Manpower Planning Using Decision Analysis: Case of Crown Company.

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ABSTRACT

This study addresses the analytic approach to decision making and its application to manpower planning in the crown section of a bottling company in Nigeria. The company produces crowns for several bottling companies and was faced with the challenge of meeting customer's demand, which varied from month to month. A work sampling technique was used to investigate the discrepancy between the level of the work force and their output. The result of the work sampling study showed that all of the departments were overstaffed with idle time and that overtime, rather than additional shifts, would reduce manpower cost. The results have been applied to the management policies that can be employed to meet increasing short term demand.

(Keywords: decision analysis, manpower planning work sampling, uncertainty)

INTRODUCTION

Decision can be defined as the act of conscious or reasoned choice among alternatives. A fundamental problem facing all decision makers is the absence of complete information about the decision environment. If all possible actions, events, and conditional outcomes could be predicted with complete confidence, then decision making would be the simple exercise of calculating the optimal action according to some predetermined criteria. However, decisions are often made within an environment of risk, uncertainty, or conflict.

The study of interest is the manpower-planning problem of the Ikeja plant of a crown company. The company is faced with the challenge of meeting customers' demands which vary from month to month. It was imperative to decide on the adequate means of meeting customer demands so that sales would not be lost to competitors. In other words, the problem is that of determining how customer demands can be met while simultaneously minimizing the cost of man-hours needed for production. Many firms claim the ability to increase output by 10% with little or no change in employment level (Johnson et al., 1972). The most common method, in the short term would be to increase overtime. Several firms also indicate the possibility of taking on extra employees on a short-term contract.

The objective of this study is to investigate the possibility of a shortfall in the workforce level with regards to output and to identify management policies that can be employed to meet fluctuating demand.

Manpower planning is all about making personnel management decisions. Unlike other production inputs such as machines, materials, and energy, the employment of personnel has other dimensions besides simply the number of people employed. It has time coupled with effort dimensions. An increase in demand will result in an increase in desired output which can only be met by an increase in the number of personnel hours, increased labor utilization, and/or increase in the use of other factors of production. Personnel output can be increased through training and education.

Decision analysis is a body of knowledge and related analytical techniques, of different degrees of formality, designed to help a decision maker choose among a set of alternatives in the light of their possible consequences. The vast majority of the decision theory literature focuses on the normative model of choice. The rapid development of behavioral theory has led to the possibility of more widespread application, particularly to Operations Research problems (Khan, 1988).

The literature on decision theory has grown rapidly over the past years. The work that perhaps best marks the beginning of this expansion is that of Von Neumann and Morgenstern in *The Theory of Games and*

Economic Behavior (Von Neuman et al., 1947). The concept of decisive dominance in a heuristic procedure has been used to rank strategic options in planning international investments of a major manpower of electrical generating sets and industrial engines decision (Iyer, 1988). Also, an expected utility maximizer choosing from a family of risky prospects and examining how choice is influenced by the decision maker's attitude to risk has been considered (Jewitt, 1989).

Different types of linear additive models have been developed and reviewed over the years. A simple and direct method is ranking. This method has been found by decision makers to be easy to use. It has led to evaluations that have found good use and have produced ranking orders which seem to correspond closely to their actual ultimate choices. This method was applied to a simple machine tool replacement decision (Morris, 1997). Bainey (1995) and Fishburn et al. (1994) provided decision theoretic procedures for evaluating fairness of allocation (including risky allocations) using the concept of envy among stakeholders. Creativity in decision-making is a function of the quality of alternatives generated. A truly creative alternative is one that is both novel and effective in achieving the decision maker's objective (Clemen, 1996).

The total cost for a given production period is influenced by managerial decisions, which are taken in reference to selected goals. If there is steady employment of workers, cost is lower than if the group of workers changes in size, because the cost associated with hiring, training, and layoff are minimized. Similarly, a decision to absorb fluctuations through finished-good inventory commits the firm to direct investment costs and the expenses associated with storage, handling spoilage, obsolescence, and adverse price changes. Also, a decision to absorb demand through buffer backlog has recognizable costs associated with it such as customer dissatisfaction, loss of future business, and adverse price change. The situation of interest is the manpower-planning problem of a crown plant in Ikeja, Nigeria.

EXISTING PLANT CAPACITY

Plant capacity is the maximum volume of flow of material, which can be produced by a plant under a given condition of material flow (Burbidge, 1971). Currently, the maximum capacity for the plant is 672 machine hours per month (24 hours/day x 28 days). If it only operates one or two shifts, the normal machine capacity is less than the maximum capacity by the number of hours not worked. If overtime is worked, these extra hours worked should be added to the normal machine capacity to give the planned machine capacity. The estimated time for maintenance and machine idle time are deducted to get the actual machine running time.

The company has two lines and each line is capable of producing an average of 11.2 cartons per hour. The company presently operates two eight-hour shifts, 24 days per month, giving a maximum operating capacity of 384 hours per month. The actual hours worked varies from the stated capacity as a result of unforeseen factors like increases in machine down time and/or improved efficiency of workers. It is imperative to decide on the adequate means of meeting customers' demand which varied from time to time so that sales will not be lost to competitors.

Decision Variables

The following feasible capacity adjustments are considered in reaction to fluctuating demand:

1) Use of overtime (i.e. increasing the working time from 40 to 48 hours per shift) will increase production by 20%. However the labor cost for working overtime is 25 – 100% higher than normal basic allowance.

2) Use of night shift: Labor cost for working night shift is 10% higher than the normal wage. This option enables production capacity per shift to increase by 100% without additional investment in plant facilities and equipment.

MODEL FORMULATION

Notations:

t = a time period (e.g. month)
I_t = surplus demand in period t
P_t = the plant operating production capacity in period t
D_t = the quantity demanded in period t
H_t = the number of hours needed to produce It in period t (hours)
q = production rate (cartons per hour)

T_{ot} = total time available as a result of overtime in period t (hours)

Tst = total time available as a result of adding night shift in period t

ρ_i = probability of occurrence of outcome i

a_i = time required to produce a unit of product i in period t

α = regular working hours

θ = overtime rate of pay during public holidays and Sundays

δ = overtime rate of pay during week days and Saturdays

C_o = total cost of overtime in period t

C_s = total cost of adding another shift in period t

C_{1t} = normal labor cost/hour in period t

C_{2t} = temporary labor cost/hour in period t

C_{3t} = night shift labor cost/hour in period t

C_{4t} = overtime cost/hour in period t

$$I_t = D_t - P_t \qquad \textbf{(1)}$$

but $H_t = I_t/q$,

hence, $H_t = (D_t - P_t)/q$,

therefore, $H_t = a_i I_t$ **(2)**

To meet the Ht hours, one of the following two actions could be taken:

1) Persuade Ht employees to work one hour overtime each or

2) Add another shift to meet the Ht hours

For action 1

$$C_o = C_{4t} T_{ot} \qquad \textbf{(3)}$$

where $H_t \leq T_{ot}$ for use of overtime.

For action 2

$$C_s = C_{31} T_{st} \qquad \textbf{(4)}$$

where $H_t \leq P_t \leq T_{st}$ for adding night shift.

DATA COLLECTION AND ANALYSIS

Printing: The materials used in the production of metal crowns include tin free sheets or tin plates (TFS), polyvinyl chloride (PVC), ink of various colors, lacquer, vanish, and white enamel. In the printing section, the TFS is trimmed on the rough side, to fit into the printing machine. The printing is then carried out in four operations viz: sizing, base coating, decoration, and vanish overcoat.

1) Sizing involves the marking on each plate, the standard crown size which gives 594 crowns per plate

2) In base coating, the sized TFS is coated with lacquer to prevent the crown from reacting with the white enamel and the bottle content. It is then dried in the oven.

3) Decoration involves the printing of colors and for each color, the plate is processed through the printing machine once. Thus for four colors, the plate is processed four times.

4) For the vanish overcoat, the vanish is spread over the decorated plates to give a glossy finish. From here the decorated plates move to the punching section.

Punching and Sorting: The three operations carried out in the punching section include punching, lining and packaging. The crowns are severed from the plate and lined with white enamel which gives the crowns the perfect fit to prevent air from entering the bottle after corking. The lining machine sorts defected crowns and has an automatic counter, which places specified numbers into cartons. These are packaged and sent to the sorting section where quality checks are carried out.

Work sampling data analysis: Work sampling has been defined as a statistical technique founded on random sampling. It is a measurement technique for the quantitative analysis of repetitive and non-repetitive activities. Work sampling is relatively inexpensive to use and is extremely helpful in providing deeper understanding of operations. Work sampling was initially utilized for the purposes other than work measurement. It was originally known as Ratio Delay or Random Check Delay study (Laufer, 1984)

For this research, a number of observations of a group of workers performing a task were made on a random basis. The state of each of the worker's activity is recorded by indicating whether he is working or idle (i.e. busy or not busy). If an adequate number of observations are made, the percentage of busy time and non-busy time in the sample can be considered as representative of what actually occurs within a predictable limit of accuracy.

Utilization factor is defined as:

$$\text{Utilization factor } (U_f) = \frac{\text{Actual man-hour of work work done } A_w}{\text{Actual man-hours for work } A_h}$$

$$U_f = \frac{A_w}{A_h} \qquad \textbf{(5)}$$

For a single worker:

$$U_f = \frac{\text{Number of times staff was found busy}}{\text{Total number of times staff was observed}}$$

Estimated man-hour of work in a department per annum:

$$E_m = U_f A_h \qquad \textbf{(6)}$$

Estimated standard man hour of work in a department per annum:

$$E_s = E_m[(\text{Sample performance rating})/100] + \text{allowance} \qquad \textbf{(7)}$$

Wasted man-hours in a department per annum:

$$W_h = A_h[1 - U_f]$$

Standard wasted man-hours per annum:

$$W_s = W_h\left[\frac{\text{Sample performance rating}}{100}\right] + allowance \qquad \textbf{(8)}$$

The number of staff required in each department was computed from:

$$N = \frac{\text{Standard man-hours of work in the department}}{\text{Available hours for work x use factor}} \qquad \textbf{(9)}$$

Table 1 shows the work sampling data for computation of useful man-hours.

Table 1: Computation of Useful Man-Hours.

Position	Observation		Utilization factor	Useful man-hours	Wasted man-hours
	Busy	Not Busy			
Oven mouth loading	40	5	0.89	18.7	2.3
Oven mouth manning	34	11	0.76	15.9	5.1
Coating machine operator	23	22	0.51	10.7	10.3
Asst. coating machine operator	20	25	0.44	9.3	11.3
Feeder machine operator	30	15	0.67	14.0	7.0
Asst feeder machine operator	18	27	0.40	8.4	12.6
Printing machine operator	14	31	0.31	6.5	14.5
Fork lift driver	23	22	0.51	10.7	10.3
Punching machine operator 1	23	22	0.51	10.7	10.3
Punching machine operator 2	9	36	0.20	4.2	16.8
Lining machine operator	24	21	0.53	11.1	9.9
Lining machine packaging	38	7	0.84	17.6	3.4
Prepackaging officer	18	27	0.40	8.4	12.6
Sorter 1	23	22	0.51	10.7	10.3
Sorter 2	21	24	0.47	9.8	11.2
Sorter 3	20	25	0.44	9.3	11.7
Sorter 4	16	29	0.36	7.5	13.5
Sorter 5	13	32	0.29	6.1	14.9
Sorter 6	11	34	0.24	5.1	15.9
Sorter 7	6	39	0.13	2.8	18.2

An activity sampling data was then collected for the various sections as shown in Table 2.

Estimated man-hours of work in a department per annum:

$$E_m = (U_f)(A_h)$$

Estimated standard man-hours in a department per annum E_s:

$$E_s = E_m\left[\frac{\text{Sample performance rating}}{100}\right] + [Allowance]$$

Table 2: Activity Sampling Data Summary Sheet.

Position	Total number of activities					Percentage of activities						Estimated time for activities					
	Related	Unrelated				Related	Unrelated					Related	Unrelated				
	Busy	1	2	3	4	Busy	1	2	3	4	Total	Busy	1	2	3	4	Total
Oven mouth loading	40	2	2	0	1	89	4.4	4.4	0	2.2	11	18.7	0.9	0.9	0	0.5	2.3
Oven mouth manning	34	4	1	2	4	76	8.8	2.2	4.4	8.8	24	15.9	1.8	0.5	0.9	1.8	5.1
Coating machine operator	23	4	2	10	6	51	8.8	4.4	22.2	13.3	49	10.7	1.8	0.9	4.7	2.8	10.3
Asst. coating machine operator	20	4	3	9	9	44	8.8	6.7	20	20	56	9.3	1.8	1.4	4.2	4.2	11.7
Feeder machine operator	30	4	3	6	2	67	8.8	6.7	13.3	4.4	33	14	1.8	1.4	2.8	0.9	7
Asst. feeder machine operator	18	4	3	14	6	40	8.8	6.7	31	13.3	60	8.4	1.8	1.4	6.5	2.8	12.6
Printing machine operator	14	0	5	10	16	31	0	11	22	36	69	6.5	0	2.3	4.6	7.6	14.5
Forklift driver	23	0	2	16	4	51	0	4.4	36	8.8	49	10.7	0	0.9	7.6	1.8	10.3
Punching machine operator 1	23	0	4	8	10	51	0	8.9	18	22.2	49	10.7	0	1.9	3.7	4.7	10.3
Punching machine operator 2	9	0	4	21	11	20	0	8.9	46.6	24.4	80	4.2	0	1.9	9.8	5.1	16.8
Pre-packaging officer	18	0	3	5	19	40	0	6.7	11.1	42.2	60	8.4	0	1.4	2.3	8.9	12.6
Lining machine operator 1	24	0	2	14	5	53	0	4.4	31.1	11.1	47	11.13	0	0.92	6.53	2.33	9.87
Lining machine 1 packaging	38	0	3	2	2	84	0	6.7	4.4	4.4	16	17.64	0	0.41	0.92	0.92	3.36
Sorter 1	23	0	6	10	6	61	0	13.3	22.2	13.3	49	10.7	0	2.8	4.7	2.8	10.3
Sorter 2	21	0	6	13	5	47	0	13.3	29	11.1	53	9.8	0	2.8	6.1	2.3	11.2
Sorter 3	20	0	6	16	3	44	0	13.3	35.5	6.6	56	9.3	0	2.8	7.5	1.4	11.7
Sorter 4	16	0	6	11	12	36	0	13.3	24	27	64	7.5	0	2.8	5.1	5.6	13.5
Sorter 5	13	0	6	13	13	29	0	13.3	29	29	71	6.1	0	2.8	6.1	6.1	14.9
Sorter 6	11	0	6	17	11	24	0	13.3	38	24	76	5.1	0	2.8	7.9	5.6	15.9
Sorter 7	6	0	6	15	18	13	0	13.3	33.3	40	87	2.8	0	2.8	7.0	8.4	18.2

Wasted man hours in a department per annum:

$$W_h = A_h(1 - U_f)$$

Wasted standard man-hours per annum:

$$W_s = W_h\left[\frac{\text{Sample performance rating}}{100}\right] + [Allowance]$$

Number of staff required in a department (N):

$$N = \frac{\text{Standard man - hours of work in the department}}{Available \text{ hours for work x staff use factor}}$$

These equations were applied to the punching and sorting sections and the summary of results is presented in Table 3.

RESULTS AND DISCUSSION

Individuals, as well as sections, have uneven workload. Table 2 shows that the busiest staff is the "oven mouth loading operator" who was found to be busy 89% of the time and the least busy worker is "sorter 7" who was found busy for just 13% of the time.

At the punching section, the average busy time was found to be 49.6% with an estimated wasted man-hours per year of 7846.27 hours. The number of personnel required is 4 workers instead of the present 7 workers.

Also, the workload of the sorters is too small. The sorters were found busy on the average, 34.9% of the time. This yielded total wasted man-hours of 13030.72 hours.

The use of overtime will cost 30,187/month for "low" demand, 58,218.48/month for "medium", and 86,788.66/month for "high" demand. This yielded an expected monetary value of 47,059.94/month (see Tables 4 and 5).

Table 3: Summary of Results for Punching and Sorting.

Section Computations	Printing	Punching	Sorting	Total
Performance rating (%)	90	87	100	
Allowance (%)	8	8	8	
Use factor (%)	92	92	92	
Average busy time	56.1	49.6	34.9	
% Average non-busy time	43.9	50.4	65.1	
Estimated man-hours/year	12476.64	7721.73	6985.58	27185.95
Estimated standard man hours	1227.11	7335.64	7544.43	27107.18
Wasted man-hours/year	9763.35	7846.27	13030.42	30640.04
Wasted standard man-hours/year	9568.08	7454	14072.85	31094.93
Existing number of staff/shift	10	7	9	26
Recommended number of staff	5.98≈6	3.58≈4	3.68≈4	14
Surplus	4	3	5	12

Table 4: Frequency of Demand Levels.

Level	Class	Mid-class	Frequency	Probability
Low	602-1712	1157	10	0.5
Medium	1713-2823	2268	8	0.4
High	2824-3934	3379	2	0.1

Table 5: Decision Matrix for Labor Cost.

Factor	Low	Medium	High	Expected value
Probability	0.5	0.4	0.1	-
Addition of shift	125184	125184	125184	125184
Use of overtime	30187.48	58218.48	868788.66	47059.94

The use of the night shift will attract a fixed cost of 122,184/month and a range of idle hours from 31 to 136 hours.

CONCLUSION

The method of decision analysis has been used to address the management policies, which can be employed to maximize sales and simultaneously minimize cost while meeting fluctuating demand within certain time constraints. A work sampling study was initiated to investigate the performance at the production department of a crown plant. The result of the work sampling study was used to calculate the cost of alternative actions and the decision analysis used to determine the most favorable decision to make at each point. It was found that all the departments were overstaffed thereby leading to a lot of idle time. The result shows that the use of overtime gives the best alternative based on cost and flexibility.

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SUGGESTED CITATION

Oyawale, F.A. and O.A. Adegboyega. 2008. "Manpower Planning Using Decision Analysis: Case of Crown Company". *Pacific Journal of Science and Technology.* 9(2):413-419.

Pacific Journal of Science and Technology