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ON BUILDING AN OR-BASED DECISIONS MODEL VIA COHERENT PLURALISM

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ABSTRACT

The problems that often arise in any business or commercial organisations are profit maximization and operating cost minimization. This work develops a heuristic framework, using computer science technology in Operations Research (OR) problems, as a contribution to the use of different techniques and/or models in combination (i.e. Coherent Pluralism). Three OR techniques are considered, and a computer high level language (QBASIC) is used to design a computer program (referred here as a computer model) that integrates these techniques. Typical data from a paint manufacturing factory are analysed. On the whole, the need for the implementation of OR techniques in management operations is emphasized.

Keywords: Coherent Pluralism; Decision Support System; Heuristic; OR techniques.

INTRODUCTION

Traditional methods of decision-making have impeded the technical efficiency of most organizations in many developing countries as well as in Nigeria. This is as a result of failures to adopt and implement the scientific systems analysis developed over the years by researchers and used in most developed countries. Studies and researches enumerate the possible courses of this breach to include lack of knowledge of the techniques as well as cost of operations. Consequently, many researchers are motivated to use different techniques or tools in combination to ease the cost of operation and simplify the managerial complex problems for a fast and better decision in what is called "Coherent Pluralism". By Coherent Pluralism, different managerial problem situations and different purposes in systems thinking, operational research, organisation theory, evaluation research, information systems and management consultancy would be addressed.

According to Meyersiek (1976), Computer models were seen as a good method of acquiring the desired results of interest expectation, risk analysis and financial planning. Omerod (1995) described his project in which cognitive mapping, soft systems methodology and strategic choice in its various phases (various soft OR methods) were used in the development of a new information systems strategy in U.S.A for Sainbbury's Supermarket.

Mingers and Brocklesby (1996) expressed the fact that Pluralists are increasingly combining different methods and methodologies as one justification for the need to examine the use of multimethodology (i.e., a combination of methodologies). They tried to measure the characteristics of different methodologies according their ability to assist appreciation, analysis exploration and action. They also stressed on the methods, tools and /or techniques viewed to be associated with it, which need not be closed ones. A case of system dynamics techniques viewed to be associated with functionalist methodology was provided to be used as a detailed cognitive design for enhancing debate in an interpretive framework. However, Jackson (1999) outline the form that pluralism needs to take if it is to be both theoretically defensible and provides the greatest benefit to practitioners.

FRAMEWORK FOR THE DECISIONS-MODEL

The framework is heuristic which involves the integration of existing OR techniques via computer science technology. The resulting model is a computer program written in a computer high level language known as QBASIC, which makes it more beneficial to the local organizations including Paint Industries, and simple enough to appreciate. The QBASIC is so chosen because it is a scientific programming language that is common in personal computers according to Brightman and Dinsdale

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(1986). The process for the framework is as follows:

Step 1:

Identify and formulate the associated problems of management.

Step 2:

Build or search for existing OR models that fit these problems and identify or define the outputs required from the model in order to achieve the objective of the task by identifying a set of inputs that are allowable within the spectrum of the algorithms.

Step 3:

Ascertain the performance quality of the algorithms by seeing to it that sequence of steps leading to a solution must be clear, unambiguous and capable of being rigorously followed.

Step 4:

Document the logic flow by translating the algorithms into a computer model (otherwise known as a program). Link inputs and outputs using series of user-defined intermediate or calculation variables and document the flow of information between them using a graphical representation like a flow chart.

Step 5:

Group the variables at each procedure into:

(a) Variable inputs (i.e., quantities that are likely to change during the project investigation).

(b) Constant inputs (i.e., quantities that can be considered constant for the scope of the investigation).

(c) Intermediate variables (i.e., variables that have been introduced into the model to link procedures as well as inputs and outputs). Then documents the available procedures.

Step 6:

List the computer program (model) and commence the computation of any chosen procedure. If a new management problem exists, go to step 1.

CASE-STUDY

A Study was conducted on the use of OR techniques in solving managerial problems by management of a typical Paint Company in Nigeria. The company produces different types of quality paints which include Peaton Synthetic Gloss and Car Lux. Production is strictly based on deterministic demand and no backlogging (i.e. shortages are permitted). The variables used in this study are shown in Table 1. In collecting the data, series of interviews with the Administrative department, the Operations department as well as the Accounts department were conducted. The format of the interviews was structured to ensure that all those interviewed were asked basic set of questions related to the purpose of the study. Focus was on the dynamics of operations which include product mix, production schedule and capital expenditure

Management objectives were identified as:

(i) determining the amount of units of Peaton Synthetic Gloss and Car Lux to be produced in a given production cycle;

(ii) determining the sequence of periods over which production could be planned optimally with unconstrained overtime and no backlogging;

(iii) determining the optimal replacement policy for replacing a particular machine of a particular age over a given number of years.

In formulating the problems using OR techniques, three models were utilized. They are:

(i) Linear programming; (ii) Inventory theory; and (iii) Dynamic programming models.

THE ASSOCIATED ALGORITHMS

The associated algorithms for the chosen techniques are:

(i) Simplex Algorithm for Linear Programming;

(ii) Production - Planning Algorithm for Inventory - Overtime Tradeoff: Planning Horizons with unconstrained Overtime and No Backlogging;

(iii) Replacement Model Algorithm for Dynamic Programming.

Details of the algorithms are available in Kunrenther (1971) and Taha (1999).

TABLE 1: VARIABLES IN THIS STUDY

VARIABLES	MEANING
M_1	Master Mixer machine
M_2	Tank Mixer machine
X_1	Peaton Synthetic Gloss
X_2	Car Lux
t_i	Age of machine in i -year
cc	Cost of acquiring a new machine
r	Expected yearly revenue
c	Operating cost of a given year – old machine
s	Salvage costs of a machine in a given period
w	Wage differential between producing a unit of products on overtime rather than regular time
h	Per unit Storage cost for one period
H	Holding costs which is equal to w/h
P^*_n	Optimal production in a given n – period
K*	The length of time in which demand must be known
R_n	Number of regular time in n – period
D_n	Demand of goods or products in n – period
I	Initial inventory on hand.
n	Number of periods
₦	Naira

TABLE 2: DEMAND REQUIREMENT/PRODUCTION CAPACITY

PERIOD	DEMAND (in tone)	UNITS OF REGULAR (in Hr)	INITIAL INVENTORY (in tone)
1	25,000	60	5,000
2	40,000	60	-
3	90,000	60	-
4	80,000	60	-
MACHINE TYPE		MASTER MIXER	TANK MIXER
CAPACITY		6,000 liters/hr	2,000 liters/hr

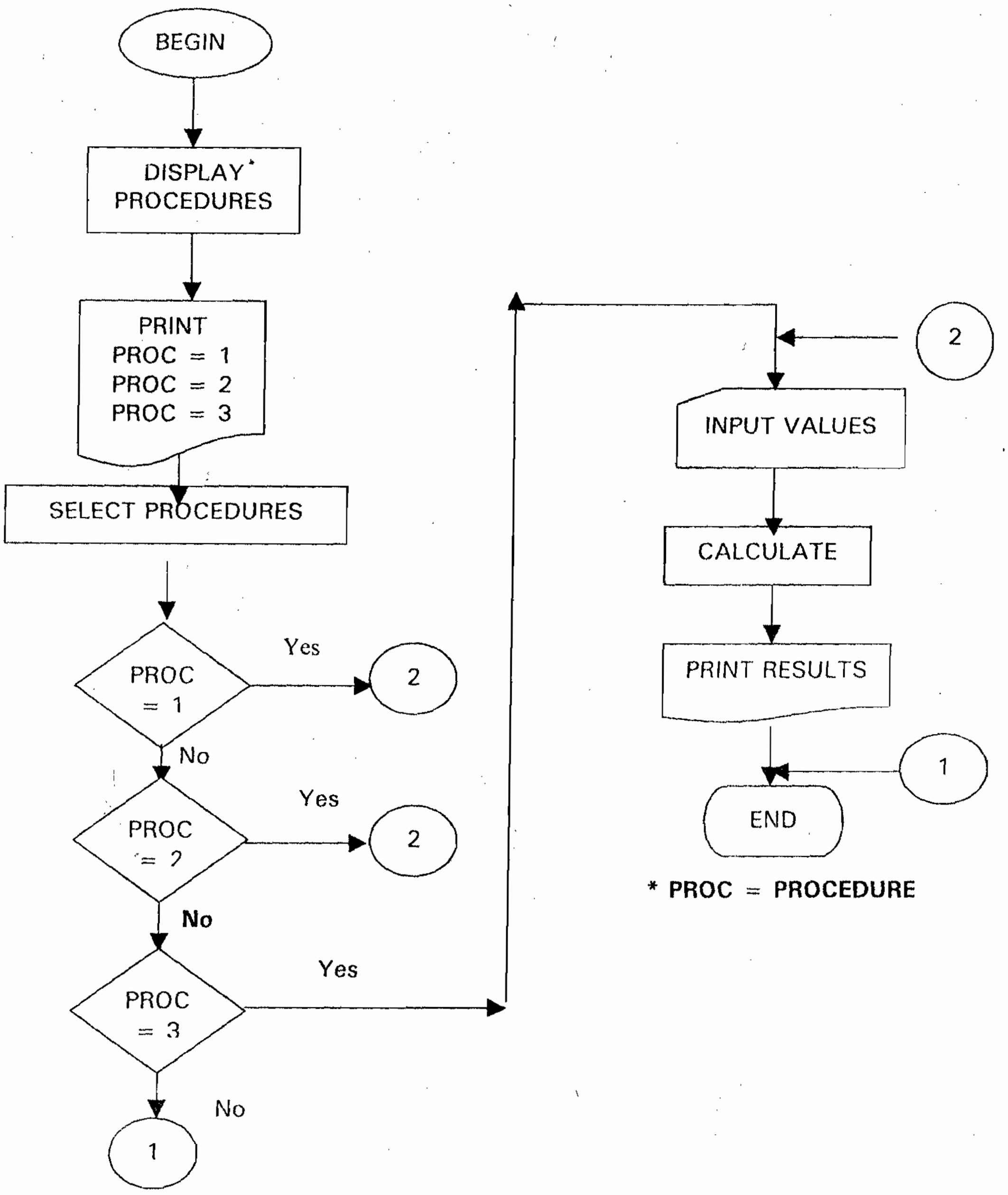
TABLE 3: CAPITAL EXPENDITURES ₦

COST OF A NEW MACHINE	8,000,000
SET-UP COSTS	51,266,469
UNIT PRODUCTION COSTS	165.87
WAGE DIFFERENTIAL	82,000
UNIT STORAGE COSTS	747,270.67
TOTAL HOLDING COSTS	2,241,812

TABLE 4: MAINTENANCE/REFURBISHMENT

YEAR	REVENUE (₦)	OPERATING COSTS (₦)	SALVAGE COSTS (₦)
1	1200000	75152	7600000
2	1050000	973400	7000000
3	700000	205900	6500000
4	95000	162583	5500000
5	1500000	57845	3500000
6	150000	58040	4000000
7	700007	146531	7000000
8	2500000	31900	6000000

Figure 1: Documentation of Logic Flow



The user program (computer model) is as shown in Appendix 2.

THE EMPIRICAL RESULTS

The results of the experiment via the computer model are as shown in the following tables:

Table 5: PRODUCT MIX
*** OPTIMUM ITERATION TABLEAU FOR LP ***

Population (OBJECTIVE. FN)	1	7	6	1	2	32
X_2	0	1	0	-0.5	0.5	2
X_1	0	0	1	0.75	-0.25	3

Table 5 shows that the company should produce two units of Car Lux and three units of Peaton Synthetic Gloss for a profit of N32.00 per unit. For a minimum of 20 hours, the total incremental profits will be

Peaton Synthetic N18.00 per liter
Car Lux N14.00 per liter

For a total volume of 160000 units of products, it is wise therefore to produce about 53% of Peaton Synthetic Gloss and 47% of Car Lux for a maximum profit.

Table 6: OPTIMAL TIMING OF CAPITAL EXPENDITURES
***** OPTIMAL POLICY TABLEAU FOR DP*****

YEAR	MAXIMUM NET INCOME (N)		OPTIMAL DECISION
8	2468100	-2000000	KEEP
7	2.770258E + 07	-3000000	KEEP
6	3.061703E + 08	-7000000	KEEP
5	3.369316E + 09	-1.15E + 07	KEEP
4	3.70624E + 10	-1.4E + 07	KEEP
3	4.076932E + 11	-1.55E + 07	KEEP
2	4.484625E + 12	-1.65E + 07	KEEP
1	4.933089E + 13	-1.69E + 07	KEEP

Based on Table 6, it could be deduced that within the period of a given eight years, the machine need not be replaced. There is much hope of mechanical efficiency.

TABLE 7: PRODUCTION-PLANNING HORIZON
***** OPTIMAL PLANNING-HORIZON TABLEAU FOR INV.*****

PERIOD	TOTAL DEMAND (in ton)	OPTIMAL PRODUCTION (in ton)
1	25000	20000
2	40000	-
3	90000	-
4	80000	-

Table 7 shows the company's anticipations and planning horizon as being only one period. Therefore, given a linear cost function or structure, it should never produce units during overtime in this period and hold the products for later period.

On the whole, the operation utilized about 600 seconds.

IMPLEMENTATION

Since management decision-making can only be improved through OR if the techniques and/or models are utilized in the organizations, according to Shultz and Slevin (1975), there is need for managements and the management of the Paint Company under study, in particular, to utilize OR approach of decision analysis through creating OR department and employing operations researchers/management scientists. This, according to Wagner (1972), will help the department to mount a massive analysis, when warranted, of an important and intricate decision-making problem. This therefore will leave no doubt whatsoever, in any executive's mind that all reasonable courses of action have been investigated, and will also make crystal clear the relative merits of specific alternative actions and their possible consequences accord as described by Hillier and Lieberman (1995).

CONCLUSION

This work has dealt with a framework for building an OR-based decisions model through coherent pluralism. The coherent framework, (i.e. the heuristic) follows a formal dependence and reliance on electronic computer, while the computer times and memory requirements are sufficiently modest to allow problems of real life and practical dimensions to be solved in a personal computer. The computational results via the computer model (the program) shows that:

(i) the objective function values found are sensitive to both cost of operation and the time frame of the production horizon. Thus, (a) there is need for the company to produce about 53% of peathon synthetic gloss and about 47% of car lux out of a given total volume of 160,000 units of production, so as to maximize profit;

(b) machine replacement should take relatively longer period than 8 years; (c) every unit of product manufactured during over-time should not be kept in stock.

(ii) a new methodology for using OR-techniques in combination to address managerial complex problems is through computer science technology;

(iii) there is need for management and the management of the Paint Company used as a case study to appreciate and implement OR techniques in the company.

On the whole, this research work represents an important contribution towards building an OR-based decisions-model via coherent pluralism.

APPENDIX 1: MATHEMATICAL MODELS

The OR models used in this work are the simplex algorithm model for the linear programming problem (LPP), the production planning model for the inventory – overtime tradeoff and the replacement model for the dynamic programming. These models are mathematically formulated as follows:

(a) Model for the LPP

Maximize $P = 6x_1 + 7x_2$ ....(1)

Subject to

$2x_1 + 3x_2 \geq 12$ ....(2)

$2x_1 + x_2 \geq 8$ ....(3)

$x_1, x_2 \geq 0$ ....(4)

which in standard form is

Maximize $P = 6x_1 + 7x_2 + 0x_3 + 0x_4$ ....(5)

Subject to

$2x_1 + 3x_2 + x_3 + 0x_4 = 12$ ....(6)

$2x_1 + x_2 + 0x_3 + x_4 = 8$ ....(7)

$x_1, x_2, x_3, x_4 \geq 0$ ....(8)

This LPP implies that;

A unit of X_1 produces an increment in profit of N6, and each unit of X_2 and incremental profit of N7.

The constraints imply:

(i) 12 hours are available on M_1 while each unit of X_1 and X_2 requires 2 hours and 3 hours respectively;

(ii) 8 hours are available on M_2 with X_1 and X_2 requiring 2 hours and 1 hour, respectively;

(iii) X_3 is unused material for X_1 production, X_4 is unused material for X_2 production. The restriction implies that no negative amount of production shall be made.

(b) Model for the inventory – overtime tradeoff:

Define $K^* = (w/h) + 1$ ....(9)

$$M^1 = \min\{R_1 - (D_1 - I), \sum_{j=2}^{n_1} (D_j - R_j)\} \quad \text{........(10)}$$

$$M^2 = \min\{\sum_{J=2}^{n_1} [R_j - (D_j - I)], \sum_{j=n_1+1}^{n_2} (D_j - R_j)\} \quad \text{........(11)}$$

If the number of cycle in a given period is greater than 2, then

$$M^{i+1} = \min\{\sum_{J=1}^{n_i} [R_i - (D_i - I)], \sum_{j=n_i+1}^{n(i+1)} (D_j - R_j)\} \quad \text{........(12)}$$

where $i > 2$

For $n = 1$,

$$D_1 - I < R_1 \quad (13)$$

$$\text{If } \sum_{j=2}^{n} (D_j - R_j) \leq 0,\ n = 2, \ldots, K^* \quad (14)$$

$$\text{Then } P_1^* = D_1 - I \quad (15)$$

Else,

$$D_1 - I \geq R_1 \quad (16)$$

(c) Model for the Dynamic programming:

Define $f(t_i)$ = maximum net income for a given ith year

where $i = 1,2,\ldots\ldots,n$

then,

$$f(t_i) = \max \begin{cases} r(I) - C(I) + f_{i+1}(t_{i+1}) \text{ ..keep} \\ r(0) - S(I) - CC - C(0) + f_{i+1}(1) \text{ ....Replace} \\ f_{n+1}(.) \,\square\, 0 \text{ for } n = 8. \end{cases}$$

APPENDIX 2: COMPUTER MODEL (PROGRAM) FOR HEURISTIC

```
19 CLS
PRINT "the procedure available are"
PRINT " 1 product mix"
PRINT " 2 machine replacement"
PRINT "3 production schedule"
PRINT
PRINT
PRINT "choose which one you wish to run"
PRINT
INPUT "make your choice"; CHOICE
IF CHOICE = 1 THEN GOSUB 1
IF CHOICE = 2 THEN GOSUB 15
IF CHOICE = 3 THEN GOSUB 13
INPUT "DO YOU WISH TO RUN ANOTHER ?"; Y$
IF Y$ = "y" OR Y$ = "Y" THEN GOTO 19
PRINT "end of RUN"
END
1 REM procedure for product mix
DIM x(9 * 10, 9 * 10)
vv = 0
INPUT "how many variables do you expect"; n
INPUT "how many equations"; m
PRINT "enter coefficients of the objective function"
FOR I = 1 TO m
FOR k = 1 TO n + 1
INPUT x(I, k)
NEXT k
NEXT I
GOSUB 2000
min = x(1, 1)
b = 1
FOR k = 2 TO n + 1
IF x(I, k) > min GOTO 600
min = x(I, k)
bb = k
c = k
```

```
600 NEXT k
PRINT "Objective element"; min
p = 99999999
FOR j = 1 TO n
IF x(j, n + 1) = 0 THEN 900
IF x(j, bb) = 0 THEN 900
v(j) = x(j, n + 1) / x(j, bb)
IF v(j) < = 0 THEN 900
IF v(j) > p THEN 900
p = v(j)
r = j
pe = x(j, bb)
900 IF x(j, n + 1) = 0 THEN 560
560 NEXT j
PRINT "pivot element"; pe
FOR k = 1 TO n + 1
IF x(r, k) = 0 THEN 1200
x(r, k) = x(r, k) / pe
1200 NEXT k
REM GOSUB 2000
FOR I = 1 TO m
bot = x(I, c) * (-1)
IF I = r THEN 400
FOR k = 1 TO n + 1
tt = x(r, k)
lk = (bot * tt) + x(I, k)
x(I, k) = lk
NEXT k
PRINT "the value", x(I, bb)
400 NEXT I
GOSUB 2000
END
2000 RESTORE
300 INPUT "should I continue printing"; Y$
IF Y$ < > "y" THEN 300
CLS
kk = 3
FOR I = 1 TO m
vv = 0
FOR k = 1 TO n + 1
vv = vv + 5
LOCATE kk, vv
PRINT x(I, k);
NEXT k
PRINT
kk = kk + 2
NEXT I
RETURN
100
RESTORE
PRINT x(I, k); x(I, bb); x(r, k); x(I, k)
RETURN
15 REM subroutine for Linear
CLS
INPUT "enter the number of times"; n
DIM f(n * 10)
DIM b(n * 10)
INPUT "enter time"; ti
INPUT "enter cost"; cc
FOR k = 1 TO n
INPUT "enter value for r", r(k)
INPUT "enter value for c", c(k)
INPUT "enter value for s", s(k)
NEXT k
FOR I = n TO 1 STEP -1
f(I) = r(I) - c(I) + (f(I + 1) * (ti + 1))
ft(I) = r(0) + s(I) - cc - c(0) + ft(I + 1)
NEXT
FOR I = n TO 1 STEP -1
PRINT I, f(I), ft(I)
NEXT I
RETURN
13 REM PROCEDURE FOR PRODUCTION SCHEDULE
INPUT "enter the number of t"; n
INPUT "enter value of w"; w
INPUT "enter value of h"; h
INPUT "enter the value of p*", p
INPUT "enter the value of k*"; k
INPUT "enter th value of I", ii
CLS
PRINT "supply data"
FOR I = 1 TO n
INPUT d(I), r(I)
NEXT I
IF d(1) - ii > r(1) GOTO 200
fd = r(1) - (d(1) - ii)
sd = (d(2) + d(3)) - (r(2) + r(3))
ml = fd
IF sd < fd THEN m1 = sd
fd1 = (r(1) + r(2) + r(3)) - (d(1) + d(2) + d(3) - ii)
sd1 = d(4) - r(4)
m2 = fd1
IF sd1 < fd1 THEN m2 = sd1
p = fd1 + sd1 + m1
PRINT p
GOTO 3000
200
p = d(1) - ii
PRINT p
3000 RETURN
```

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