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Application of Transportation Problem Models on Cattle Business in Niger State Using Russell's Approximation Method

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ABSTRACT: To run a successful cattle business, you will have to select a cattle market where the cattle trader will purchase the cattle to be delivered whenever the customers need them, however, there are so many problems in the distribution of cattle to various markets. Hence, the objective of this paper was to evaluate the transportation problem models on cattle business in Niger state, Nigeria at a minimum cost using Russell's Approximation Method by selecting seven cattle markets (Bangi, Beji, Ibeto, Kawon-Kontagora, Kuta, Mariga and Tungar-Malam) in Niger state for distribution to some selected locations in Akure, Ibadan, Ilorin, Ijebu-Ode, Lagos and Oshogbo in the South Western part of Nigeria at a minimum cost. The Russell's Approximation method is used to find the Initial Basic Feasible Solution (₦36, 703, 723.98). The optimality method is tested via Stepping Stone Method and found it to be not optimal. Furthermore, the optimal solution is found using MS Excel solver. The minimum cost of transportation is found to be ₦36, 159,785.13.

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Keyword: Cattle transportation; Optimality Test; Approximation Method; Destination

The transportation problem is a special class of linear programming problems with an objective to transport homogeneous product manufactured at several plants (origins) to a number of different destinations at a minimum time (Hamdy, 2018). Cattles are found throughout Nigeria, but are most common in the northern of the country. Almost half the total cattle population is permanently resident within the sub-humid zone. There are different types of cattle. The Humped zebu cattle are the most common cattle found in the north central and north western Nigeria, but limited numbers of *Keteku* are found in the south western part. *Muturu* are found in the southern part and *Kuri* cattle occur in the north-eastern part of the country, Mubi *et al* (2012). Cattle business, no doubt, is a lucrative business employing a large number of people across the nation, especially in Zamfara, Sokoto, Katsina, Borno, Yobe, Jigawa, Adamawa, Kano, Bauchi and part of Niger and Kaduna areas of the north, where it is common to see entire families or communities earning their livelihood from cattle rearing. One of the primary reasons for Fulanis in taking animals to distant markets is that over the years it has been observed that the Fulanis are not real consumers of cattle but breeders. Hence, seasonal movement of cattle from northern to southern takes place. The policy of the government on livestock transportation is noticed in extension of roads that will link rural settles with urban settlers. Hence, the objective of this paper was to evaluate the transportation problem models on cattle business in Niger state, Nigeria

MATERIALS AND METHODS *General Mathematical Model:* The pay-off matrix of a transportation problem model is given in table 1

Table 1: Pay-off Matrix

		Destinations						Capacity
		1	2	3	…	*j*	n	
Sources or Origin	1	C_{11} X_{11}	C_{12} X_{12}	C_{13} X_{13}	…	C_{1j} X_{1j}	C_{1n} X_{1n}	a_1
	2	C_{21} X_{21}	C_{22} X_{22}	C_{23} X_{23}	…	C_{2j} X_{2j}	C_{2n} X_{2n}	a_2
	3	C_{31} X_{31}	C_{32} X_{32}	C_{33} X_{33}	…	C_{3j} X_{3j}	C_{3n} X_{3n}	a_3
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	i	C_{i1} X_{i1}	C_{i2} X_{i2}	C_{i3} X_{i3}	…	C_{ij} X_{ij}	C_{in} X_{in}	a_i
	m	C_{m1} X_{m1}	C_{m2} X_{m2}	C_{m3} X_{m3}	…	C_{mj} X_{mj}	C_{mn} X_{mn}	a_m
Requirement		b_1	b_2	b_3	…	b_j	b_n	

Where C_{ij}, i = 1, 2, 3, …, m; $_j$ = 1, 2, 3, …, n, is the unit transportation cost from the *i*th origin to *j*th destination, X_{ij} is the quantity shipped from the *i*th origin to *j*th destination, a_i is the supply available at origin *i* and b_j is the demand at destination *j*. (Juraj, 2014)

Minimize: $Z = \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij} x_{ij}$

Subject to
$\sum_{i=1}^{n} x_{ij} \leq S_i$ for i = 1,2, ..., m(supply) and
$\sum_{j=1}^{n} x_{ij} \leq D_j$ for j = 1,2, ..., n(demand)
$x_{ij} \geq 0$

For a feasible solution to exist, it is necessary that total capacity equals total requirements.

Total supply = Total demand. OR $\Sigma a_i = \Sigma b_j$, where Σa_i is the total capacity (supply) and Σb_j is the total requirement (demand).

Russell's Approximation Method (RAM): The Russell's approximation method is an iterative procedure for computing a basic feasible solution of a transportation problem. The initial basic feasible solution obtained by this method is either optimal or very close to the optimal solution**.**

Steps in Russell's Approximation Method: For each source row still under consideration, determine its $\bar{U}_i$ (largest cost row *i*).
(ii) For each destination column still under consideration, determine its $\bar{V}_j$ (largest cost in column *j*).
(iii) For each variable, calculate $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$.
(iv) Selecting the variable having the most negative $\Delta - value$, break ties arbitrarily.
(v) Allocate as much as possible. Eliminate necessary cells from consideration. Return to a.

After computing an initial basic feasible solution, we must now proceed to determine whether the solution so obtained is optimal or not. There are three methods of optimality test (i) Stepping Stone Method and (ii) Modified Distribution Method. For the purpose of this research Stepping Stone method is use to test the optimality of the initial basic feasible solutions of the two methods discussed above.

RESULTS AND DISCUSSION

Demand is greater than supply! Recreate this model with an extra (dummy) row that has a supply equal to the difference between total supply and total demand. Dummy row has been added. The most negative Δ_{ij} is –19933.48 in cell Tunga/Ibadan. The allocation to this cell is min (362, 1179) = 362 as shown in table 2. This exhausts the supply of Tunga-Malam and leaves 817 cattle with Ibadan. The most negative Δ_{ij} is –17251.84 in cell Kawo/Akure. The allocation to this cell is min(440, 424) = 424 as shown in table 2. This exhausts the demand of Akure and leaves 16 cattle with Kawo. The most negative Δ_{ij} is –16297.27 in cell Bangi/Ilorin. The allocation to this cell is min(443,549) = 443 as shown in table 2. This exhausts the supply of Bangi and leaves 106 cattle with Ilorin.
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Table 2: Modified Table

Cattle Markets	Locations						
	Akure	**Ibadan**	**Ijebu-Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**
Bangi	13972.51	10281.07	12670.26	6081.09	14270.26	7589.19	443
Beji	13455.00	10024.05	12274.33	6243.24	13509.20	7308.10	219
Ibeto	13662.02	9681.34	12432.69	6486.48	14270.26	7420.56	243
Kawon-Kont.	11592.03	9424.32	10294.58	5837.85	13318.91	6296.22	440
Kuta	15524.96	10538.03	12749.46	8108.10	16172.96	8432.40	811
Mariga	12420.00	8569.56	10294.58	5675.67	13794.60	6745.94	1476
Tungan-Mal.	16249.50	6854.05	12907.85	4861.86	15697.30	8825.94	362
Dummy	0	0	0	0	0	0	1730
DEMAND	424	1179	885	549	1920	767	

Table 3: Iteration I: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Markets	Locations							
	Akure	**Ibadan**	**Ijebu -Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	-15822.71	-14527.22	-14507.85	-16297.27	-16172.96	-15507.01	443	**14270.26**
Beji	-16303.70	-14023.18	-14142.72	-18037.82	-16172.96	-15027.04	219	**13509.20**
Ibeto	-16857.74	-15126.95	-14745.42	-15891.88	-16172.96	-15675.64	243	**14270.26**
Kawo	-17976.38	-14432.62	-15932.18	-15589.16	-16172.96	-15848.63	440	**13318.91**
Kuta	-16897.50	-16172.96	-16331.35	-16172.96	-16172.96	-15918.50	811	**16172.96**
Mariga	-17624.10	-18141.43	-16407.87	-16227.03	-16172.96	-15874.60	1476	**13794.60**
Tungan- Malam	-16249.50	***-19933.48***	-16249.50	-19495.74	-16725.16	-16249.50	362	**16249.50**
Dummy	-16249.50	-10538.03	-12907.85	-8108.10	-16172.96	-8825.94	1730	**0**
DEMAND	424	1179	885	549	1920	767		
$\bar{V}_j$	**16249.50**	**10538.03**	**12907.85**	**8108.10**	**16172.96**	**8825.94**		

Table 4: Iteration II: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Markets	Locations							
	Akure	**Ibadan**	**Ijebu – Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	-15822.71	-14527.22	-14349.46	-16297.27	-16172.96	-15113.47	443	**14270.26**
Beji	-15579.16	-14023.18	-13984.33	-15374.06	-16172.96	-14633.50	219	**13509.2**
Ibeto	-16133.20	-15126.95	-14587.03	-15891.88	-16172.96	-15282.10	243	**14270.26**
Kawo	**-17251.84**	-14432.62	-15773.79	-15589.16	-16172.96	-15455.09	440	**13318.91**
Kuta	-16172.96	-16172.96	-16172.96	-16172.96	-16172.96	-16172.96	811	**16172.96**
Mariga	-16899.56	-15763.07	-16249.48	-16227.03	-16172.96	-15481.06	1476	**13794.6**
Tungan	16249.50	6854.05 **(362)**	12907.85	4861.86	15697.30	8825.94	0	
Dummy	-15524.96	-10538.03	-12749.46	-8108.10	-16172.96	-8432.40	1730	**0**
DEMAND	424	817	885	549	1920	767		
$\bar{V}_j$	**15524.96**	**10538.03**	**12749.46**	**8108.1**	**16172.96**	**8432.4**		

Table 5: Iteration III: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Markets	Locations							
	Akure	**Ibadan**	**Ijebu – Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	13972.51	-14527.22	-14349.46	**-16297.27**	-16172.96	-15113.47	443	**14270.26**
Beji	13455.00	-14023.18	-13984.33	-15374.06	-16172.96	-14633.50	219	**13509.2**
Ibeto	13662.02	-15126.95	-14587.03	-15891.88	-16172.96	-15282.10	243	**14270.26**
Kawo	11592.03 **(424)**	-14432.62	-15773.79	-15589.16	-16172.96	-15455.09	16	**13318.91**
Kuta	15524.96	-16172.96	-16172.96	-16172.96	-16172.96	-16172.96	811	**16172.96**
Mariga	12420.00	-15763.07	-16249.48	-16227.03	-16172.96	-15481.06	1476	**13794.6**
Tungan	16249.50	6854.05 **(362)**	12907.85	4861.86	15697.30	8825.94	0	
Dummy	0	0	0	0	0	0	1730	**0**
DEMAND	0	817	885	549	1920	767		
$\bar{V}_j$		**10538.03**	**12907.85**	**8108.10**	**16172.96**	**8825.94**		

Table 6: Iteration IV: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Markets	Locations							
	Akure	**Ibadan**	**Ijebu – Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	13972.51	10281.07	112670.26	6081.09 **(443)**	14270.27	7589.19	0	
Beji	13455.00	-14023.18	-13984.33	-15374.06	-16172.96	-14633.50	219	**13509.2**
Ibeto	13662.02	-15126.95	-14587.03	-15891.88	-16172.96	-15282.10	243	**14270.26**
Kawo	11592.03 **(424)**	-14432.62	-15773.79	-15589.16	-16172.96	-15455.09	16	**13318.91**
Kuta	15524.96	-16172.96	-16172.96	-16172.96	-16172.96	-16172.96	811	**16172.96**
Mariga	12420.00	-15763.07	**-16249.48**	-16227.03	-16172.96	-15481.06	591	**13794.6**
Tungan	16249.50	6854.05 **(362)**	12907.85	4861.86	15697.30	8825.94	0	
Dummy	0	-10538.03	-12749.56	-8108.10	-16172.96	-8432.40	1730	**0**
DEMAND	0	817	885	106	1920	767		
$\bar{V}_j$		**10538.03**	**12907.85**	**8108.10**	**16172.96**	**8825.94**		

Table 7: Iteration V: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Market	Locations							
	Akure	**Ibadan**	**Ijebu – Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	13972.51	10281.07	12670.26	6081.09 **(443)**	14270.27	7589.19	0	
Beji	13455.00	-14023.18	12274.33	-15374.06	-16172.96	-14633.50	219	**13509.2**
Ibeto	13662.02	-15126.95	12432.69	-15891.88	-16172.96	-15282.10	243	**14270.26**
Kawo	11592.03 **(424)**	-14432.62	10294.58	-15589.16	-16172.96	-15455.09	16	**13318.91**
Kuta	15524.96	-16172.96	12749.46	-16172.96	-16172.96	-16172.96	811	**16172.96**
Mariga	12420.00	-15763.07	10294.58 **(885)**	**-16227.03**	-16172.96	-15481.06	1476	**13794.6**
Tungan	16249.50	6854.05 **(362)**	12907.85	4861.86	15697.30	8825.94	0	
Dummy	0	0	0	0	0	0	1730	**0**
DEMAND	0	817	0	106	1920	767		
$\bar{V}_j$		**10538.03**		**8108.10**	**16172.96**	**8432.94**		

The most negative Δ_{ij} is –16249.48 in cell Mariga/Ijebu-Ode. The allocation to this cell is min (1476,885) = 885 as shown in table 2. This exhausts the demand of Ijebu-Ode and leaves 591 cattle with Mariga. The most negative Δ_{ij} is –16227.03 in cell Mariga/Ilorin. The allocation to this cell is min (591, 106) = 106 as shown in table 2. This exhausts the demand of Ilorin and leaves 485 cattle with Mariga. The most negative Δ_{ij} is –16172.96 in cell Kuta/Oshogbo. The allocation to this cell is min (811, 767) = 767 as shown in table 2. This exhausts the demand of Oshogbo and leaves 44 cattle with Kuta. The most negative Δ_{ij} is –16172.96 in cell Ibeto/Lagos. The allocation to this cell is min (243, 1920) = 243 as shown in table 16. This exhausts the supply of Ibeto and leaves 1677 cattle with Lagos. The most negative Δ_{ij} is –16172.96 in cell Dummy/Lagos. The allocation to this cell is min (1730, 1677) = 1677 as shown in table 2. This exhausts the demand of Lagos and leaves 53 cattle with Dummy.

Table 8: Iteration VI: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Markets	Locations							
	Akure	**Ibadan**	**Ijebu – Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	13972.51	10281.07	12670.26	6081.09 (443)	14270.27	7589.19	0	
Beji	13455.00	-14023.18	12274.33	6243.24	-16172.96	-14633.50	219	**13509.2**
Ibeto	13662.02	-15126.95	12432.69	6486.48	-16172.96	-15282.10	243	**14270.26**
Kawo	11592.03 (424)	-14432.62	10294.58	5837.85	-16172.96	-15455.09	16	**13318.91**
Kuta	15524.96	-16172.96	12749.46	8108.10	-16172.96	**-16172.96**	811	**16172.96**
Mariga	12420.00	-15763.07	10294.58 (885)	5675.67 (106)	-16172.96	-15481.06	485	**13794.6**
Tungan	16249.50	6854.05 (362)	12907.85	4861.86	15697.30	8825.94	0	
Dummy	0	-10538.03	0	0	-16172.96	-8432.94	1730	**0**
DEMAND	0	817	0	0	1920	767		
$\bar{V}_j$		**10538.03**			**16172.96**	**8432.94**		

Table 9: Iteration VII: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Markets	Locations							
	Akure	**Ibadan**	**Ijebu – Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	13972.51	10281.07	12670.26	6081.09 (443)	14270.27	7589.19	0	
Beji	13455.00	-14023.18	12274.33	6243.24	-16172.96	7308.10	219	**13509.2**
Ibeto	13662.02	-15126.95	12432.69	6486.48	**-16172.96**	7420.56	243	**14270.26**
Kawo	11592.03 (424)	-14432.62	10294.58	5837.85	-16172.96	6296.22	16	**13318.91**
Kuta	15524.96	-16172.96	12749.46	8108.10	-16172.96	8432.40 (767)	44	**16172.96**
Mariga	12420.00	-15763.07	10294.58 (885)	5675.67 (106)	-16172.96	6745.94	485	**13794.6**
Tungan	16249.50	6854.05 (362)	12907.85	4861.86	15697.30	8825.94	0	
Dummy	0	-10538.03	0	0	-16172.96	0	1730	**0**
DEMAND	0	817	0	0	1920	0		
$\bar{V}_j$		**10538.03**			**16172.96**			

Table 10: Iteration VIII: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Markets	Locations							
	Akure	**Ibadan**	**Ijebu – Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	13972.51	10281.07	12670.26	6081.09 (443)	14270.27	7589.19	0	
Beji	13455.00	-14023.18	12274.33	6243.24	-16172.96	7308.10	219	**13509.2**
Ibeto	13662.02	9681.34	12432.69	6486.48	14270.26 (243)	7420.56	0	
Kawo	11592.03 (424)	-14432.62	10294.58	5837.85	-16172.96	6296.22	16	**13318.91**
Kuta	15524.96	-16172.96	12749.46	8108.10	-16172.96	8432.40 (767)	44	**16172.96**
Mariga	12420.00	-15763.07	10294.58 (885)	5675.67 (106)	-16172.96	6745.94	485	**13794.6**
Tungan	16249.50	6854.05 (362)	12907.85	4861.86	15697.30	8825.94	0	
Dummy	0	-10538.03	0	0	**-16172.96**	0	1730	**0**
DEMAND	0	817	0	0	1677	0		
$\bar{V}_j$		**10538.03**			**16172.96**			

Table 11: Iteration IX: $\Delta_{ij} = (\bar{U}_i + \bar{V}_j)$

Market	Locations							
	Akure	**Ibadan**	**Ijebu – Ode**	**Ilorin**	**Lagos**	**Oshogbo**	**SUPPLY**	$\bar{U}_i$
Bangi	13972.51	10281.07	12670.26	6081.09 (443)	14270.27	7589.19	0	
Beji	13455.00	**-10538.03**	12274.33	6243.24	13509.20	7308.10	219	**10024.05**
Ibeto	13662.02	9681.34	12432.69	6486.48	14270.26 (243)	7420.56	0	
Kawo	11592.03 (424)	-10538.03	10294.58	5837.85	13318.91	6296.22	16	**9242.32**
Kuta	15524.96	-10538.03	12749.46	8108.10	16172.96	8432.40 (767)	44	**10538.03**
Mariga	12420.00	-10538.03	10294.58 (885)	5675.67 (106)	13794.60	6745.94	485	**8569.56**
Tungan	16249.50	6854.05 (362)	12907.85	4861.86	15697.30	8825.94	0	
Dummy	0	-10538.03	0	0	0 (1677)	0	53	**0**
DEMAND	0	817	0	0	0	0		
$\bar{V}_j$		**10538.03**						

The most negative Δ_{ij} is –10538.03 in cell Beji/Ibadan. The allocation to this cell is min (219, 817) = 219 as shown in table 2. This exhausts the supply of Beji and leaves 598 cattles with Ibadan. Since all the locations except Ibadan in table 11 are satisfied, no need to calculate Δ_{ij}. The supply of the remaining markets should be allocated to Ibadan in table 2. From table 12: The allocation is as follows; 443cattle should be transported from Bangi to Ilorin; 219 cattle from Beji to Ibadan; 243cattle transported to Lagos from Ibeto; while, 424 and 16 cattles be taken from Kawo-Kontagora to Akure and Ibadan respectively. Others to be transported are 44cattle and 767cattle from Kuta to Ibadan and Oshogbo. Cattle 485, 885 and 106 should be transported from Mariga to Ibadan, Ijebu-Ode and Ilorin respectively. 362cattle from Tungar-Malam to Ibadan. 53 and 1667cattles transported to Ibadan and Lagos respectively from other markets which cost ₦36,703,723.98. The number of allocated cells (13) is equal to m + n – 1 (i.e 8 + 6 – 1 = 13). This is non–degenerate. *Optimality Test.* The optimality test using stepping stone method as shown in Table 13. From table 14 above results, there is negative in the results of the operation which indicate that the allocation not optimal. **Interpretation:** From table 15, it indicates that the cattle trader should transport 443cattle from Bangi to Ilorin; 29 and 190cattle from Beji to Ilorin and Lagos respectively; 77cattle and 166 cattle from Ibeto to Ilorin and Oshogbo respectively; 424 and 16cattle to Akure and Oshogbo respectively from Kawon–Kontagora; 226cattle and 585cattle from Kuta to Ibadan and Oshogbo; 591 and 885 from Mariga to Ibadan and Ijebu–Ode respectively; 362cattle from Tunga to Ibadan. And, 1730cattle be transported to Lagos from other markets. This will cost the trade ₦36, 159, 785.13. The summary of the allocation and cost of transportation is shown in table 16.

Table 12: Initial Basic Feasible Solution

Market	Location						
	Akure	Ibadan	Ijebu-Ode	Illorin	Lagos	Oshogbo	Row Total
Bangi				443			443
Beji		219					219
Ibeto					243		243
Kawon-Kontagora	424	16					440
Kuta		44				767	811
Mariga		485	885	106			1476
Tungan-Malam		362					362
Dummy		53			1677		1730
Column Total	424	1179	885	549	1920	767	5724 \ 5724
Total Cost	36,703,723.98						

Table 13: Initial Basic Feasible Solution operation

Cattle Market	Locations						
	Akure	Ibadan	Ijebu – Ode	Ilorin	Lagos	Oshogbo	SUPPLY
Bangi	13972.51	10281.07	12670.26	6081.09 (443)	14270.26	7589.19	443
Beji	13455.00	10024.05 (219)	12274.33	6243.24	13509.20	7308.10	219
Ibeto	13662.02	9681.34	12432.69	6486.48	14270.26 (243)	7420.56	243
Kawon – Kontagora	11592.03 (424)	9424.32 (16)	10294.58	5837.85	13318.91	6296.22	440
Kuta	15524.96	10538.03 (44)	12749.46	8108.10	16172.96	8432.40 (767)	811
Mariga	12420.00	8569.56 (485)	10294.58 (885)	5675.67 (106)	13794.60	6745.94	1476
Tungan –Malam	16249.50	6854.05 (362)	12907.85	4861.86	15697.30	8825.94	362
Dummy market	0	0 (53)	0	0	0 (1667)	0	1730
DEMAND	424	1179	885	549	1920	767	

Key:

	Occupied Cells
	Unoccupied Cells

Closed loop and paths of unoccupied cells: The results of the operations are given in table 14 below

Table 14: Closed loop and paths of unoccupied cells

	Akure	Ibadan	Ijebu – Ode	Ilorin	Lagos	Oshogbo	Supply
Bangi	2647.82	1306.09	1970.28	(443)	5295.29	719.84	443
Beji	1081.24	(219)	525.28	-886.92	3485.15	-610.32	219
Ibeto	-2957.95	-4588.92	-3562.57	-4889.89 +	(24[illegible] -	-[illegible]07	243
Kawo	(424)	(16)	-672.74	-510.58	407[illegible].59	-840.47	440
Kuta	2637.22	(44)	486.53	463.96	563[illegible].93	(767)	811
Mariga	1500.73	(485) +	(885)	(106) -	5225.04	282[illegible]01	1476
Tunga	7045.74	(362)	4328.8	901.7	884[illegible].25	407[illegible].52	362
Dummy	-2349.71	(53) -	-1725	2893.89	(166[illegible]7) +	210[illegible].63	1730
Demand	424	117[illegible]	885	549	[illegible]20	767	

Key:

	Occupied Cells		+	Increasing cell	Close Paths
	Unoccupied Cells		-	Decreasing cell	

Table 15: Optimal Allocation Table:

Cattle Market	Locations						
	Akure	Ibadan	Ijebu – Ode	Ilorin	Lagos	Oshogbo	SUPPLY
Bangi				**443**			**443**
Beji				**29**	**190**		**219**
Ibeto				**77**		**166**	**243**
Kawon – Kontagora	**424**					**16**	**440**
Kuta		**226**				**585**	**811**
Mariga		**591**	**885**				**1476**
Tungan –Malam		**362**					**362**
Dummy					**1730**		**1730**
DEMAND	**424**	**1179**	**885**	**549**	**1920**	**767**	
TOTAL COST	₦36,159,785.13						

Table 16: Allocation table (Cost in ₦)

From	To	No. cattle to be transported	Cost of transportation per cattle	Total cost of transportation
Bangi	Ilorin	443	6081.09	2693922.87
Beji	Ilorin	29	6243.24	181053.96
Beji	Lagos	190	13509.20	2566748
Ibeto	Ilorin	77	6486.48	499458.96
Ibeto	Oshogbo	166	7420.56	1231812.96
Kawon – Kontagora	Akure	424	11592.03	4915020.72
Kawon – Kontagora	Oshogbo	16	6296.22	100739.52
Kuta	Ibadan	226	10538.03	2381594.78
Kuta	Oshogbo	585	8432.40	4932954
Mariga	Ibadan	591	8569.56	5064609.96
Mariga	Ijebu – Ode	885	10294.58	9110703.3
Tunga – Malam	Ibadan	362	12907.85	2481166.1
Other Markets	Lagos	1730	Unknown	Unknown
				₦36, 159, 785.13

Conclusion: the interpretation from table 12 clearly shows and gives the numbers of cattle to be transported to the various states/cities from the different cattle markets in the North. The outcome also shows that, certain numbers of the cattle can be transported from a market to more than one particular state/city. For instance, Cattle 485, 885 and 106 can be transported from Mariga to Ibadan, Ijebu-Ode and Ilorin respectively with the total cost stated in table 12. While, the optimality test carried out gives a less cost for transportation of cattle to various locations in the South west of Nigeria with the minimum cost in table 16 above. And, to satisfy the demand of cattle in Lagos, one thousand seven hundred and thirty cattle should be transported from other markets.

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