

Figure 5: Recruiting budget

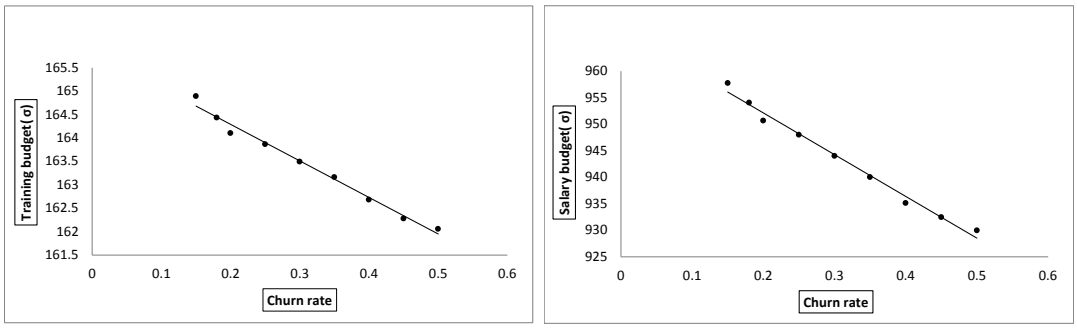

Figure 6: Training budget and salary budget

recruiting time and low promotion rate. On the other hand, the vacancies in lower level rises due to the huge base number. So the full rate of the company decreases when churn rate rises. Since training budget and salary budget are closely related to full rate, both of them decrease when turnover rate goes up.

6.3 Analysis for Task 5

We apply following changes to our model to simulate the required process:

- Change the churn rate of junior managers and experienced supervisors to 30%
- Prohibit external recruiting
- Promoting only qualified employees

The result of simulation is shown in **Figure 7** and **Table 6**. All the data shown is an average of ten predictions. While the number of positions occupied remains stable with origial conditions, it drops remarkably with modified conditions.

We list specific data of each level in **Table 6**. In the modified case, the numbers of employees are lower than original case especially those of the middle levels. Since there is no external recruiting in modified case, it is obivious that the full rate will decrease due to employees' leave. Although some qualified employees

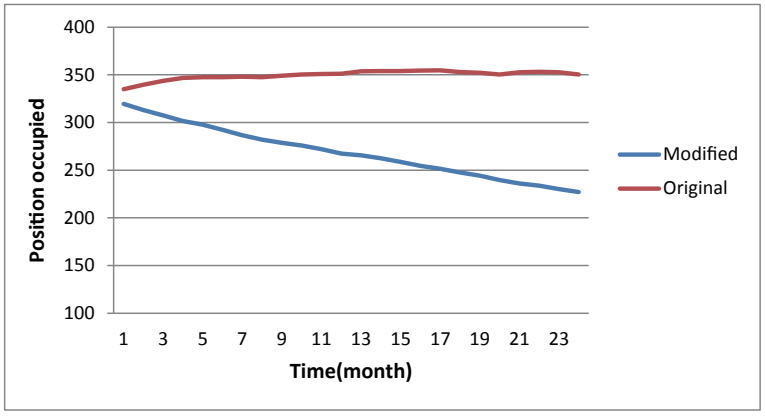

Figure 7: Status of position

Level of Position	Modified	Original
Senior manager/Executive	5.6	8.4
Junior manager/Executive	9.0	18.4
Experienced supervisor	7.4	23.0
Inexperienced supervisor	9.2	23.2
Experienced employee	72.6	107.4
Inexperienced employee	99.6	149.6
Administrative clerk	24.0	24.0

Table 6: Status of position

can be promoted into higher level, the high churn rate of the middle level and difficulty of satisfying the promotion conditions make the numbers of middle level employees relatively low. The situation given in task 5 will cause unrecoverable damage to ICM's HR health. With the full rate of middle level employees lower than 50%, the HR structure is broken into fragments and the company won't be able to function normally.

7 Team Science and Multi-layered Network

This part summarizes the potential use of team science and multi-layered networks in this problem.

Team Science shows how team works with team and how team members intereffect. The theory is helpful for promoting team cohesiveness and teamwork effeciency. The existing researches suggest that an organization aiming to improve its teamwork effeciency should establish its team cognition, evaluate the individuals appropriately, provide team training and try to identify the factors that influence the team performance[8][9].

A well-designed model can be great helpful to achieve goals listed above. Multi-layered model is a good example. We will introduce how to connect our model to the other organizational network layers such as information flow, trust, influence

and friendship. Number the layers from 0 to k.

$$G^{\alpha} = (V^{\alpha}, E^{\alpha}), \alpha = 1, 2, \ldots, k$$

Each E^{α} is colored by a specific color. G^0 reprensents the network we built before, $G^1, G^2, \ldots, G^k$ represent the other layers added.

Still, in each network layer G_{α}, N_i represents employee i. The edge e_{ij} connects between two nodes N_i and N_j. Each edge has a value w_{ij}^{α} proving the weight of edge e_{ij}^{α}, positive correlated to the strength of connection between two employees in network layers α. Then we connect these network layers together to built a general network $G_e = (V, E, C)$, V is node set, C is color set, $E \subset V \times V \times C$ is edge set[10]. In the general model, different layers effect each other. Take an example, if the friendship between employee indexed by i and employee indexed by j is deeper, with other conditions same, their information flow will be more fluent. w_{ij}^{α} is changing with time flows and G_e is a dynamic network.

However, the human capital network plays a leading role to other network layers. In the general network, if an empolyee churns or is reassigned, the edge related to him will change. That is, w_{ij}^{α} get a new value for all α. Hence, human capital network takes the lead in this effort.

8 Sensitivity Analysis

We analyze sensitivity of our model by running the program with modified parameters. The results are shown in **Table 7**.

Parameter	Variation	N	p	Training Budget	Salary Budget	Recruit Budget	Total Budget
r	+5%	0%	+1.3%	+0.46%	+0.6%	-0.49%	+0.5%
	-5%	+0.8%	-4%	-3.5%	-4.4%	-8.5%	+4.5%
c	+5%	-1.4%	-2.1%	-0.2%	-0.5%	+12.4%	+0.1%
	-5%	0%	+1.1%	0.4%	+0.7%	-11.7%	+0.1%
ra	+1	-0.9%	-0.6%	-1.2%	-1.7%	+24.0%	-0.5%
	-1	+1.1%	+6.7%	+1.0%	+0.8%	-17.4%	-0.1%

Table 7: Sensitivity analysis

With c rising, N and p keeps stable. When c drops, they varies more clearly. It is because in current condition, the positions are nearly all occupied. It won't make obvious change if c rises. For the similar reason, N and p changes little when c drops while they changes more clearly when c increases. If ra drops to 1, N and p increase considerably, which proves that reducing middle manangers' churn rate is quite beneficial to HR health. As for the budget requirements, training budget, salary budget and total budget stay stable, while recruiting budget changes quite obviously. It is because the change of these paramenters greatly changed the number of the newly-recruited employees. The other budgets change relatively lower because they are mainly associated to N, which doesn't change much while ra varies.

9 Strengths and Weaknesses

Strengths

- Our model make full use of the theory of multilayer networks so that it quantizes the relation accurately and reasonablly.
- Our model exellently proves the interaction among these factors: leave probability, promotion probability and productivity.
- The network we built includes both microcosmic and macrocosmic which react to each other.
- Our model is robust according to sensitivity test.

Weaknesses

- Limited by the time, we neglected sorts of factors which are not so significant. In fact, the model still has space to be perfected.
- Our result involves some randomness.

10 Conclusions

For Task 1, we propose an Employee Relation Model based on the SNA (social network analysis) technique. Meanwhile each node (employee) in the network has several characteristics which are used to evaluate the employee corresponding to the node. We calculate the grade of each employee by evaluating based on AHP (analytic hierarchy process) technique. Based on these grades, we predict the promotion probability for each employee in the company.

For Task 2, we establish an Organizational Churn Model to simulate the effects caused by the leaving of employees. Furthermore, we introduce a new method to calculate the productivity considering five factors, including churn rate, team cohesiveness, employee ability, work experience and salary.

For Task 3 and 4, we calculate the budget for the next two years and analyze the influence of different churn rates. Our data show that the cost of recruitment increases, while the cost of training and salary decreases when the churn rate rises.

For Task 5, we simulate the situation which doesn't have external recruitment, and get the result that the amount of employees decreases rapidly.

For Task 6, we discuss the potential usage of team science and multi-layered network and apply them into our model.

Moreover, we propose an improved version of our model which can analyze the influence of reassignment and provide reference value to HR managers for incentive mechanism.

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