QUANTITATIVE ANALYSIS FOR HUMAN RESOURCE PLANNING AND ITS RELATIONSHIP TO HUMAN RESOURCE INFORMATION SYSTEM

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Abstract-Human Resource Planning is not only an alternative of choices, but it is needs of companies. Various quantitative analysis techniques have been used in order to plan human resource. This paper describes some quantitative analysis techniques such as operations research and simulation briefly. Then, Human Resource Information System is explained. A brief discussion is offered to evaluate the characteristics of various quantitative analysis for human resource planning and its relationship to Human Resource Information System.

1. Introduction

1.1. Background

The most important resource in a company is its human resource. As human being, human resource should plan the other production factors. In the same time, as a production factor, human resource itself also has to be planned carefully.

It is significant to keep the equilibrium between the desired and potential of human resource. If the desired human resource is more than the potential human resource means there is a lack of human resource. On the other side, if the desired

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human resource is less than the potential human resource, then it will give redundancy. Both lack of human resource and redundancy should be avoided. A qualified human resource planning will give a good impact to others. If the planning of human resource is unsuitable, it will influence to the others not to be success. Because of this consequence, human resource planning should be performed systematically. Since human resource is human being, to plan human resource is more difficult than the others. That is why, a general manager's point of view is needed to design human resource planning.

Human resource planning can be defined as an effort to get the right number of qualified people into the right place at the right time in order to anticipate future business and environmental demands of the company. Human resource planning as part of human resource management should be determined based on the characteristics of its management itself.

Based on the definition above, explicitly, human resource planning has two aspects: quantitative and qualitative aspects. Since both aspects are important, companies should prepare a system which give possibility for practice of quantitative and qualitative approach simultaneously.

To understand the meaning of the right number of qualified worker into the right place, we should understand the job meaning. Qualitative aspect, is usually handled by systematical human resource development procedure, such as job description and job specification. Job is nature of an employment activities, that is all activities performed while working on a job.

Quantitative aspect is also important for getting the right number of worker at the right time. How can the needs of worker be decided? Who should determine the number of new worker might be recruited? Usually, managers be going to do such duties. It is rather difficult to 'guess' by instinct how many workers should be recruited. In place of supporting this duties, quantitative analysis is significant. Quantitative analysis are constructed by mathematical model which suitable to the each problem occurred. Mathematical model is designed from some mathematical equations, from the easier to the difficult model, from the linear to non linear model.

Quantitative analysis should be supported by qualitative aspect. In order to design the model, it should be decided the type of workers, or qualification of workers. For this purpose, job description and job specification are important.

1.2. Previous Research
Many quantitative analysis are used for human resource planning such as statistical analysis, operations research, simulation, etc.

Some researchers have already applied such techniques to solve human resource planning problems. Patz (1970) and Williams (1985) used linear programming; Lopez and Watson (1979), and Purwadi (1995) practiced system simulations.

Williams model has two objectives: to minimize redundancy, and to minimize cost. The model was built in order to manage how to recruit, how to retrain, how to avoid redundancy, etc. There are four elements which are related with this problem. These are recruitment, training, redundancy and short time working. Linear programming can not solve two problems simultaneously. So, each objective function is solved separately.

Purwadi's model was designed in order to plan human resource at Toyota Motor Corporation, Japan. The problem can be described as follows. Manpower Planning System (MPS) consists of relationships among recruitment, promotion, redundancy, overtime work and retirement of workers. The main goal is to maintain the effectiveness of manpower equals one which means that there is an equilibrium between desired human resource and potential (available) human resource. By using this model, it can be analyzed the effect of changing of technological innovation, social factors, etc.

1.3. Purposes

The purposes of this paper are to study the importance of quantitative analysis to human resource planning; to examine and to contrast some quantitative analysis techniques which are commonly used in human resource planning; and to discuss its relationship to Human Resource Information System.

2. Quantitative Analysis for Human Resource Planning

2.1. Definition

Quantitative analysis which also referred to management science is utilized to solve problems in order to help decision makers make more applicable decision through giving the outputs of quantitative analysis.

Quantitative analysis techniques are used in combination with qualitative techniques to identify and understand the case of human resource problems. This techniques emphasis on quantities, flows and mathematical modeling, which appeared
to be the main concern of human resource planning.

Using quantitative analysis for human resource planning is a process of making variables and equations which leads us directly to an empirical operational identification of human resource planning. Then it leads us to treat the problem as a system rather than dealing partially. Thinking the human resource problem as a system help us to understand the sequences of variable and parameter change to the whole system.

The final purpose of using quantitative analysis approach is to get the decision of object amount such as the number of workers who should be recruited, the number of product which should be produced, the number of stock which should be provided, etc. Eventhough the problem is solved by quantitative analysis techniques, the last decision depend on the human decision makers, because quantitative analysis don’t take over but support the managerial decision making process. The quantitative analysis and decision maker can make two ways "dialogue", so it is possible and necessary for decision making to ask questions more specifically and explicitly, and then the quantitative analysis will give the solution.

2.2. The Steps of Quantitative Analysis

Quantitative analysis approach follows a general steps: observation, problem definition, model construction, solution, and implementation which can be described their correlation as Figure 2.

Observation step describes the whole condition of system in which the problem occurred. The first thing to consider is the business strategy. How is the development of the company in the near future? How is policy making (strategic planning) and management decision making intersect? This problem should be detailed specified or defined on problem definition step. Based on the problem definition, the next step, that is model construction, is constructed by some mathematical model equations through quantitative analysis. When building a model, it should be keep in mind the assumptions. The next steps is running the model, then it will get a solution. This solution should be discussed before implementation of model.
Moreover Dhebar (1993) explained about the steps of quantitative analysis which can be detailed explained as a methodology as follows.

a. A clear, concise, and coherent problem definition.
b. A transparent representation of the problem structure and the accompanying analytical model.
c. Choice of the right quantitative analysis as a problem-solving tool
d. Choice of the appropriate computational vehicle
e. Explicit statement of all assumptions.
f. Systematic spreadsheet development and documentation of logic.
g. The sensitivity of the analysis to change in assumptions.
h. Credible and effective communication of justified recommendation.

Quantitative Analysis for human resource planning is used mainly for determining human resource needs through forecasting, scheduling, etc. Sensitivity analysis is performed by changing the parameter of variable model. Running simulation or model can be practiced for program and evaluate the system characteristics.
Forecasting human resource is to estimate the future human resource requirements in term of number and skills. The objective of human resource forecast is to present a detailed description of people required with the greatest possible details as to when, where, with what characteristics and at what cost.

Many techniques can be operated for designing quantitative analysis. Basically, people use judgment or instinct. But, it needs experienced people who have sensitive instinct. Experience is very important for making decision through judgment or instinct which is difficult because it takes a long time to get such workers. In other words, judgment or instinct based decision making is very abstract to be done by common people. To go to reduce the instinct factor in decision making process then people use quantitative analysis techniques such as statistical methods, operation research, and modeling or simulation. By using these techniques, it does not mean that the human instinct is not important. Human decision making is helped by using the output of quantitative analysis.

2.3. Requirements of Human Resource Planning

The central issues of determining human resource is the comparison of human resource 'demand' and 'supply', and determining how two sides can be equated. By adjusting the resource ability and operating work systems, the 'demand' and 'supply' can be seen through plotting abstract demand and supply curves.

Before deciding the requirements of human resource, it should be determined the requirements of strategic management and middle management, which can be described as Figure 3. The middle management level should focus on how missions, objectives and goals are to be implemented.

2.4. The Characteristics of Quantitative Analysis

Are all quantitative analysis techniques suitable for human resource planning? When, what and how quantitative analysis techniques can be put to use for human resource planning? In order to answer these questions, it is important to discuss the characteristics of those techniques themselves. The assumptions of the quantitative analysis are important to consider. Before using such techniques, we should confirm that the environmental system is suitable to the model assumptions.

This paper will explain the use of some quantitative analysis such as operation research and simulation. Each of these techniques can be described as follows.

2.4.1. Operation Research : Linear Programming
Policymaking
- Establishing missions, objectives and goals (Choosing final products)
- Implementing instruments
- Technological design

Implementation
- Organizational design
- Resource Allocation
- Technology (Types of tasks)

Operational Personnel Requirements
- Job design
- Scheduling
- Work load
- Staffing standards

Figure 3. Human resource management functions and Decisions (Mc.Gregor, 1991, p.105)

Operations Research, actually "a built-in" or "ready to use" of mathematical model. Linear Programming is the most popular technique of operations research.

Linear Programming is used for solving problem in short time planning. To solve a problem through linear programming is to find the solution of an objective function based on several constraints. Application of linear programming is wide scope, from transportation problems, assignment problems to human resources planning.

Usually, it will be assumed that everything happens on the first day of the beginning of that model during formulating the problem and building the program. Sometimes, this assumption can be far from the truth.

Linear Programming has one objective function and more than one constraints. The objective function of linear programming is only one. That is why, if some problems there are more than one objective function, they must be solved separately and they can not be solved simultaneously.
2.4.2. Simulation

Simulation is a quantitative procedure which describes the basic behavior of the model. Simulation is possible to change the parameter of the model by trial and error for evaluating the system behavior during certain length of time.

The best management science tool for analyzing a system behavior is simulation model. The real world behavior can be analyzed by using simulation model which is designed by mathematical equations.

Table 1 shows the result of Watson and Baecher survey about the application of quantitative analysis for management. The result indicates that simulation technique is the third method which is frequently applied.

Table 1. Some Quantitative Analysis for management

<table>
<thead>
<tr>
<th>Rank</th>
<th>Methods</th>
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<tbody>
<tr>
<td>1</td>
<td>Economic analysis</td>
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<tr>
<td>2</td>
<td>Statistic analysis</td>
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<tr>
<td>3</td>
<td>Simulation</td>
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<tr>
<td>4</td>
<td>Linear Programming</td>
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<tr>
<td>5</td>
<td>Inventory Model</td>
</tr>
<tr>
<td>6</td>
<td>PERT/CPM</td>
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<tr>
<td>7</td>
<td>Integer Programming, Dynamic Programming</td>
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<tr>
<td>8</td>
<td>Goal programming</td>
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<tr>
<td>9</td>
<td>Searching Techniques</td>
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<tr>
<td>10</td>
<td>Queuing Technique</td>
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3. Human Resource Information System

3.1. The Characteristics of HRIS

The complexity of companies increase gradually. In term of human resource, the personal relationships are getting distant. Personal data are getting bigger and bigger. It is difficult to manage data in a big amount and variations. They should be controlled to have a good information system.

Almost today's companies use computer to gather, analyze, and communicate information. Increased of human resource information requirements in one side and
the information technological development in the other side, support to each other to build Human Resource Information System (HRIS). The interrelationship between HRIS and business strategies can be described as Figure 4.

HRIS is a system which gives the needs and feasibility of information within the human resource development. The development of HRIS depend on the development of computer technology itself.

![Figure 4. The relationship between Business Strategy and HRIS](image)

HRIS can be defined as a method by which an organization collects, maintains, analyzes, and reports information on human resource and jobs. Human resource and job's data should be installed into the computer system, then analyze them, and presenting them for supporting decision maker. About 80% of major companies in USA has a manager HRIS who should need both a technical and a human resource management background (Cascio, 1989).

There are some advantages and disadvantages of HRIS. The primary advantages can be explained as follows. HRIS produces more accurate and more timely information for operating, controlling and planning purpose. HRIS improves planning to get the best and to reduce costly mistakes. Human resource planning can be greatly assisted by Human Resource Information System.

On the contrarily, it can be expensive in terms of the financial cost and labor requirements necessary. Getting too detailed data also causes increasing in cost. Other disadvantages are described by some problems which still occurred, such as privacy problem.

3.2. Human Resource Information System Evolution

HRIS has been developing since 1950s. Moreover Byars and Rue (1994) explained that the evolution of HRIS which can be divided into three generations. Each generation is indicated by certain characteristic.
a. The first generation (1950s - 1970s)

The first generation was indicated by replacing the manual process of information-keeping systems to computerized systems. Data storage has been moved from the file cabinet to mainframe which were in the care of a computer group. Human resource personnel feel dependent on the computer group.

b. The second generation (1970s - 1980s)

The main point of this generation was initiated by the introduction of the mini computers which handle a network of simultaneous users. The process of computer system becomes more interactive processing. The job of human resource manager is not so different, but it can be handled more rapidly.

c. The third generation (1980s - now)

This last generation is indicated by developing software technology, and stressing that HRIS is not only computerization of the manual job, but already started to develop systems to integrate the various areas within the application of software. The application of mini computers were taken place by Personal computers with cheaper in cost.

3.3. The Functional Components and The Steps of HRIS

In order to realize the use of information system, HRIS is built by some functional components. Based on its sequence, functional components can be divided into three parts: input, process and output. The correlation among these components are described at Figure 5.

Input consists of two parts: data collection and data validation. The important thing in this part is to decide where, when, and how will the data should be collected. Data has to be updated continuously, for getting the suitable information. Data maintenance in process part, is responsible for updating data. In the output part, reporting is the most customary, because the majority of HRIS user’s are

Figure 5. Functional Components of HRIS
concerned with information and reporting as the final goal.

Implementation of HRIS involves some steps. These can be summarized as follows.

a. Preparations. It should be explained that HRIS can assist management in making certain decision. It is better to do feasibility study in order to evaluate the present systems and details the benefits of an HRIS. Project team should be selected to continue the next steps.

b. System Design. The first thing in this step is to decide the requirements specifies in detail what the HRIS will do. It is important to match management's need for an HRIS. Hardware and software should be decided for designing HRIS.

c. Implementation. Before implementation of HRIS, the members of the project team should be trained. Implementation of HRIS is started with the sequence of steps: collecting data, validating data, running, maintenance, and evaluation which has been described in Figure 5. The functional components of human resource information system is provided by designing a Personnel Inventory.

4. The Relationship between Human Resource Planning and HRIS

4.1. Integrated Human Resource Planning System

It is undoubtful that HRIS supports to human resource planning. Information and reporting of HRIS is useful to be considered before deciding human resource planning. An integrated human resource planning system requires three kinds of information:

a. Personnel inventory that provides database which described the recent condition of workers qualitatively and quantitatively such as number of workers, knowledge, skills, abilities, experience, etc. So it can also be said a data bank. According to Cascio (1989), some uses of a personnel inventory are: identification of candidates for promotion, management succession planning, assignment to special project, transfer, training, reporting, compensation plan, career planning, and organizational analysis.

b. Human Resource Demand Forecast. Demand forecast means the desired human resource needs in the near future. In the process of realization the production schedule, it should be decided how many workers in each job at any time. Because of the change of certain factors such as technological innovation, social factors, etc., the needs of human resource in each job is change: increase or decrease. That is why human
resource planning is considerable to be forecasted in order to decide how many workers should be allocated in each job.

c. Human Resource Supply Forecast. Supply forecast means the actual or available human resource that is the total workers at particular time. The total workers are available to support the production process.

Personnel inventory which is designed by HRIS becomes the resource information for forecasting human resource demand and supply.

4.2. The Effect of Japanese Management and Western Management

There are some differences between HRIS based on Japanese Management and Western Management, such as job and labor market. These differences give impact in how to forecast human resource.

Job can be explained through job description and job specification. Generally, it can be spoken that job description is detailed analysis and definition of a job; all the duties, responsibilities, and conditions required in the performance of a particular job. Job specification is personnel requirements of particular job. Job specification sets the skills, education, and experience required for a particular position. In other words, job specification is an explanation about the workers who should handle each job. As far as possible, it is important to apply job description and job specialization as a basic standard in order to accomplish capable and qualified workers.

Both job description and job specification in Japanese management is designed wider in scope than Western management. Because of this scope of the job, Japanese management seems not to have job description and job specification. In Japanese Management, job is not strictly divided among workers. Eventhough each job for each worker is decided, but they tend to be a group or a teamwork, that they should understand what the other worker do. They tend to become generalist rather than specialist. They can be transferred from one department to other department easily.

On the contrarily, workers in Western Management are more specialist rather than generalist. They are allocated in the certain job, and consist of many layers of workers. Western Management divides job very specifically, one man for one job. Forecasting of human resource should be done in every job. It is very difficult to transfer workers from one job to other job.
Internal labor market is used by Japanese Management. Internal labor market means the set of structured employment relationship within a company which has a set of rules that governs all jobs and their interrelationship. The key to understand internal labor market is the concept of Japanese company-specific skill. It become more advantages for the company to keep workers who already have had a specific skill, even though the company should pay higher wages than to recruit and train new workers from external labor market.

The planning of human resource for the first level workers is done by recruiting new workers from outside the company. The others are filled by the recent workers intern company. Western Management selects the first level worker from external company. The higher levels are provided not only by workers who already in the company, but also by new workers from outside company.

5. Programming of Quantitative Analysis and Human Resource Information System

Recently, the application of computer in quantitative analysis and human resource information system is very broad and complex, such as: computer-based training, word processing, database management, spread sheets for salary planning, statistical analysis, telecommunications which provide the possibility to communicate
one computer to others through electronic mail, internet, etc.

Those applications are performed by using certain programming language computer software. There are two big categories of computer software:

a. General purpose languages, for example Basic, Pascal, FORTRAN, C, etc.

b. Special purpose languages, for example QSB and LINDO for operation research; Dynamo and SIMAN for simulation, dBase for Human Resource Information System; etc.

Computer software has already developed from time to time to obtain a special purpose languages. Actually, any quantitative analysis techniques can be written in general purpose language such as Basic, Pascal, FORTRAN or C. In order to make easier, more convenient, and more user friendly, many software companies developed special purpose of computer software or program packages.

There are many advantages in using a special purpose language. Describing the problem situation is easier than general purpose languages, diagnosing or checking the logic equation can be done as easy as syntax error checking, and programming only need short time.

By using a special purpose software, there is not any constrain for mathematical model structure. Format of the report can not be designed by user freely, but usually it is already given by the software. A good special purpose software already provides some choices for format of the report. Williams’ model was designed by using LP-solve, and Purwadi’s model was DYNAMOIII.

The advantages of using special purpose languages for human resource planning are: they reduce time and effort for programming; model formulation, system description and system analysis can be done easier.

6. Conclusion

Human resource needs to be planned systematically, because it can reduce uncertainty of the future, and it will leads to success. Human Resource Planning parallels the plans for the business as whole, from the strategic planning to tactical or operational planning. Strategic planning is the process to set objectives and to decide actions to achieve them.

Historically, many researchers have been using quantitative analysis for modeling Human Resource Planning. Since not all decision makers have a good feeling,
quantitative analysis techniques can become a guidance for them because quantitative analysis can reduce the human instinct.

The model environment such as the model assumptions should be discussed before using certain quantitative analysis techniques. Because quantitative analysis can be done as far as the assumptions are suitable to the system occurred.

Operations Research techniques such as Linear Programming is tool for solving problems through a plan approach which is one problem solving methodology by describing the problem definition, model construction, solution and implementation. The result of these techniques are optimum for certain sub-system and not optimum for the whole system.

Linear Programming is the most popular technique of operations research which is used for solving problems in the short term planning. That is why linear programming is suitable to human resource planning as far as the problems have only one objective.

Simulation is a technique of developing a system model of the real world situation that is possible for repeating the experiment many times. By changing the value of parameters, the model can be run many times until result a good human resource planning. Logic or mathematical structure is used for building the model. The model is designed through making many logical mathematical equations such as the numbers of workers, new workers who should be recruited, etc.; and generally for long term.

Human Resource Planning through quantitative analysis is usually done by using computer. HRIS is generally created through computer also. So the development of software technology is important. HRIS is positively support to human resource planning.

The application of quantitative analysis for modeling Human Resource Planning based on Japanese Management is easier than Western style. Mathematical equations which describing the interconnection of factors can be created smoothly because of lifetime employment system and internal labor market. On the contrarily, designing human resource planning model through quantitative analysis based on western management, it should be concern to the possibility of labor turnover, external labor market, etc. which have to design through more complex mathematical equations.
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