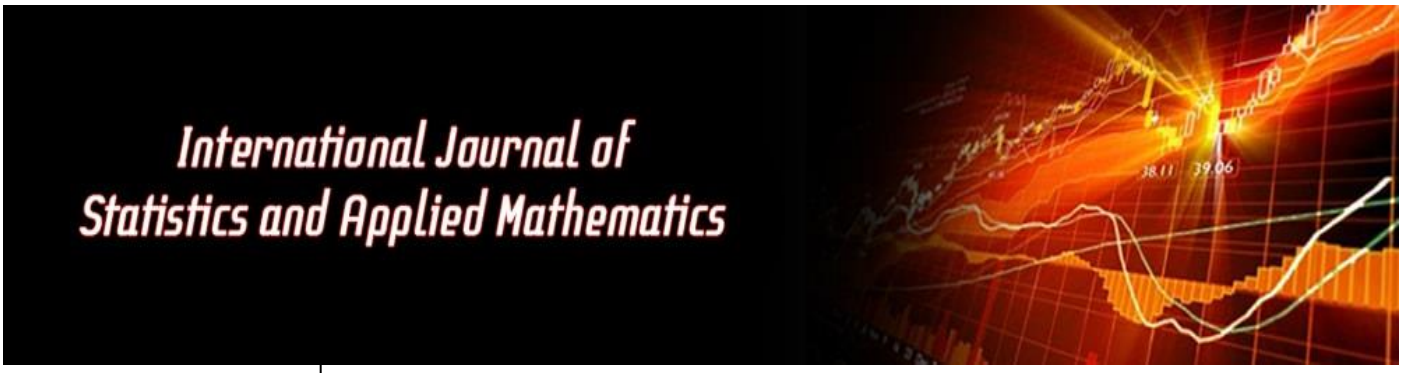
International Journal of Statistics and Applied Mathematics 2023; 8(1): 26-29



ISSN: 2456-1452
Maths 2023; 8(1): 26-29

https://www.mathsjournal.com
Received: 15-10-2022
Accepted: 20-12-2022

Izevbizua O
Department of Mathematics, University of Benin, Benin City, Nigeria

Olowu OO
Department of Mathematics, University of Benin, Benin City, Nigeria

Corresponding Author:
Izevbizua O
Department of Mathematics, University of Benin, Benin City, Nigeria

The revenue generating model for radio and television stations

Izevbizua O and Olowu OO

DOI: https://doi.org/10.22271/maths.2023.v8.i1a.923

Abstract
The primary inventory of radio/television stations is airtime. Radio/television airtimes are used for adverts, paid announcements, sponsored programmes, etc. Airtime on radio/television stations is subdivided into three subunits; prime time, fixed time and normal time and the total revenue generated per day by the radio/television station is the sum of revenue from all three subunits of airtime. In this work, we derive the revenue function for each subunit of time and thereafter derive the revenue-generating function for the radio/television station. A numerical example is given to demonstrate the use of the model.

Keywords: Revenue, airtime, inventory, function, adverts

1. Introduction
The airtime on radio and television stations forms a special type of non-regular fixed lifetime inventory system [1, 2, 3, 4, 5]. A non-regular fixed lifetime inventory system is one in which items outdated in one period but become useful in the next period. Simply put, outdated items are not discarded from inventory [6, 7]. The usefulness or utility of the items is renewed at the start of the next period. For radio and television stations, a period is a day (1440 minutes) and any minute or multiples of minutes can be used for adverts/paid announcement/sponsored programmes. Any minute not used for adverts/ paid announcement/ sponsored programmes is considered outdate [8, 9, 10] and whenever there is no airtime/space for adverts/paid announcement in a day, shortage is assumed.

Airtime on radio and television stations are classified into prime times, fixed times and normal times. Prime times on radio and television refers to the time of the day when the highest number of people are listening or watching. Prime times can be in the morning or evening, in Nigeria, prime times on radio/television stations are between 6 am – 7:30 am in the morning or 8 pm - 9 pm in the evening. Advertising rates are highest during prime times [11] because of peak viewing and listening times on television and radio. Besides the regular prime times on radio/television stations, the broadcast of major events such Africa cup of nations, World cup, Olympic games, common wealth games, Europe champions league, etc. creates more prime times for radio/television stations. Commercials can be ran at the start, half way or ending of such major events. Many big, medium and small companies take advantage of the high number of listeners and viewers to advertise their goods and services.

Fixed times on radio and television refers to anytime of the day that has been paid for by a company, government agencies or individuals to advertise their goods and services. That time of the day is reserved for the company, agency or individuals. Like other radio/television adverts, fixed time adverts has a minimum duration of one minute and can be extended to any desired number of minutes by the customers. Some fixed time adverts/programmes can run for 2 days, 4 days, 1week, a quarter or even a year and can renewed by the customers if they desire to continue at the end of the period. The price for fixed time adverts is less than that of prime time adverts, since fixed time adverts may run for a long period of time. Fixed time adverts are a major source of revenue for radio and television stations in Nigeria.

Normal times on radio/television stations refers to any time that is not prime nor fixed. Adverts rates are lowest during normal times.

There are no permanent normal times on radio, as customers can fix anytime by simply paying for the time, for the desire number of days or quarters. The total revenue of a radio/television station is the sum of revenues from the three subunits of time.

2. Description of the model

This work is aimed at deriving the total revenue function for a radio/television station. Adverts on radio and television are classified into prime time adverts, fixed time adverts and normal time adverts. The prime time adverts are the most expensive while the normal time adverts are the least expensive. The total revenue for a day is the sum of revenue from all three classes of adverts. Some adverts are only for a period while others can last for more than one period, especially the fixed time adverts.

Now if

X Represents the number of minutes used for prime time adverts in a day

Y Represents the number of minutes used for fixed time adverts in a day

Z Represent the number of minutes used for normal time adverts in a day.

Then the total minutes used for adverts in a day is

$$\Omega = X + Y + Z$$

Its possible for X to be zero, which means there is no prime adverts for the day. But Z *and* Y are hardly zero.

3. Assumptions and Notations

Assumptions

1. The minimum time for a radio/television advert is one minute.
2. The total revenue for a period is the sum of revenues from prime times adverts, fixed times adverts and normal times adverts.
3. There is a fixed operating cost for the radio/television stations.
4. Prime times not used for adverts in a period is considered outdated, but become useful in the next periods.
5. Whenever there is no space/airtime for adverts, shortage is incurred.
6. When a radio/television station suddenly goes off air, there is a periodic penalty for every adverts already paid for until the station comes back on air.
7. The number of days an advert/paid programme can run is not fixed and determined by the customer.
8. The number of minutes for any advert/paid programmes is discrete.
9. There is a fixed number of minutes allocated daily to prime time adverts.

Notation

X = total number of minutes used for prime time adverts in a day.

Y = total number of minutes used for fixed time adverts in a day.

Z = total number of minutes used for normal time adverts in a day

$b_i,\ i = 1,2,..x$ Prime time adverts in a day

Fixed time adverts in a day

$c_i,\ i = 1,2,..z$ Normal time adverts in a day

$p_i,\ i = 1,2,3.$ Unit price for prime time, fixed time and normal time adverts respectively.

$t_i,\ i = 1,2,\ldots$ Number of minutes used for one adverts.

$\phi_i,\ i = 2,\ldots$ Number of days an advert is fixed.

θ = shortage cost per minute

λ = outdate cost per minute.

$R_i,\ i = 1,\ 2,\ 3$ = revenue from prime time, fixed time and normal time adverts

Derivation of total revenue function

The components of the total revenue function for a radio/television station are the revenue functions, the set up cost, the shortage cost, the outdate cost and the penalty cost.

The revenue function

The total revenue per period for radio/television station is the sum of revenues from the prime times, fixed times and normal times.

Prime time revenue

Let the prime time adverts for a day be $b_1, b_2, b_3, \ldots b_x$ and the duration of the adverts be $t_1, t_2, t_3, \ldots t_x$. If the unit price for a prime time adverts is p_1 then the revenue generated from prime time adverts is

$$R_1 = b_1 p_1 t_1 + b_2 p_1 t_2 + \ldots + b_x p_1 t_x \tag{1}$$

Fixed time revenue

Let the fixed time adverts for a day be $a_1, a_2, a_3, \ldots a_y$ and the duration of the adverts be $t_1, t_2, t_3, \ldots t_y$. If the unit price for fixed time adverts is p_2, then the revenue generated from fixed time adverts is

$$R_2 = a_1 p_2 t_1 + a_2 p_2 t_2 + \ldots + a_y p_2 t_y \tag{2}$$

Its important to note that some fixed time adverts can run for more than a day. If ϕ is the number of days the fixed adverts will run, then the revenue will be

$$R_{22} = \phi_2 a_1 p_2 t_1 + \phi_3 a_2 p_2 t_2 + \ldots + \phi_y a_y p_2 t_y \tag{3}$$

Equation (2) represents the situation where all fixed time adverts are all for one day while equation (3) represents the situation where the number of days for the fixed time adverts are greater than or equal to two days

Normal time revenue

Let the normal time adverts be $c_1, c_2, c_3, \ldots c_z$ and the duration of the adverts are $t_1, t_2, t_3, \ldots t_z$.

If the unit price for normal times adverts is p_3, then the revenue from normal time adverts is

$$R_3 = c_1 p_3 t_1 + c_2 p_3 t_2 + \ldots + c_z p_3 t_z \quad (4)$$

Therefore the revenue function by the radio/television per day is given by

$$R = (b_1 t_1 + b_2 t_2 + \ldots + b_x t_x) p_1 + (a_1 t_1 + a_2 t_2 + \ldots + a_y t_y) p_2 + (c_1 t_1 + c_2 t_2 + \ldots + c_z t_z) p_3 \quad (5)$$

Or

$$R = (b_1 t_1 + b_2 t_2 + \ldots + b_x t_x) p_1 + (\phi_2 a_1 t_1 + \phi_3 a_2 t_2 + \ldots + \phi_y a_y t_y) p_2 + (c_1 t_1 + c_2 t_2 + \ldots + c_z t_z) p_3 \quad (6)$$

Shortage cost

Shortage occur whenever there is no space/airtime for adverts that is every available space for adverts has been booked up. This particularly apply to prime time adverts since the number of minutes allocated to prime time adverts is fixed. So, if the number of minutes X available for prime time adverts is less than the number of minutes X_d demanded for prime time advert, then shortage will be $X_d - X$. Therefore shortage cost will be

Shortage cost = $\theta \int_X^{\infty} (X_d - X) f(X_d)$ (7)

Outdate cost

outdate occur when the number of minutes allocated to prime time adverts is more than the number of minutes demanded for prime time adverts, that is $X_d < X$.

Outdate cost = $\lambda \int_0^X (X - X_d) f(X_d)$

Setup cost

There is a fixed set up cost for radio/television stations.
Set cost = P

Penalty cost

Whenever a radio/television station is off air as a result of natural disaster or any other reason, a penalty cost is incurred for paid adverts/programmes that cannot be broadcast. Adverts and paid programmes will not be aired. If the radio/television station is off air for n days and the number of prime time adverts, fixed time adverts and normal time adverts affected are q_x, q_y, q_z respectively, the penalty cost will be

Penalty cost = $n[k_x q_x + k_y q_y + k_z q_z]$

Where k_x, k_y, k_z are penalty per prime time adverts, fixed time adverts and normal time adverts respectively?
The total revenue function for a radio/television station is given by the sum of equations

$$TRF = (b_1 t_1 + b_2 t_2 + \ldots + b_x t_x) p_1 + (a_1 t_1 + a_2 t_2 + \ldots + a_y t_y) p_2 + (c_1 t_1 + c_2 t_2 + \ldots + c_z t_z) p_3 - \theta \int_X^{\infty} (X_d - X) f(X_d) - \lambda \int_0^X (X - X_d) f(X_d) - n[k_x q_x + k_y q_y + k_z q_z] + P$$

or

$$TRF = (b_1 t_1 + b_2 t_2 + \ldots + b_x t_x) p_1 + (\phi_2 a_1 t_1 + \phi_3 a_2 t_2 + \ldots + \phi_y a_y t_y) p_2 + (c_1 t_1 + c_2 t_2 + \ldots + c_z t_z) p_3 - \theta \int_X^{\infty} (X_d - X) f(X_d) - \lambda \int_0^X (X - X_d) f(X_d) - n[k_x q_x + k_y q_y + k_z q_z] + P \quad (11)$$

Numerical Examples

We give a numerical example to demonstrate the use of the model. A total of ten adverts each, from prime time, fixed time and normal time was documented for a radio station and the total revenue generated for the day was computed with our model. Shortage and outdate were assumed to be zero. A computer programme in Mathematical 8 was designed to carry out the operations. The fixed operating cost was assumed to be 50,000,000.

Table 1: Revenue from prime time adverts in a day

Class of adverts.	Number of adverts	Duration of advert	Price per minute	Revenue from adverts	Total revenue from prime time adverts R_1
b_1	11	1	20,000	220,000	1,300,000
b_2	12	2	20,000	480,000	
b_3	3	3	20,000	180,000	
b_4	4	4	20,000	320,000	
b_5	1	5	20,000	100,000	
b_6	-	-	-	-	
b_7	-	-	-	-	
b_8	-	-	-	-	
b_9	-	-	-	-	
b_{10}	-	-	-	-	

Table 2: Revenue from fixed time adverts in a day

Class of adverts.	Number of adverts	Duration of advert	Price per minute	Revenue from adverts	Total revenue from fixed time adverts R_2
a_1	10	1	8,000	320,000	4,672,000
a_2	7	2	8,000	448,000	
a_3	6	3	8,000	1,008,000	
a_4	2	4	8,000	448,000	
a_5	8	5	8,000	640,000	
a_6	4	6	8,000	576,000	
a_7	3	7	8,000	672,000	
a_8	2	8	8,000	256,000	
a_9	1	9	8,000	144,000	
a_{10}	1	10	8,000	160,000	

Table 3: Revenue from normal time adverts in a day

Class of adverts	Number of adverts	Duration of advert	Price per minute	Revenue from adverts	Total revenue from normal time adverts R_3
c_1	2	1	6,000	12,000	894,000
c_2	1	2	6,000	12,000	
c_3	7	3	6,000	126,000	
c_4	2	4	6,000	48,000	
c_5	3	5	6,000	90,000	
c_6	1	6	6,000	36,000	
c_7	4	7	6,000	168,000	
c_8	6	8	6,000	288,000	
c_9	1	9	6,000	54,000	
c_{10}	1	10	6,000	60,000	

Now the total revenue generated for the day is

$$R = R_1 + R_2 + R_3$$

$$R = 1{,}300{,}000 + 4{,}672{,}000 + 894{,}000 = 6{,}866{,}000$$

4. Conclusion

We have derived the total revenue function for computing the daily revenue for a radio/television station. Airtime on radio/television stations is divided into prime time, fixed time and normal time and the total revenue per day is the sum of revenue from all classes. The model also include costs against radio/television stations such as outdate cost, shortage cost and penalty cost. The stations management aim to minimize the costs and maximize revenue.

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