MAXIMISING PROFITS FROM PASSENGER TRANSPORT SERVICE USING TRANSPORTATION MODEL ALGORITHM (PART 2) - The Advantage of Shadow Pricing

By

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ABSTRACT

The diversity and complexity of the different types of passenger transportations in operation today invokes the need for an efficient transport service management system. Existing transportation models tend towards proffering solution for finding the least cost combination for delivering cargoes from various depots to known remote customer destinations. This paper which is the second part of the same title adopts shadow pricing to modify the existing model for use in the management of passenger transport services. It uses a case study approach to investigate the effect of non-application of a scientific based approach to vehicle capacity assignment management technique in the Nigerian private transport sector. Using worked examples the paper clearly suggests that adopting the transportation model algorithm for assigning and reassigning vehicle to routes especially during peak periods of activity, holidays or festivities will optimize operational decisions.

Keywords: Transportation; Passenger; Contribution; Shadow Price; Manifest; Route; Models; Volume; Algorithm; Profit.

JEL Classification: R41, C63, M49.

INTRODUCTION

The first part of this paper titled *Maximizing Profits From Passenger Transport Service Using Transportation Model* Algorithm published earlier has already stated that the primary objective of a business entity is to maximize owners equity (VanHorne, 1977; Brockington, 1988). Passenger transport service business in Nigeria is the most competitive, most vulnerable and most volatile of all sectors in the Nigerian economy. The reasons for these are not too difficult to discern. First Nigerians are highly mobile people willing to travel at short notice; secondly, apart from road transportation which is even characterized by lack of effective government coordination, other forms of transport are still highly underdeveloped; thirdly, most transport operators in Nigeria are still "***traditional***" in their approach to doing business due to the virtually low level of intellectual development prevailing amongst them. Furthermore, the transport business brings in very high and quick returns than other forms of business especially during festivity periods.

Within the past two decades, many good and promising transport companies have come and gone with most unable to withstand the pervading competition while others simply mismanaged their successes. One thing stands out though, and that is the deficiency of these transporters in the management of ***peak periods***. This is mostly caused by their inability to apply resourceful and scientific methods such as mathematical algorithms in the assignment and scheduling of passenger vehicles and manpower resources. The objective of this paper is to espouse the need for the use of mathematical models and scientific algorithms in the scheduling and assignment of organizational inputs for the purpose of optimizing the use of organizational resources. We shall do this by taking example from a true transport business situation in Nigeria using a modified transportation modeling technique adapted especially for the purpose of this paper. The first paper uses a somewhat simplified and less complicated approach, in this paper, however, we shall modify the approach to estimating the best vehicle assignment formula by using shadow pricing technique. The reader is advised to download the first paper from http://papers.ssrn.com/abstract=1005417 and get familiar with it first, in order to fully comprehend this second part.

A Case Study

We shall use the same case data that was used in the first paper but with slight modifications. A bus company operates from Enugu, Aba, Calabar, Onitsha and Port-Harcourt in the east to Lagos, Ibadan, Ilorin, Kano and Jos. It has a total of 175 serviceable buses in its fleet. The buses were sent out on a typical day during the December peak period to convey eastern bound passengers returning for the Christmas in the following order: Lagos 54 buses, Ibadan 20 buses, Ilorin 26 buses, Kano 56 buses and Jos 19 buses. A report from the Kano depot manager indicates that 6 of the 56 buses sent to Kano have been grounded for repairs which normally take days to complete.

The passenger expectations to the five eastern routes are Aba 2160 passengers, Enugu 1980 passengers, Port-Harcourt 2100 passengers, Calabar 1860 passengers and Onitsha 3240 passengers.

The following table holds the number and mix of passengers available at each of the five originating cities:

TABLE 1: PASSENGER AVAILABILITY TABLE

TO	Lagos	Ibadan	Ilorin	Kano	Jos	Total
Aba	720	240	300	720	180	2160
Enugu	960	180	120	540	180	1980
P/H	780	300	240	660	120	2100
Calabar	840	240	120	360	300	1860
Onitsha	1140	480	300	840	480	3240
TOTAL	**4440**	**1440**	**1080**	**3120**	**1260**	**11,340**

The contribution per passenger (after adjusting for direct costs on full load) on each route is tabulated bellow:

TABLE 2: CONTRIBUTION PER PASSENGER

	Lagos	**Ibadan**	**Ilorin**	**Kano**	**Jos**
Aba	1932	1932	2078	2325	1679
Enugu	1950	1950	2096	2143	1696
P/H	2214	2214	2361	2607	1961
Calabar	2714	2714	2661	2589	2161
Onitsha	1750	1750	1896	2143	1496

Expectations

With the four vital information as above in hand, all we are expected to do is to:

(a) Find the total value of contribution expected above (the *initial value*);

(b) Apply a mathematical algorithm to rearrange or re-assign the buses in accordance with passenger availability and route profitability;

(c) Find the total value of contribution expected after the reassignment (the *final value*) and compare it with the initial value.

Procedure

First we convert the *number of passenger per route* to the *number of buses per route* by dividing the number of passengers by 60 for each route. Here, 60 is assumed as the maximum number of passengers per bus (full load). See table 3 bellow.

TABLE 3: BUS REQUIREMENTS PER ROUTE

	Lagos	**Ibadan**	**Ilorin**	**Kano**	**Jos**
Aba (36)	12	4	5	12	3
Enugu (33)	16	3	2	9	3
P/H (35)	13	5	4	11	2
Calabar (31)	14	4	2	6	5
Onitsha (54)	19	8	5	14	8
Total (189)	**74**	**24**	**18**	**52**	**21**

Next, we compare the bus requirements with the bus availability at the various depots:

TABLE 4: COMPARISON OF BUS REQUIRED WITH BUS AVAILABLE

	(Total)	**Lagos**	**Ibadan**	**Ilorin**	**Kano**	**Jos**
Available	(168)	54	20	26	50	19
Required	(189)	74	24	18	52	21
Surplus/(Shortfall) -		**(20)**	**(4)**	**8**	**(2)**	**(2)**

As seen from the analysis, Lagos, Ibadan, Kano and Jos have shortfalls while only Ilorin has surplus buses. The initial assignments at the various depots are tabulated below.

	Lagos	Ibadan	Ilorin	Kano	Jos
Aba	10	4	5	10	3
Enugu	14	3	2	9	3
PHC	12	4	4	11	2
Calabar	8	2	2	6	5
Onitsha	10	7	5	14	6
Idle Vehicles	-	-	8	-	-
Total @ Depot	54	20	26	50	19

The problem now is how to ensure that the optimal decision is reached. Normally, the guiding principle will be the ability to make optimal allocation. We do this by first assessing the present position by way of calculating the total contribution available from the current assignment as follows:

From Lagos Depot (Available = 54 buses) To:

City	**No of Buses**	**(Contribution X 60)**	**Total Contribution**
Aba	10	115, 920	1,159,200
Enugu	14	117,000	1,638,000
P/H	12	132,840	1,594,080
Calabar	8	162,840	1,302,720
Onitsha	10	105,000	1,050,000
	Total from Lagos		**6,744,000**

We also calculate from Ibadan depot with 20 buses to each of the five eastern destinations using similar calculations as above, as well as for each of the other depots at Ilorin, Kano and Jos. After these computations are done, the contributions expected from all routes are given in table 5 as follows:

TABLE 5: INITIAL EXPECTED CONTRIBUTIONS BY DEPOTS

DEPOT	CONTRIBUTION
Lagos Depot	6,744,000
Ibadan Depot	2,406,720
Ilorin Depot	2,329,680
Kano Depot	7,005,000
Jos Depot	2,029,680
TOTAL INITIAL EXPECTED CONTRIBUTION =	**20,515,080**

Next, we try to maximize the above contribution by making further comparative analysis and re-assignments on the basis of some shadow contribution computations. To begin with, we set out the table of required and available buses from each of the routes to their various destinations making our initial reassignments on the basis of highest contribution as follows:

TABLE 6: COMPARATIVE BUS STATISTICS TABLE

	Lagos	Ibadan	Ilorin	Kano	Jos	Total
Available	54	20	26	50	19	169
Aba	12:10	4:4	5:5	12:10	3:3	36:32
Enugu	16:14	3:3	2:2	9: 9	3:3	33:31
PHC	13:12	5:4	3:3	11:11	2:2	35:33
Calabar	14: 8	4:2	2:2	6: 6	4:4	31:23
Onitsha	19:10	8:7	5:13	14:14	8:6	54:50
Difference	(20)	(4)	+8	(2)	(2)	(20)

The order of this first assignment is determined by the various depot management.

To re-allocate vehicles for optimum decision we shall make the following series of calculations. Remember, however, that reassigning vehicles from one depot to another certainly has cost implications which must be considered in the final analysis. This is because transferring a vehicle from one route to another will involve costs such as fuel, oil, minor maintenance expenses as well as lost time.

From table 6 above, we can see that the depots requiring buses are Lagos (20), Ibadan (4), Kano (2) and Jos (2).

Tabulated below are additional costs of re-assigning vehicles from one depot to another.

Table 7: COST OF SENDING A BUS FROM DEPOT TO DEPOT

	LAGOS	**IBADAN**	**ILORIN**	**KANO**	**JOS**
LAGOS	-	5000	8000	20000	18000
IBADAN	5000	-	4000	18000	16000
ILORIN	8000	4000	-	16000	14000
KANO	20000	18000	16000	-	4000
JOS	18000	16000	14000	4000	-

COMPUTATION OF SHADOW PRICES (CONTRIBUTION)

To commence our computation, we assign letters to both the originating and the destination depots as follows:

Let A = Aba; L = Lagos

E = Enugu; B = Ibadan

P = Port-Harcourt; R = Ilorin

C = Calabar; K = Kano

O = Onitsha; J = Jos

With the above, the routes can be re-designated as follows:

AL = Aba-Lagos; AB = Aba-Ibadan; AR = Aba-Ilorin; AK = Aba-Kano; AJ = Aba-Jos

EL = Enugu-Lagos; EB = Enugu-Ibadan; ER = Enugu-Ilorin; etc.

PL = PHC-Lagos; PB = PHC-Ibadan; PR = PHC-Ilorin; PK = PHC-Kano; etc.

CL = Calabar-Lagos; CB = Calabar-Ibadan; CR = Calabar-Ilorin; etc.

OL = Onitsha-Lagos; OB = Onitsha-Ibadan; OR = Onitsha-Ilorin; etc.

Now let us build the route satisfaction table:

Route	Satisfied	Unsatisfied	Contribution
AL	11	1	1932
AB	4	-	1932
AR	5	-	2078
AK	10	2	2325
AJ	3	-	1679
EL	14	2	1950
EB	3	-	1950
ER	2	-	2096
EK	9	-	2143
EJ	3	-	1696
PL	12	1	2214
PB	4	1	2214
PR	4	-	2361
PK	11	-	2607
PJ	2	-	1961
CL	8	6	2714
CB	2	2	2714
CR	2	-	2661
CK	6	-	2589
CJ	5	-	2161
OL	10	9	1750
OB	7	1	1750
OR	5	-	1896
OK	14	-	2143
OJ	6	2	1496

Assuming that we can divide the contribution per route between the destination and originating depots, we can use the resulting values to compute shadow contributions (shadow prices) in order to find out depots requiring re-allocation of buses. Thus, we can proceed by assuming that the first destination contribution for the first satisfied route (AB) is zero. Therefore, using ‘D’ to represent the destination contribution and ‘R’ to represent the originating contribution, we have:

Route	Relationship	
AB:	D(A) + R(B) = 1932	equation (1)
AR:	D(A) + R(R) = 2078	equation (2)
AJ:	D(A) + R(J) = 1679	equation (3)
EB:	D(E) + R(B) = 1950	equation (4)
EK:	D(E) + R(K) = 2143	equation (5)
PK:	D(P) + R(K) = 2607	equation (6)

CR:	D(C) + R(R) = 2661	equation (7)
OL:	D(O) + R(L) = 1750	equation (8)
OK:	D(O) + R(K) = 2143	equation (9)

We have selected only these nine satisfied routes because we are only interested in knowing the values of the five destination contributions and the five originating contributions i.e. D(A), D(E), D(P), D(C), D(O), and R(L), R(B), R(R), R(K) as well as R(J) which are all connected in the above nine equations and which we need for the computation of shadow contributions for all routes.

***GETTING VALUES OF* 'D' *AND* 'R'**

Since D(A) is assumed to be zero as per transportation model convention, therefore, equations (1), (2) and (3) will produce:

R(B) = 1932

R(R) = 2078

R(J) = 1679

In equation (4), if R(B) = 1932, then D(E) + 1932 = 1950

Thus, D(E) = 1950 – 1932 = 18

In equation (5), if D(E) = 18, then 18 + R(K) = 2143

Thus, R(K) = 2143 – 18 = 2125

In equation (6), if R(K) = 2125, then D(P) + 2125 = 2607

Thus, D(P) = 2607 – 2125 = 482

In equation (7), if R(R) = 2078, then D(C) + 2078 = 2661

Thus, D(C) = 2661 – 2078 = 583

In equation (8), if R(K) = 2125, then D(O) + 2125 = 2143

Thus, D(O) = 2143 – 2125 = 18

In equation (9), if D(O) = 18, then 18 + R(L) = 1750

Thus, R(L) = 1750 – 18 = 1732

Hence, the values for the destinations and originating contributions are:

D(A) = 0

D(E) = 18

D(P) = 482

D(C) = 583

D(O) = 18

R(L) = 1732

R(B) = 1932

R(R) = 2078

R(K) = 2125

R(J) = 1679

COMPUTATION OF SHADOW CONTRIBUTIONS (SHADOW PRICES)

Route	*Relationship*	*Computation*	*Value*
AL	D(A) + R(L)	0 + 1732	1732
AB	D(A) + R(B)	0 + 1932	1932
AR	D(A) + R(R)	0 + 2078	2078
AK	D(A) + R(K)	0 + 2125	2125
AJ	D(A) + R(J)	0 + 1679	1679
EL	D(E) + R(L)	18 + 1732	1750
EB	D(E) + R(B)	18 + 1932	1950
ER	D(E) + R(R)	18 + 2078	2096
EK	D(E) + R(K)	18 + 2125	2143
EJ	D(E) + R(J)	18 + 1679	1697
PL	D(P) + R(L)	482 + 1732	2214
PB	D(P) + R(B)	482 + 1932	2414
PR	D(P) + R(R)	482 + 2078	2560
PK	D(P) + R(K)	482 + 2125	2607
PJ	D(P) + R(J)	482 + 1679	2161
CL	D(C) + R(L)	583 + 1732	2315

CB	D(C) + R(B)	583 + 1932	2515
CR	D(C) + R(R)	583 + 2078	2661
CK	D(C) + R(K)	583 + 2125	2708
CJ	D(C) + R(J)	583 + 1679	2262
OL	D(O) + R(L)	18 + 1732	1750
OB	D(O) + R(B)	18 + 1932	1950
OR	D(O) + R(R)	18 + 2078	2096
OK	D(O) + R(K)	18 + 2125	2143
OJ	D(O) + R(J)	18 + 1679	1697

TABLE 8: REALLOCATION OF BUSES USING SHADOW CONTRIBUTIONS (SHADOW PRICE)

ROUTE	ACTUAL PRICE	SHADOW PRICE	DIFF.	MAX NEED	EXISTING BUSES	ADJT	FROM TO	FINAL ALCTN
AL	1932	1732	+200	12	10	+2	OB	12
AB	1932	1932	-	4	4			4
AR	2078	2078	-	5	5			5
AK	2325	2125	+200	12	10	+2	OR	12
AJ	1679	1679	-	3	3			3
EL	1950	1750	+200	16	14	+2	OR	16
EB	1950	1950	-	3	3			3
ER	2096	2096	-	2	2			2
EK	2143	2143	-	9	9			9
EJ	1696	1697	-1	3	3			3
PL	2214	2214	-	13	12			12
PB	2214	2414	-200	5	4			4
PR	2361	2560	-199	4	4			4
PK	2607	2607	-	11	11			11
PJ	1961	2161	-200	2	2			2
CL	2714	2315	+399	14	8	+6	OR	14
CB	2714	2515	+199	4	2	+2	CK	4
CR	2661	2661	-	2	2			2
CK	2589	2708	-119	6	6	-2	CB	4
CJ	2161	2262	-101	5	5			5
OL	1750	1750	-	19	10			10
OB	1750	1950	-200	8	7	-2	AL	5
OR	1896	2096	-200	5	13	-10	CL,EL,AK	3
OK	2143	2143	-	14	14			14
OJ	1496	1697	-201	8	6			6

BASIS OF REALLOCATION ADJUSTMENTS

The shadow contributions (shadow prices) computed and used above helped to indicate routes where adjustments are necessary. Any route which produced a negative difference between actual and shadow price desires a reduction in allocation of buses as the present allocation reduces total contribution by the amount indicated in negative per passenger per bus. On the other hand, any route which produces a positive difference requires an increase in allocation because any increase in the present allocation will increase the total contribution by the amount indicated in positive per passenger per bus. For instance, route AL (Lagos-Aba) indicates that any increase in allocation to that route will increase the total contribution per passenger per bus to the tune of N200; in the same vein, route OR (Onitsha-Ilorin) indicates that any increase in allocation to that route will reduce the total contribution per passenger per bus by the sum of N200. In other words, pulling out a bus from that route will save a loss of N200 per passenger per bus. However, in making adjustments you must ensure that you pull out only from a route which has the same or less negative number with the transferee route. That is, the route with the positive value must be greater than or equal to the absolute value of the route with the negative value from where transfer is sought. For instance, it will be unwise to transfer from OJ to CB because the absolute value of OJ is 201 which is greater than the positive value of CB which is 199. The resultant effect will be a net negative value of -2 (i.e.199-201) which still reduces the total contribution. But if, however, the positive value is greater than the absolute value of the negative value then the transfer will increase total contribution by that difference. Any route with no difference is a neutral or fulfilled route. No adjustment is necessary in this case except for the purpose of transferring to a route with a positive value.

EVALUATION OF TOTAL CONTRIBUTIONS AFTER REASSIGNMENTS

From Lagos Deport (Available now = 64) To:

City	Number	Contribution	Total Contribution
Aba	12	115,920	1,391,040
Enugu	16	117,000	1,872,000
P/H	12	132,840	1,594,080
Calabar	14	162,840	2,279,760
Onitsha	10	105,000	1,050,000
	Total from Lagos Depot		**8,186,880**

We shall also carry out similar calculations for other depots using the finally assigned number of buses for each route. The final contribution expected from all routes is given in table 9 bellow:

TABLE 9: FINAL EXPECTED CONTRIBUTIONS BY DEPOTS

DEPOT	CONTRIBUTION
Lagos Depot	8,186,880
Ibadan Depot	2,522,400
Ilorin Depot	2,102,160
Kano Depot	6,973,320
Jos Depot	2,029,680
Total Gross Expected Contribution	**21,814,440**

This is a remarkable improvement from the initial total contribution of N20,515,080, however, it still has to be adjusted for cost of transferring buses from one depot to another.

TABLE 10: ANALYSIS OF COST OF REASSIGNMENTS

FROM	TO	QTY	COST	TOTAL
OB (Ibadan)	AL (Lagos)	2	5000	10,000
OR (Ilorin)	AK (Kano)	2	16000	32,000
OR (Ilorin)	EL (Lagos)	2	8000	16,000
OR (Ilorin)	CL (Lagos)	6	8000	48,000
CK (Kano)	CB (Ibadan)	2	18000	36,000
TOTAL COSTS OF REASSIGNMENTS				142,000

STATEMENT OF FINAL EXPECTED CONTRIBUTION

Total Expected Contribution as per table 9	21,814,440
Less: Total Costs of Reassignments	142,000
Final Expected Contribution	21,672,440
Less: Total Initial Contribution	20,515,080
INCREASE IN CONTRIBUTION AFTER ADJUSTMENTS	1,157,360

DISCUSSION

From the final expected contribution figure, it is clear that our little exercise has yielded a very big positive result. The difference between the initial and final figures from the analysis above clearly indicates that the optimal decision has been reached.

In this paper, we had a situation where vehicles are less than the required passengers at some depots and where passengers are less than the available vehicles at others. These two situations were dealt with using shadow pricing technique which produced expected losses and gains as fallout of the initial vehicular assignments. These unearned losses and gains became the criteria for the purpose of vehicular reassignments because they indicate the routes that requires more vehicles, those that requires less and those that are to be left alone.

The statement of final expected contribution above clearly indicates that the reallocation exercise produced additional overall contribution of N1.157m just for one home bound operation. If the peak period persists as it always do, the bus company will be talking in terms of multiples of such surplus profits. We have considered only the homebound journey peak periods in the above analysis, normally all transport operators in Nigeria have the peak periods both ways – the home bound passengers and the return journey passengers. Just as you can make transfer from one destination depot to another, you can also make transfers from one originating depot to another using exactly the same basis and cost implications as in this analysis.

Conclusion

Passenger transport service business in Nigeria is a very big and competitive one. It is easy to make quick profits and it is also easy to pack-up. The guiding principle is to adopt the best and most dynamic approach to administration especially in the area of scarce resource or limiting factor management. Application of the transportation management model algorithm as modified in this paper will be a very good step in the right direction.

References

Brockington, R. B. (1988), ***FINANCIAL MANAGEMENT***, Fourth Edition, Eastleigh, Hants: DP Publications Limited

Enyi, E. P. (2007), "Maximizing Profits From Passenger Transport Service Using Transportation Model Algorithm", **SSRN ELECTRONIC PUBLICATION** @ http://papers.ssrn.com/abstract=1005417

Lucey, T. (1996), ***QUANTITATIVE TECHNIQUES – An Instructional Manual***, Winchester, Hampshire: D.P. Publications

Stafford, L. W. T. (1981), ***BUSINESS MATHEMATICS***, Second Edition, Estover, Plymouth: Macdonald and Evans Limited

Van Horne, J. C. (1977), ***FINANCIAL MANAGEMENT AND POLICY***, Englewood Cliffs: Prentice Hall International