Linear Programming Model for Joint-Venture Human Resources Planning

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Abstract- New businesses face challenges in the planning stage and it gets more challenging when merging two companies or forming a new joint-venture. Joint ventures particularly encounter difficulties with measuring the required manpower hiring and training in order to start up efficiently. This paper describes the importance of human resources planning in joint ventures. It is followed by a linear programming (LP) model that can fit new joint ventures and provides the optimal workforce hiring & training with the minimum cost in order to start up efficiently. The goal is to minimize the cost related to workforce hiring and training while satisfying the business requirements.

Index Terms— Joint-venture, Optimization, Hiring, Training, Operations Research, Linear Programming.

1 INTRODUCTION:

1.1 Definition of Joint Venture

Success through collaboration is a golden principle that most international businesses consider when forming a joint venture (JV). An international joint venture is usually defined as the joining of two or more companies from different areas and specialties to exchange resources and share risks and benefits. Most of the time, one of the partners is located in the same jurisdiction of the JV which contributes legally, functionally and logistically to the success of this formation. The inputs of each partner is based on its capabilities, strengths and the nature of the enterprise (1). Planning is a critical stage that defines the path to achieve the set objectives and goals of forming such businesses. All aspects and functions such as strategies, systems, responsibilities, equipment and staff need to be included at this stage.

1.2 Human Resources Planning

The first product is a milestone that joint ventures seek and look for since the first day of the agreement especially for the manufacturing joint ventures. However, international JV participants invest a lot of money and recourses in such projects to fulfill the demand of the construction and startup before they reach this milestone. Having the required number and types of employees to run a joint-venture and start paying back its expenses once it is ready is a big deal that requires early and accurate planning. Market benchmark and business operations studies are crucial to come up with a precise forecast that enables the company to act accordingly. Therefore, recruitment and training need to be conducted as planned in order to run the business smoothly when the time comes.

2. LINEAR PROGRAMMING MODEL

2.1 General Description

Most of the JVs have two main aspects to focus on when it comes to human resources planning: hiring & training. Every department has specific responsibilities that require a minimum number of workers and specific qualifications such as years of experience and degree of education. These qualifications need to be categorized and converted into a number of employee types. Most of the time a mix of employees with experienced professionals, fresh graduates, and apprentices are required to form the workforce which can be used as default employee types. The quantity of workers can be decided based on the working hours and number of shifts for each unit.

Training is also important in order to insure that employees get familiar with the new technology or business model they will work on once the JV is ready to run. After the hiring process a specific percentage is determined which represents the portion of the hired employees per department to send for training. It is essential to locate training providers that are able to coach the hired employees

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and help them practice similar future tasks. A training provider can be one of the participants in the joint-venture or an outsource provider depending on the availability of the training and the specialty level in the training program. Clearly, every training provider has a limited capacity based on the number of available trainers and the size of the plant. Running a JV business normally without serious distractions is also another factor that training providers consider when deciding on the capacity of the training site. Training duration varies based on the employee type (e.g. an employee with experience will require less training than a fresh graduate employee). Selection of training locations is a big part of the plan and will significantly impact the cost.

2.2 Data Collection & Analysis

2.2.1 Hiring & Training

All departments need to be listed and contacted through a focal point in order to have a proper communication channel. Every department needs to submit the minimum required number of employees for each category and for each training program. On one hand, most probably the training program is only available in one or some of the selected centers but the training center must have at least one of the needed training programs. However, on the other hand, the capacity of each training type at each training center is collected by contacting the center's coordination office.

2.2.2 Cost

In this LP model the cost was studied in detail to determine a general description that can be used to formulate and solve the problem. The hiring cost item included in this model is the recruitment process cost. The training cost includes: training fees, housing, allowance, and travel which are all, except for the last item, related to the training duration. The cost can be calculated as following:

$$\text{Total cost} = \text{hiring cost} + \text{Training cost}$$

$$\text{Hiring cost} = \text{Recrutment cost}$$

$$\text{Training cost} = (\text{training fee} + \text{housing} + \text{allowance}) \times \text{training duration} + \text{travel}$$

2.3 Formulation

2.3.1 Decision Variables & Objective Function

The goal is to estimate the minimum cost of the overall training for the required number of employees that need to be hired in order to fulfill each department's requirements.

$$\text{Minimize } Z = \sum_{i=1}^{n}\sum_{j=1}^{m}\sum_{k=1}^{s}\sum_{l=0}^{r} C_{i,j,k,l}\, X_{i,j,k,l}$$

Where i: Department, j: Training program, k: Employee Type, and l: Training Location.

Z: the total cost of hiring and training.

$C_{i,j,k,l}$: Cost of hiring and training a new employee in department i on training program j for employee type k at location l.

$X_{i,j,k,l}$: Number of employees to be hired and trained in department i on training program j for employee type k at location l.

2.3.2 Constraints

After analyzing the data, the constraints and decision variables were formulated in a linear programming form. There are 3 types of constraints; department requirements, training location capacity, and the training portion constraints. Integer constraints and non-negativity constraints are also included.

1. Hiring Requirement Constraints for each department (i):

$$X_{i,j,k} \geq H_{i,j,k}$$

$H_{i,j,k}$: Required number of employees in department i for program j with employee type k.

2. Training Capacity Constraints:

$$X_{i,j,l} \geq T_{i,j,l}$$

$T_{i,j,l}$: Maximum number of employees in department i on program j at training location l.

3. Training Portion Constraints:

$$X_{i,j,l} \leq P_i \times X_{i,j,l}$$

P_i: Percentage of hired employees to send for training from each department

4. Integer Constraints

$$X_{i,j,k,l} = \text{integer}$$

The model is an integer programming model due to its nature of having discrete variables.

5. Non Negativity Constraint

$$X_{i,j,k,l} \geq 0$$

2.3.3 Problem Mapping

A visual network representation helps to understand the connections between department i, training program j, employee type k, and training location l.

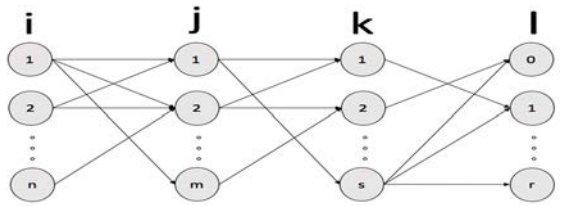

Fig. 1. A visual representation for connections between department i, training program j, employee type k and training location l.

As shown in the diagram, for those employees who will be trained on the site or do not have training assignments, a dummy training location (0) is introduced with a training cost that equals to zero. In addition to that, big M method can be used in the solution to indicate the infeasible connections between nodes.

2.4 Solution

Once the formulation is completed and based on the dataset size, a proper linear programming method (e.g. Simplex or a linear programming software such as LINDO, XL Solver or Lingo) is used to do the calculations and find the optimal solution. Human resources size plays a role in selecting the proper software. For instance, a large human resources system requires a more advanced software version that can handle large datasets. Running the proper software will provide the optimal solution.

2.4 Post Optimality

After obtaining the optimal solution based on the described formulation, post optimality or sensitivity analysis needs to be conducted. These analyses measure how the optimal solution changes, that is if the problem data such as the right hand side values (RHS) or the objective function coefficients change. At this stage, "what if" questions can be raised and answered which might result in management decisions such as increasing the capacity of one of the resources.

2.4.1 RHS change

The shadow price or dual price for a constraint is an important term which is defined as the rate of change of the objective function with respect to the change of the RHS of that constraint.

$$shadow\ price = \frac{change\ in\ objective\ function}{change\ in\ RHS}$$

There is an allowable RHS change for each individual constraint which indicates the change range that leads to the same shadow price with no effect on the optimal solution.

2.4.1.1 Hiring constraint change

Changing the right hand side for a particular hiring constraint can be done either by increasing or decreasing the required number for a particular department, training program, and employee type. The objective function is observed and then evaluated based on the shadow price. By having such information the management can evaluate the worth of making such change and then make the proper decision.

2.4.1.2 Training center capacity constraint

The JV can look into the impact of any possible change in a particular training center's capacity. Usually, the desired change in such type of constraints is to increase the available seats unless there is a doubt that the determined capacity affects the training quality. The planning team needs to consider the marginal benefit from changing the training center's capacity and evaluate the impact on the objective function. The impact is dependent on the rate of the setup and fixed cost to the variable cost related to the number of assigned trainees. If the results are satisfying and the change is desired, further negotiation with the training center is needed.

2.4.1.3 Training Portion Constraint

Revisiting the assigned training portion of the hired employees might be effective for some departments. Task technicality, criticality, and training complexity lead to increase the training assignments. However, decreasing the percentage is an option for reducing the cost or giving up the assignments to other departments based on the business needs. The change in this category is decided by the top management to insure the enforcement of any change and to consider the alignment of all parties.

2.4.2 Objective Function Coefficient Constraint

Possible changes of the objective function coefficients directly impact the optimal solution. A less total minimum cost contributes to the model's objective. However, it makes room for further utilization of resources if the already obtained cost is acceptable. Lowering the prices is a negotiable topic in real life applications and can be achieved in such a project by taking the post optimality results and performing further discussions with the training providers. In some cases, changing training plans and compressing training duration leads to an agreement.

3. Conclusion

In this paper, we have discussed an effective linear programming model that can be used to find the optimal hiring and training assignments for Joint-Ventures. This model needs to be employed at early planning stages and requires all parties to cooperate and provide accurate data. Hiring needs need to be addressed by each department and a mixture of employee types, as well as, qualifications and skills should be carefully considered. Training providers can be one of the joint-venture partners or be a third party depending on the availability. Formulation was mathematically based on operations research and the goal was to find the optimal hiring and training quantity for the enterprise that achieves the total minimum cost. Training center's limited seats, hiring requirements, and rate of training assignments were enforced in the model. The optimal solution is then obtained by using one of the linear programming algorithms or by running a proper commercial software. Post optimality analysis is then conducted to investigate possible changes in the model that will lead to a desired outcome. Marginal benefits representation provides valuable information that management can use to make the right decision. Human resources planning is crucial for Joint-Ventures and such model can be a strong tool to use.

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