A Dynamic Programming Model for Organisational Designing

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Abstract
Organisational design problems have been formulated as that of minimising personnel related costs subject to some constraints with a heuristics as solution procedures. The difficulty of verifying the effectiveness of such heuristics in producing optimal organisation structures has created model acceptability problems. The objective of this study is to develop an organisational design algorithm that guarantee optimal organisational structure with minimum personnel related costs. The model was applied to an organisations design problem of an existing firm. The study provides a methodology for assessing the effectiveness of the existing heuristics.
Keywords: Organisational design, Organisational structure, Optimal organisation, Personnel cost Dynamic programming.

1. Introduction

Kreitner (2005) defined organisational structure as "a visual display of an organisation's positions and lines of authority that is useful as a blueprint for deploying human resources, in which the vertical hierarchy establishes the chain of command that coordinates the efforts of the organisation and the horizontal specialization denotes the division of labour". Other definitions of organisation structure have been reported (Horling, and Lesser, 2004; Mabey et al, 2001; Mintzberg, 1989; Mullins, 1993; Robbins and Coulter, 2002), but, Kreitner (2005) appeared to have captured most of the aspects mentioned by others. Organisational structure is also a tool for allocating work and responsibilities, which enable managers to plan, direct, organise and control the activities (Mabey, Salman. and Storey, 2001; Mullins, 1993).

The importance of an organisational structure, particularly, in relation to size, strategy, technology, environment and culture has been reported (Burns and Stalker, 1961; Powell, 1991; Pugh et al, 1969; Miller, 1989; Mintzberg, 1989; Robert, 2004; Saraph and Sebastian, 1992). Organisation's structure determines the number and types of entities, positions, levels, and span of control in the organisation. It also influences the relationship of the authorities, data flow, resource allocation, coordination patterns and other system characteristics (Carley and Gasser, 1999; Freeland and Moore, 1977 and Hayden et al., 1999). Simply put the shape, size and characteristics of organisational structure can affect the behaviour (effectiveness and efficiency) of the organisation (Birkinshaw et al , 2002; Ethirraj and Levinthal, 2004; Horling and Lesser; 2004; Khandwalla, 1973; Rindova and Kotha, 2001; Victor et al, 2000).

Organisational structure has effects both the strategic positioning of the organisation and its operational efficiency (Charles-Owaba, 2002; Robbins and Coulter, 2002; Hax and Majluf, 1981). It also determines number of operational option for an organisation striving to achieve its goals. For example, Cochran, (2002) argued that poor organisational performance is due to poor leadership and poorly structured organisational processes or mismatch of its components while (Malhotra, 2001) argued that it is due to incorrect understanding and misapplication of the notion of control.

A good structure should ensure that managers at the decision centres receive the right, accurate, reliable, adequate and timely information; adequate resources; and the right level of authority and responsibilities in the various functional or divisional areas. Inadequacy or excess of each of these may be harmful (Wildavsky, 1983) Thus, organisation's structure has profound influence on its effectiveness and competitive ability (Rivkin and Sigglekow, 2003; Vroom, 2006).

The importance of organisational structure to proper functioning and competitiveness of organisations has led to the application of operations research tools to design optimal organisations as solution to real life business organisational problems (Charles-Owaba, 1987; Charles-Owaba, 1998; Charles-Owaba, 2002; Ofiabulu,. and Charles-Owaba, 2013).

In the study, (Ofiabulu and Charles-Owaba, 2013), organisational design problem was formulated of minimisation of personnel related costs, subject to supervision, waiting time and apex position constraints. The span of control, the number of management levels, number of managers/supervisors per level were the design variables while the number of the lowest cadre of personnel and human interaction dynamic factors were the design parameters.

However, the solution procedure the design problems, being a heuristic, does not guarantee an optimal organisation structure. Associated with every heuristic is a problem of verifying model effectiveness and acceptance. The development of a solution procedure that guarantees optimal solution to the organisational design problem with the hope of enhancing the model's acceptability constitutes the problem of this study. In particular, the problem is that of formulate an organisational design problem in terms of known design variables; design parameters; shape, size and policy constraints and then evolve a solution procedure, which guarantees an optimal business organisational structure with minimum personnel related costs.

In searching for a solution procedure to the above stated problem, we note that if the objective functions and constraints are linear then the problem is easily handled with the much celebrated simplex algorithm. Otherwise, we have only two general categories of approaches: explicit enumeration and implicit enumeration. The former serves no useful purpose when the design variables are continuous quantities. Besides, it is known to be the most inefficient approach. Among the implicit enumeration techniques are integer programming, branch and bound and dynamic programming. Of these three, the last two are suitable for any type of mathematical problem. However, for problems with easily noticeable structures suggestive of stage-by-stage solution procedure, the dynamic programming solution approach is usually recommended (Pfaffenberger and Walker, 1976). In view of the hierarchical nature of organisation structure, the possibility of using the dynamic programming framework as the basis for solution will be investigated in this research work.

The motivating factor for this study is that a dynamic programming model of an organisational design will not only guarantee optimal structure but also provides adequate framework and information for a computer program for logistic support. Thus, it may be possible to rapidly produce optimal design for new business organisations or redesign old ones. Indeed, owners of existing organisations can easily evaluate their respective organisational structures to verify the current performance status and compare with those of others nationally or internationally. Optimal business organisations will produce quality goods at lower prices and improved standard of living.

2. Notations and Assumptions

2.1. Notation

A_{ij}: Number of hours per day by the worker at j^{th} position of the i^{th} level of the organisation in hours.

b_{ij}: Hourly rate of worker/decision maker at j^{th} position of the i^{th} level of the organisation in ₦/hour

K_{ij}: The span of control is the number of subordinates at $(i-1)^{th}$ level that reports directly to boss at the j^{th} position of the i^{th} level of the organisation.

L_{ij}: This is the average number of cases in for the attention of decision maker/boss at j^{th} position of the i^{th} level of the organisation.

$\overline{L}_{ij}$: This is the average number of cases that waited for the attention of decision maker/boss at j^{th} position of the i^{th} level of the organisation.

M: The highest level of the entire organisation for which N_i =1

N_{ij}: This is the number of positions of the j^{th} type at the i^{th} level of the organisational structure. This may be number of functional or divisional (j) managers or supervisors at the i^{th} level of the organisation i=0,1, 2,M

N_{0j}: Number of operation positions of j^{th} type at the 0^{th} level of the organisation

NL: Number of management levels of the entire organisational structure

NM: This is the number of positions at levels 2 and above of the organisational structure

NS: Number of first level managers or supervisors of the organisational structure

S: Organisational size is the total number of positions of the completely organisational structure.

SC: Average Span of control of managers is the number of subordinates per level.

S_0: Operation position size of the organisation

W_{ij}: This is the average waiting time of cases (from subordinate and the boss's superior) that came for the attention of the boss at the j^{th} position of the i^{th} level of the organisation.

λ_{ij}: This is the rate at which the boss at the j^{th} position of the i^{th} level of the organisational structure .is consulted by the subordinates.

μ_{ij}: This is the rate at which the boss at j^{th} position and i^{th} level attend to cases that came for his attention.

ρ_{ij}: This is ratio of the cases' arrival rate to the service rate of cases for the boss at j^{th} position and i^{th} level. This is the measure of information traffic intensity between each boss at j^{th} position of the i^{th} level and his subordinates a $(i-1)^{th}$ levels and his superior at the $(i+1)^{th}$ level of the organisation.

f_i Personnel related cost function of i^{th} level of organisational structure.

F This is the total daily costs of operating the whole organizational structure.

2.2. Assumptions

1. Every employee is of normal health, highly motivated and at least, has one job to perform in the organisation;
2. The chance that personnel in a work unit will work most harmoniously is highest when the authority and responsibility to control the activities of the unit is assigned to one and only one boss at any given moment;
3. Standard workload (that is suitable for the position) and not maximum possible workload is assigned to every staff;
4. The organisation is a non-fully automated business organisation.
5. It is a personnel-personnel or personnel-machine interaction, stochastic and dynamic decision and operation work system;
6. The workload of a boss (superior) at decision center is proportional to his/her span of control (K_{ij});
7. Requests, response to directives, situational reporting, classifications, authorizations, counseling are features of superior-subordinate relationships;
8. Arrival of cases for and departure from the boss are stochastic events; which follows (FIFO) First come, first served consultation discipline;
9. The superior is experienced enough to handle a decision center. Otherwise, there will be a large heap of cases at every moment;
10. Data for parameter estimation are collected from the interaction stochastic and dynamic system, when it has passed from the transient to a steady state;
11. The time a case leaves its location and travels to the superior's desk is negligible.

3, Personnel related cost function

Consider an organisation structure (Ofiabulu and Charles-Owaba, 2013) with $j = 1, 2, 3, \ldots\ldots, J$ types of positions at $i = 1, 2, 3, \ldots\ldots, M$ decision levels. Level 0 (i = 0) consists of the lowest cadre of workers; level 1 (i = 1) is the supervisory level; while levels 2 and above (i > 1) are pure decision position as depicted in Figure 1. For a typical work unit with the boss at the j^{th} position of the i^{th} level with K_{ij} subordinates (span of control). The boss can be viewed as a server in a queuing system with the jobs or cases being problems, clarifications, instructions, directions and so on, from finite source of K_{ij} subordinates under him or her. For such a work unit

The total daily costs related to personnel related cost of the organisational work unit ($DPOC_{ij}$) is estimated thus

$$DPOC_{ij} = DWC_{ij} + DIC_{ij} + DPC_{ij} \quad \ldots\ldots (1)$$

$$DPOC_{ij} = (b_{i-1,j} W_{ij} L_{ij} + b_{ij} P_{ij} A_{ij} + b_{ij} A_{ij}) \quad \ldots\ldots (2)$$

Where

- $DWC_{ij} = b_{i-1,j} W_{ij} L_{ij}$ is the waiting cost associated with the time lost by the subordinates while waiting for the attention of the boss.

- $DIC_{ij} = b_{ij}P_{ij}A_{ij}$ is costs of idleness of a boss who has very few subordinates and so less than enough jobs to do.
- $DPC_{ij} = b_{ij}A_{ij}$ Is the cost associated with the daily pay of personnel in the work unit

The daily personnel operating cost $DPOC_i$ for organisational structure at the i^{th} level, for $i \geq 1$ is

$$f_i = \sum_{j=1}^{N_I}(b_{i-1,j}W_{ij}L_{ij} + b_{ij}P_{ij}A_{ij} + b_{ij}A_{ij}) \qquad (4)$$

At the operation positions, level, $i = 0$, since the positions have no subordinates, DCW_0, and $DCI_0 = \mathbf{0}$, but the daily personnel cost is given by

$$f_0 = \sum_{j=1}^{N_0}\left[b_{0j}A_{0j}\right] \qquad (5)$$

The total daily costs of operating the whole organizational structure is given by

$$F = \sum_{i=1}^{M}\left[\sum_{j=1}^{N_i}\left[b_{i-1,j}W_{i,j}L_{i,j} + b_{i,j}A_{i,j}(P_{i,j}+1)\right]\right] + \sum_{j=1}^{N_0}\left[b_{0,j}A_{0,j}\right] \qquad (6)$$

From literature (Ofiabulu and Charles-Owaba, 2013; Taha, 1986):

$$L_{ij} = \sum_{n=0}^{K_{ij}+2} nP_{(n)ij} = \sum_{n=0}^{K_{ij}+2} C_n^{K_{ij}+2} n!\rho_{ij}P_{ij} \qquad (7)$$

$$W_{ij} = \frac{L_{ij}}{\lambda_{ij}} = \frac{L_{ij}}{\lambda_{ij}(K_{ij} - L_{ij})} = \frac{(\overline{L}_{ij} + 1 - P_{ij})}{(1 - P_{ij})\mu_{ij}} \qquad (8)$$

$$P_{ij} = [\sum_{n=0}^{1} C_n^{K_{ij}+2} n!\rho_{ij}^n + \sum_{n=2}^{K_{ij}+2} C_n^{K_{ij}+2} n!\rho_{ij}^n]^{-1} \qquad (9)$$

Substituting P_{ij}, $W_{i,j}$ and $L_{i,j}$ in equations 4 and 6.

$$f_i = DPOC_i = T\sum_{j=1}^{Ni}\left(b_{i-1}\left[\frac{\left(\sum_{n=2}^{K_I}(n-1)C_n^{K_i}n!\rho_i^n + \sum_{n=1}^{K_I}C_n^{K_i}n!\rho_i^n\right)^2}{\mu_i\left(\left(\sum_{n=1}^{K_i}C_n^{K_i}n!\rho_i^n\right) + \left(\sum_{n=1}^{K_i}C_n^{K_i}n!\rho_i^n\right)^2\right)}\right] + b_iA_i\left(\frac{2 + \sum_{n=1}^{K_I}C_n^{K_i}n!\rho_i^n}{1 + \sum_{n=1}^{K_I}C_n^{K_i}n!\rho_i^n}\right)\right) \qquad (10)$$

and

$$F = T\sum_{i=1}^{M} N_i \left(\left(b_{i-1} \left[\frac{\left(\sum_{n=2}^{K_I} (n-1) C_n^{K_i} n! \rho_i^n + \sum_{n=1}^{K_I} C_n^{K_i} n! \rho_i^n \right)^2}{\mu_i \left(\left(\sum_{n=1}^{K_i} C_n^{K_i} n! \rho_i^n \right) + \left(\sum_{n=1}^{K_i} C_n^{K_i} n! \rho_i^n \right)^2 \right)} \right] + b_i A_i \left(\frac{2 + \sum_{n=1}^{K_I} C_n^{K_i} n! \rho_i^n}{1 + \sum_{n=1}^{K_I} C_n^{K_i} n! \rho_i^n} \right) \right) \right) + (N_0 b_{0,j} A_{0,}) \quad \ldots\ldots\ldots\ldots (11)$$

$$f_I = f(b_{i-1}, b_i, \rho_i, K_i, \mu_i, \lambda_i, A_i, N_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

$$F \; = f(b_{i-1}, b_i, \rho_i, K_i, \mu_i, \lambda_i, A_i, N_i, N_0, M, b_0) \quad \ldots\ldots\ldots (13)$$

The personnel related cost associated with an organisational structure ($\boldsymbol{F}$) and the daily personnel related cost associated with the ith level of the organisation, are function of the parameters: consultation rate of the subordinates (λ_{ij},); the boss's service rate (μ_{ij}); the hourly pay at the positions b_{ij} ; the number of hours of work (A_{ij}); number of operation positions (N_0); number of positions per level (N_{ij}); the span of control (K_{ij}) and the number of levels (M)

3.1. Organisational Design problem:

The organisational design problem is that of determining values of variables set $V(N_i, K_i, M,)$, given the values of parameter set θ such that personnel related cost of operating the organisation structure will minimum. The design problem is stated as thus:

Minimize $F = f(, M, K_i, N_i, \theta \;)$; where F is as given in equation 17

Subject to: following organisational design constraints:

$\sum_{j=1}^{N_i} K_{ij} \le N_{i\text{-}1}$ Supervision constraints

$N_M = 1$ Apex position constraint

$W_i(K_i,\; N_i,\; \phi) \le A_{ij}$ Waiting time constraint

$N_i, K_i, M \ge 0$ None negativity constraint

3.2. The existing Solution Method

The heuristics solution approach developed in Charles-Owaba (2002) is as outlined below:

Step 0 Determine the total number of operation positions N_0, of a particular organisation and the available hours of work A

Step 1 Set the level of organisation $i = 1$

Step 2: Determine the μ_i : the rate at which the boss attends to the subordinates and the rate at which the subordinates consults the boss, λ_i, for the level i

Step 3a: Substitute N_i with $\dfrac{N_{i-1}}{K_{ij}}$ in F function

Step 3b: Compute the values of F, functions for K_{ij} values 2,3,…… N_0 and determine the K_{ij} for which the value of F_i, functions is minimum for total daily personnel costs f and for which W_{ij} is less than A_{ij} and denote it as K_{ij}^*

Step 4: Determine the number of positions N_i at level i $N_I = \frac{N_{i-1}}{K^*_{ij}}$

Step 5: If N_i = 1 Go to Step 7

Step 6: Set $i = i+1$ and go to step 2

Step 7: $N_M = \frac{N_{M-1}}{K^*_{Mj}}$ NM=1, $N_{M-1} = \frac{N_{M-2}}{K^*_{M-1,j}}$,.................. $N_1 = \frac{N_0}{K^*_{1j}}$

Step 8: END

This method obtains an optimal solution for lower level and uses it as input to the higher levels

4. Dynamic Programming DP Approach

The general dynamic Programming approach to problems is to optimize in stages.

We denote the level of the organisation as the stages with the span of control K_i as the stage variables and the number of positions at the level N_i as the stage decision variables.

The equation relating a stage to another is

$$F_i(i, N_i, K_i, \theta_l) = f_i(i, N_i, K_i, \theta_l) + F^*_{i-1}(i-1, N^*_{i-1}, K^*_{i-1}, \theta_{l-1})$$

where

- $F_i(i, N_i, K_i, \theta_l)$ is the value of the personnel related costs up to the level i^{th} of the organisation for any pairs of feasible of N_i and K_i (i.e. all N_i and K_i for which $N_i K_i = N_{i-1}$ and $W_{ij}(N_i, K_i, \theta_i) \le A_i$)
- $f_i(i, N_i, K_i, \theta_l)$ is the value of the criterion function personnel related cost at the i^{th} level of the organisation, for any pair of feasible of N_i and K_i (i.e. $N_i K_i = N_{i-1}$ and $W_{ij}(N_i, K_i, \theta_i) \le A_i$)
- $F^*_{i-1}(i-1, N^*_{i-1}, K^*_{i-1}, \theta_{l-1})$ is the minimum value of the function at the stage $\mathbf{i-1}$
- N^*_{i-1}, K^*_{i-1}, are the optimal values at the $\boldsymbol{i}-1$ stage of number of positions and span of control respectively

4.1. Dynamic Programming Solution Algorithm for Minimising Personnel Related Cost

The problem here is that of finding the a combination of the number of positions per level N_i and corresponding span of control K_i such that F is minimum and that Nm=1.We note that $N_i K_i \le N_{i-1}$ and allow little variation DX in the number of operation position so that there is enough factors (N_i and K_i).

Step 1: Set $i = 0$

Determine the number of operation positions for each work type N_{0j}

Compute the personnel cost at **oth** level as $f^*_0 = N_0 A_0 b_0$

Allow a small integer variation of about (DX<3) on N_{0j} to ensure that enough factors of N_0 are available for consideration especially when N_0 is a prime number (Note: that N_i x K_i = N_0)

Step 2: Set $i = 1$

Determine the set of pairs of N_1 and K_1 for which

$$N_0 - DX \le N_1 K_1 \le N_0 + DX \quad \forall \quad K_1 = 2, 3, 4, ...N_0$$

and $W_1(N_1, K_1, \theta) \le A$

Step 3: For each pair of N_{1j} and K_{1j} determined in step 2 Compute the waiting time $W_1(N_1, K_1, \theta_1)$ using equation 8. If $W_1(N_i, K_i, \theta_i) > A_1$, Discard the pair of N_i and K_i otherwise Compute the operating costs $f_i(N_i, K_i, \theta_i)$ for all the feasible pairs of N_i and K_i using equation 10.

Step 4 For every N_i and K_i pair whose $f_i(N_i, K_i, \theta_i)$ was determined in step 3. Calculate the $F_i(N_i, K_{i,} \theta_1) = f_i(N_i, K_{i,} \theta_1) + F_{i-1}^*(N_{i-1}^*, K_{i-1}^*, \theta_{1-1})$ Write out for every N_i, and all the $F_i(N_i, K_{i,} \theta_1)$ and K_is corresponding to each $F_i(N_i, K_{i,} \theta_1)$ Determine for every N_i the minimum $F_i(N_i, K_{i,} \theta_1)$ as the total personnel cost and denote it as $F_1^*(N_i, K_1^*, \theta_1)$ Note also the value of K_1^* corresponding to the $F_1^*(N_i, K_1^*, \theta_1)$

Step;5 Determine the minimum $F_1^*(N_i, K_1^*, \theta_1)$ for all the N_i at the i stage and denote it as $F_1^{**}(N_i, K_1^*, \theta_1)$. If $F_1^{**}(N_i, K_1^*, \theta_1)$ corresponds to N_i =**1**, Go to step 10. If $F_1^{**}(N_i, K_1^*, \theta_1)$ corresponds to $\mathbf{N_i \geq 2}$ Note $F_1^*(N_i, K_1^*, \theta_1)$ for N_i =**1** at this stage and denote as **L* (** N_i **)** and note its K_1^* value

Step:6 Set $i = i + 1$. Determine the feasible pairs of Ni and K_{ij} for which $N_i K_i \in \{N_{i-1}\}$

Step:7 For each pair of N_1 and K_1 determined as feasible in step 6, Compute the waiting time $W_i(N_i, K_i, \theta_i)_j$ using equation 8. If waiting time $W_i(N_i, K_i, \theta_i) > A_i$, Discard the pair of N_i and K_i otherwise compute the personnel related costs $f_i(N_i, K_i, \theta_i)$ for all the feasible pair of N_i and K_i using equation 10. $F_i(i, N_i, K_{i,} \theta_1) = f_i(i, N_i, K_{i,} \theta_1) + F_{i-1}^*(i-1, N_{i-1}^*, K_{i-1}^*, \theta_{1-1})$ for the feasible pair of N_i and K_i Write out for every N_i, and all the $F_i(N_i, K_{i,} \theta_1)$ and K_is corresponding to each $F_i(N_i, K_{i,} \theta_1)$ Determine for every N_i the minimum $F_i(N_i, K_{i,} \theta_1)$ in the and denote it as $F_1^*(N_i, K_1^*, \theta_1)$ Note also the value of K_1^* corresponding to the $F_1^*(N_i, K_1^*, \theta_1)$ Determine the minimum $F_1^*(N_i, K_1^*, \theta_1)$ for all the N_i at the **i** stage and denote it as $F_1^{**}(N_i, K_1^*, \theta_1)$

Step:8 If $F_1^{**}(N_i, K_1^*, \theta_1)$ corresponds to N_{ij}=1, Go to step 10. If $F_1^{**}(N_i, K_1^*, \theta_1)$ corresponds to $N_i \geq$ **2.**

Denote $F1_1^*(i, N_i, K_1^*, \theta_1)$ for N_i =**1** at this stage as $L^*(N_{i-1} = 1)$ and note its K_i value

Step:9 Go To Step:6

Step:10 If $F_1^{**}(N_i, K_1^*, \theta_1)$ for (N_i = 1) is greater than L* (N_{i-1}) (if it exists) Go To step 12

Step:11 $F_1^{**}(N_i, K_1^*, \theta_1)$ for $\mathbf{N_i}$=**1** is the minimum personnel related cost value of the organisational structure **i** is the number of level M

- $N_M = 1$
- $N_{M-1} = K_M^*$
- $N_{i-1} = N_i K_i^*$
- ……………………
- $N_0 = N_1 K_1^*$.

Step 12: F** =L* **(** N_{i-1} **)** is the minimum personnel related cost F value of the organisational structure

- $i - 1 = M$ is the number of level M
- $N_M = 1$
- $N_{M-1} = K_M^*$
- $N_{i-1} = N_i K_i^*$
- …………………

- $N_0 = N_1 K_1^*$.

Step 13: End

6. Application: The case of a tyre manufacturing company

The model outlined in this study was used to redesign a tyre manufacturing company. Parameter values were determined using work-study tools. The existing organisational structure is presented in table 1, while the values of the related parameters and other information are presented in table 2. The existing organisational structure has three departments with staff strength of 248: 46 decision positions; 204 operation positions and 6 organizational levels. The design problem was solved using the heuristics and the dynamic programming algorithm.

7. Results and Discussion

The Dynamic programming (DP) design algorithm produce smaller organizational structures as evident in the results presented in Tables 2 and 3.than the heuristics. The personnel related cost of operating organizational structure and the 'Number of management level' of the DP designed structure (₦ 39,145,580.00) and (2) were respectively smaller than that of the heuristic-designed (₦42,949,433.48) and (3) for the organisation. This observation also holds for the number of managers and number of supervisors as shown in Tables 2 and 3. However, average the span of control per level of the DP-designed structure (12) was higher compared to that (7) of the Heuristic-designed.

The reason for these differences is that DP algorithm, being an implicit enumeration, searches the entire solution space for the set of span of management, which will result in the global optimum of each design problem. On the hand the Heuristic search selects stage optimal as final for that stage of design and uses it as input for the next stage. This may lead to sub optimality at other stages. This is also evident in the solution values corresponding of the DP-designed structure being better than those of the heuristic-designed as presented in Tables 2 and 3.

However, in terms of computation time, the implicit enumeration approach, the DP algorithm, has more processing time (15.06) than the Heuristic (1.65) as shown in Tables 3. It is clear from Figures 3 that the DP algorithm time exhibits a degree-4 polynomial for operation positions varying between 40 and 140 while the heuristic time displayed a quadratic curve. At this range of operating positions, the DP algorithm is relatively efficient since the literature defines efficiency in terms of the degree of polynomial or exponential curves (Johnson et al, 2002; Kwon et al, 2005). However, whether or not it is efficient, there is a consolation, the computation time is only in seconds ranging between 0.1 and 15.06. Hence, barring memory problems, for even large problems, organizational design with the DP algorithm may be feasible on Personal Computers.

Relative to the existing organisational structures of the company, the DP designed algorithm substantially reduced the value of the personnel related costs by 64.51% compared to 61.06% by heuristics method. The operation position were determined applying the Using work study principles to quantify the actual amount of work available in man-hours, the operation positions reduced from 204 to 145.

8. Conclusions

The dynamic programming algorithm produced optimal organisational structures with minimum personnel related costs, lower number of management levels and higher average span of control than those by the existing heuristic as shown in Table 2 and 3.The heuristic computational time was very low (efficient) compared to the dynamic programming algorithm. Computation times for both methods are between 1.5 and 16 seconds. It can be concluded that both method have low computation costs.

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Table 1Existing organisational structure and Parameter values for Case 2

Level	Hours	Cases/ hour		₦/ hour		
I	A	λ_i	μ	B	Ni	Kij
4	8	2..15	2.5	874..6	1	4
3	8	1.25	1.75	583.33	4	3
2	8	1.33	3.378	291.75	12	2
1	8	0.94	4.37	197.4	29	7
0	8	-	-	82.16	204	-

Table 2 Designed organisational structures

	DP		Heuristics		Existing	
Level	Ni	Ki	Ni	Ki	Ni	Ki
4	-	-	-	-	1	4
3	-	-	1	2	4	3
2	1	11	2	8	12	2
1	11	13	13	11	29	7
0	145	-	145	145	204	-
F	₦39,145,580.00		₦42,949,433.48		₦110296007	

Table 3.Organisational characteristics

1.	Personnel Utilisation	39,145,580.00	42,949,433.48
2.	Computation time	15.06	1.65
3.	Number of management level	2	3
4.	Number of managers	1	2
5.	Number of supervisors	11	13
6.	Average span of control	12	7
7.	The size of organization	167	169

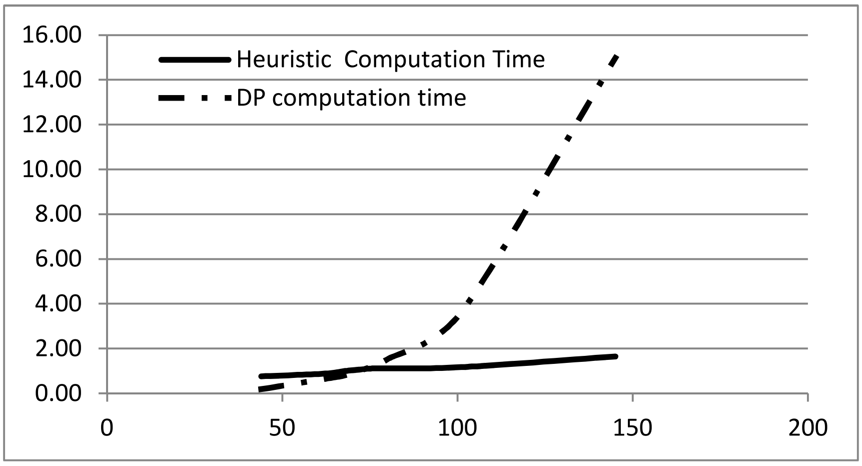

Figure 4.8 DP and Heuristic Computation time