Certain Results and Tables Relating to QSS-1 with Multiple RGS Plan as Reference Plan

V. Kaviyarasu (Corresponding author) & K. K. Suresh

Assistant Professor and Professor, Department of Statistics, Bharathiar University

Coimbatore 641046, TN, India

E-mail: kaviyarasu@buc.edu.in

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Abstract

This paper enlarges the concept of Quick Switching System and Multiple Repetitive Group Sampling Plan in to a new procedure for construction and selection of Quick Switching System with Multiple Repetitive Group Sampling Plan as reference plan indexed through Acceptable Quality Level (AQL), Limiting Quality Level (LQL), Indifference Quality Level (IQL) and its operating ratio. Poisson unity values have been tabulated to facilitate the operation and construction of the plan. Illustrations are also provided for selection of plan parameters.

Keywords: Quick switching system, Multiple repetitive group sampling plan, Acceptable quality level, Limiting quality level, Indifference quality level and operating ratio

1. Introduction

Acceptance sampling plan is used to either accept or reject a lot based on the sampling inspection. The primary objective of sampling inspection is to reduce the cost of inspection while at the same time assuring the customer to satisfy an adequate level of quality on items being inspected. Inspection of raw materials, semi finished products, or a finished product is an important part of quality assurance. When inspection is done for the purpose of acceptance or rejection of a product, and it is based on adherence to a standard the type of inspection procedure employed, such a procedure is usually called acceptance sampling. Sampling is widely used in government sector and industry for controlling the quality of shipment of components, supplies and final products.

2. Quick Switching System

Dodge [1969] has proposed a new sampling inspection-involving normal and tightened inspection plans which are usually referred to as two-plan system. Extensively, Romboski [1969] presents a system of immediate switching to tightened inspection when the rejection comes under normal inspection. Due to instantaneous switching between normal and tightened plans, this system is referred to as 'Quick Switching System (QSS)'. Romboski [1969] has studied the merits and demerits of switching rules of QSS when it is compared with two-plan system (m, d). The rule of QSS is retained at $m = 1$ where as tightened rule is made when $d > 1$. Further, Romboski [1969] introduces Quick Switching System Plan of type QSS-1 (n, C_N, C_T) with single sampling plan as a reference plan [(n, C_N) and (n, C_T) are respectively the normal and tightened single sampling plan with $C_T < C_N$].

3. Multiple Repetitive Group Sampling Plan

The concept of Repetitive Group Sampling (RGS) plan was introduced by Sherman [1965] in which acceptance or rejection of a lot is based on repeated sample results in the same lot. Soundararajan and Ramaswamy [1984] have derived the operating characteristics curve and various designing procedure for the selection of plan parameters. The disadvantage of RGS plan is that it has only a fixed group sample size but no fixed sample size, the second or subsequent samples have to be taken when the lot is neither good nor bad. Gaurishankar and Mohapatra [1993] have developed a new repetitive group sampling plan named as Conditional RGS plan. Gaurishankar and Joseph [1994] proposed another new RGS plan which is an extension of Conditional RGS plan designated as Multiple Repetitive Group Sampling plan in which disposal of a lot on the basis of repeated sample results is dependent on the outcome of the inspection of the immediate preceding i lots. Further they derived the formulae for OC and ASN function. Later Gauri Shankar and Joseph [1994] have studied the MRGS plan using the inflection point for the OC curve.

Devraj Arumainayagam [1991] has studied QSS-1 with RGS plan as reference plan, Suresh K. K. [1993] has studied Acceptance Sampling using Acceptable and Limiting Quality Levels. Suresh.K.K and Kaviyarasu.V [2008] have studied

QSS-1 with Conditional RGS Plan as Reference plan indexed with Acceptable Quality Level (AQL), Limiting Quality Level (LQL), Indifference Quality Level (IQL) and its Operating Ratio. This paper provides a new procedure for selection of QSS-1 with Multiple RGS plan indexed through certain basic quality levels, which are tailor made for industrial shop floor applications.

4. The Quick Switching System with Multiple Repetitive Group Sampling Plan as reference plan

As proposed by Romboski [1969] and also by Devaraj Arumainayagam [1991], a Quick Switching system with Multiple Repetitive Group Sampling plan of type QSMRGSP-1 plan is carried out through the following steps:

Step 1: Draw a random sample of size n from a large lot of size N and test each unit for conformity towards specified requirements.

Step 2: Under normal inspection, inspect the plan under Multiple RGS with the parameters n, u_1 and u_2. If a lot is accepted, continue step 2, otherwise go to step 3.

Step 3:Under tightened inspection, inspect the plan under Multiple RGS with the parameters n, v_1 and v_2. If a lot is accepted go to step 2 for the next lot, otherwise continue with step 3.

Thus a Quick Switching Multiple Repetitive Group Sampling Plan of type QSMRGSP-1 plans is characterized with six parameters namely, n, u_1, u_2, v_1, v_2 and acceptance criteria i. When $i = 0$ one find that QSMRGSP-1 plan is reduced to QSRGSP-1. Here it may also be noted that QSMRGSP-1 plan is applicable only to a stream of lots but not for isolated lots, where as the QSRGSP-1 plan is applicable for both. The OC function of the Quick Switching Multiple RGS plan is based on Romboski [1969] and Devaraj Arumainayagam [1991]. The expression for OC function of Quick Switching MRGS plan(QSMRGSP)-1 plan is derived from the following equations,

$$P_a(p) = \frac{P_T}{1 - P_N + P_T}, \tag{1}$$

where,

$$P_N = \frac{P_r(X \leq u_1)}{[1 - P_r(X \leq u_2) + P_r(X \leq u_1)]} \tag{2}$$

and

$$P_T = \frac{P_r(X \leq v_1)}{[1 - P_r(X \leq v_2) + P_r(X \leq v_1)]} \tag{3}$$

5. Selection of QSMRGSP-1

For construction and evaluation of the Quick Switching Multiple Repetitive Group Sampling plan, the np values presented in tables were derived under the procedure stated by Duncan [1965]. Tables are used to derive individual plan to meet specified values of fraction defectives and probability of acceptance. It requires the specifications of AQL (p_1), LTPD (p_2), Producers risk (α), Consumers risk (β) and acceptance criteria i. The steps to be followed are,

(1) Specify p_1 - Acceptable Quality Level (AQL), p_2 - Lot Tolerance Proportion Defective (LTPD), producer risk (α) and consumer risk (β).

(2) The operating ratio is OR = p_2 / p_1 and $m = np$.

(3) Choose the plan parameters having u_1, u_2, v_1, v_2 and i associated with an operating ratio which is nearest in the corresponding table.

(4) Determine the sample size $n = np_2 / p_1$.

(5) The OC Curve may be drawn by dividing the values of np shown for the plan by sample size n to obtain p associated with 0.95 for Pa(p).

(6) Thus, the plan consists of six parameters namely: n, u_1, u_2, v_1, v_2 and i may chosen from the given tables.

Example: Suppose a Quick Switching Multiple RGS plan is desired with Pa(p_1) = 0.95 for having p_1 = 0.02 and p_2 = 0.08 then,

(1) p_1 = 0.02, α = 0.05, p_2 = 0.08 and β = 0.10.

(2) OR = 0.08 / 0.02 = 4.

(3) The operating ratio is OR = 4 in the table 4 which is nearest to the desired ratio is 4.4294 for which the plan parameters are $u_1 = 1$, $u_2 = 5$, $v_1 = 1$,v_2 =4 when $i = 2$ and $np_1 = 0.9510$.

(4) The sample size n = np_2 / p_1 = 0.9510 / 0.02 = 47.55 ≈ 48.

(5) The OC curve is obtained by dividing the values of np is given below

$P_a(p)$	0.99	0.95	0.90	0.50	0.10	0.05	0.01
p	0.5769	0.9560	1.2495	1.9759	4.3528	5.5346	7.4278

(6) The desired system with plan parameters is, $u_1 = 1$, u_2 =5, $v_1 = 1$, v_2 =4 when $i = 2$ and $n = 48$. i.e., QSMRGSP-1(48; 1, 5; 1, 4).

6. Designing the Systems with Given Sample Size and a Point on the OC Curve

It can be used to design a system of type QSMRGSP-1 when the sample size is fixed at a point on the OC curve [p, Pa(p)] is specified. To design a system let n=90 p=0.01 and Pa(p) = 0.95, scan the column headed with Pa(p) = 0.95, when $i = 1$ to find the np value which is nearer to the desired value 90*0.01 = 0.9. The value approximately equals to 1.0427 which corresponds to the parameters $u_1 = 1$, u_2 =3, $v_1 = 1$, v_2 =2 when $i = 1$. Thus the desired QSMRGSP-1 has the parameters n=90, $u_1 = 1$, u_2 =3, $v_1 = 1$, v_2 =2 when $i = 1$.

7. Glossary of Symbols Used

p = incoming quality of the submitted lot
$P_a(p)$ = Probability of Acceptance
P_N = probability of acceptance under normal inspection
P_T = probability of acceptance under tightened inspection
u_1 and u_2 = acceptance numbers under normal inspection
v_1 and v_2 = acceptance numbers under tightened inspection
i = preceding lots
x = number of non-conforming units found in sample
p_1 = Acceptable Quality Level (AQL) at which $P_a(p) \approx 0.95$
p_2 = Limiting Quality Level (LQL) at which $P_a(p) \approx 0.10$
p_0 = Indifference Quality Level (IQL) at which $P_a(p) \approx 0.50$

8. Construction of Tables

The expression for probability of acceptance under the assumption with Poisson model, the composite OC function of QSMRGSP-1 is given through equation (1) with

$$P_N = \frac{\sum_{x=0}^{u_1} e^{-np}(np)^x/x!}{1 + \left[\sum_{x=0}^{u_1} e^{-np}(np)^x/x! - \sum_{x=0}^{u_2} e^{-np}(np)^x/x!\right]\left[\sum_{x=0}^{u_1} e^{-np}(np)^x/x!\right]^i} \tag{4}$$

$$P_T = \frac{\sum_{x=0}^{v_1} e^{-np}(np)^x/x!}{1 + \left[\sum_{x=0}^{v_1} e^{-np}(np)^x/x! - \sum_{x=0}^{v_2} e^{-np}(np)^x/x!\right]\left[\sum_{x=0}^{v_1} e^{-np}(np)^x/x!\right]^i} \tag{5}$$

For various values of AQL and LTPD with their associated risk, one can solve the equation (4) and (5), by substituting in equation (1) using iterative technique for selected combinations of u_1, u_2, v_1, v_2 and i. Accordingly the operating values are listed in Table 4, 5 and 6. Using computer programming with C++, the iterative solutions for $m = np$ are obtained and provided respectively in table 1, 2 and 3.

9. Conclusion

Traditionally, Quick Switching System and Multiple RGS Plan have wide potential applications in industries to ensure a higher standard of quality attainment and increased customer satisfaction. Here, an attempt is made to apply the concept of Quick Switching System with Multiple RGS plan as a reference plan to propose a new plan designated as Quick Switching Multiple Repetitive Group Sampling Plan of type QSMRGSP-1 in which disposal of a lot on the basis of normal and tightened plan. Repetitive Group Sample result is dependent on the immediate proceeding stream of lots. Poisson unity values have been tabulated for a wider range of plan parameters. The present development would be a valuable addition to the literature and a useful device to the quality practitioners. The concept of this article may be used for assistance to quality control engineers and plan designers in the development of further plans, which were useful and tailor made for industrial shop-floor situations.

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Table 1. Unity values for QSMRGSP-1 (n, u_1, u_2, v_1, v_2) when i = 1

u_1	u_2	v_1	v_2	0.99	0.95	0.90	0.50	0.10	0.05	0.01
0	2	0	1	0.2465	0.4814	0.6888	1.0196	2.7836	3.7927	5.3946
0	3	0	1	0.2473	0.4844	0.6941	1.0315	2.7858	3.7932	5.3947
0	3	0	2	0.2475	0.4866	0.6996	1.0662	2.8081	3.8036	5.3957
0	4	0	3	0.2475	0.4869	0.7007	1.0810	2.8266	3.8144	5.3973
1	2	0	1	0.5058	0.8430	1.0932	1.4686	3.0189	3.9428	5.4405
1	3	0	1	0.6058	0.9488	1.1978	1.5487	3.0394	3.9513	5.4410
1	3	1	2	0.6373	1.0427	1.3460	2.0595	4.3678	5.5396	7.4278
1	4	1	2	0.6595	1.0762	1.3844	2.0914	4.3703	5.5401	7.4278
1	4	1	3	0.6614	1.0852	1.4011	2.1454	4.3913	5.5486	7.4288
1	5	1	2	0.6621	1.0824	1.3930	2.1048	4.3723	5.5411	7.4278
1	5	1	4	0.6643	1.0937	1.4151	2.1884	4.4143	5.5596	7.4298
2	3	1	2	0.9067	1.4109	1.7547	2.4923	4.5608	5.6571	7.4608
2	4	1	3	1.1162	1.6184	1.9539	2.6274	4.5898	5.6681	7.4618
2	5	1	3	1.1836	1.6894	2.0240	2.6794	4.6018	5.6726	7.4618
2	6	1	3	1.1978	1.7092	2.0462	2.7035	4.6103	5.6761	7.4623
2	6	1	5	1.2018	1.7211	2.0638	2.7394	4.6378	5.6926	7.4648
2	7	1	4	1.2034	1.7228	2.0649	2.7361	4.6303	5.6871	7.4633
2	7	1	6	1.2042	1.7263	2.0710	2.7545	4.6513	5.7016	7.4668
2	7	2	3	1.2212	1.7873	2.1741	3.1628	5.8053	7.0922	9.1956
2	7	2	5	1.2263	1.8080	2.2105	3.2662	5.8463	7.1097	9.1971
3	4	1	3	1.3335	1.9108	2.2763	2.9985	4.8484	5.8562	7.5344
3	4	2	3	1.3696	2.0254	2.4529	3.5026	5.6134	7.1942	9.2231
3	5	1	2	1.5732	2.1116	2.4553	3.1041	4.8759	5.8682	7.5354
3	5	2	3	1.6502	2.2739	2.6745	3.6089	5.9839	7.1972	9.2236
3	6	1	2	1.6856	2.2177	2.5572	3.1825	4.9064	5.8837	7.5369
3	6	1	5	1.7162	2.2618	2.6056	3.2325	4.9334	5.9002	7.5399
3	6	2	5	1.7922	2.4310	2.8372	3.7529	6.0259	7.2152	9.2251
3	7	2	4	1.8253	2.4610	2.8627	3.7568	6.0179	7.2102	9.2241
3	8	3	6	1.8362	2.5294	2.9895	4.2760	7.1979	8.5643	10.8357
4	6	2	3	2.1620	2.8294	3.2452	4.1274	6.2505	7.3728	9.2821
4	6	2	5	2.1940	2.8808	3.2971	4.1843	6.2730	7.3838	9.2836
4	7	3	6	2.4261	3.1797	3.6470	4.7866	7.3694	8.6623	10.8612
5	7	2	6	2.7057	3.4163	3.8356	4.6887	6.6041	7.6299	9.3860
5	7	3	6	2.8047	3.6190	4.0999	5.2089	7.5965	8.8134	10.9112
5	7	4	6	2.8369	3.7237	4.2635	5.6859	8.6473	10.0457	12.4179

Table 2. Unity values for (n, u_1, u_2, v_1, v_2) when i = 2

u_1	u_2	v_1	v_2	0.99	0.95	0.90	0.50	0.10	0.05	0.01
0	2	0	1	0.2195	0.4250	0.6144	0.9100	2.7614	3.7853	5.3945
0	3	0	1	0.2195	0.4260	0.6159	0.9135	2.7614	3.7853	5.3945
0	3	0	2	0.2195	0.4270	0.6179	0.9270	2.7639	3.7858	5.3945
0	4	0	3	0.2195	0.4275	0.6184	0.9320	2.7639	3.7858	5.3945
1	2	0	1	0.4764	0.7884	1.0255	1.3810	2.9914	3.9323	5.4400
1	3	0	1	0.5374	0.8509	1.0870	0.4234	2.9969	3.9338	5.4000
1	3	1	2	0.5654	0.9340	1.2185	1.9239	4.3483	5.5336	7.4273
1	4	1	2	0.5749	0.9485	1.2355	1.9359	4.3483	5.5336	7.4273
1	4	1	3	0.5759	0.9530	1.2440	0.9604	4.3508	5.5341	7.4273
1	5	1	2	0.5759	0.9510	1.2385	1.9404	4.3488	5.5336	7.4273
1	5	1	4	0.5769	0.9560	1.2495	1.9759	4.3528	5.5346	7.4273
2	3	1	2	0.8775	1.3490	1.6754	2.3939	4.5398	5.6496	7.4603
2	4	1	3	1.0230	1.4830	1.7989	2.4589	4.5443	5.6506	7.4603
2	5	1	3	1.0580	1.5195	1.8349	2.4834	4.5468	5.6511	7.4603
2	6	1	3	1.0640	1.5279	1.8444	2.4929	4.5483	5.6516	7.4603
2	6	1	5	1.0615	1.5324	1.8509	2.5034	4.5508	5.6526	7.4603
2	7	1	4	1.0660	1.5329	1.8514	2.5034	4.5508	5.6526	7.4603
2	7	1	6	1.0665	1.5339	1.8534	2.5084	4.5528	5.6531	7.4603
2	7	2	3	1.0855	1.5989	1.9629	2.9648	5.7813	7.0852	9.1951
2	7	2	5	1.0880	1.6099	1.9818	3.0118	5.7853	7.0862	9.1951
3	4	1	3	1.2945	1.8344	2.1829	2.8883	4.8069	5.8367	7.5324
3	4	2	3	1.3420	1.9619	2.3689	3.3988	5.9549	7.1882	9.2231
3	5	1	2	1.4814	1.9879	2.3189	2.9623	4.8189	5.8407	7.5314
3	5	2	3	1.5539	2.1359	2.5184	3.4558	5.9569	7.1887	9.2231
3	6	1	2	1.5489	2.0499	2.3779	3.0028	4.8284	5.8442	7.5329
3	6	1	5	1.5619	2.0664	2.3949	3.0148	4.8304	5.8447	7.5329
3	6	2	5	1.6374	2.2234	2.6064	3.5158	5.9619	7.1897	9.2231
3	7	2	4	1.6529	2.2374	2.6189	3.5203	5.9619	7.1902	9.2231
3	8	3	6	1.6684	2.3064	2.7404	4.0218	7.1433	8.5438	10.8342
4	6	2	3	2.0674	2.6949	3.0893	3.9763	6.2035	7.3528	9.2806
4	6	2	5	2.0849	2.7189	3.1138	3.9918	6.2055	7.3533	9.2806
4	7	3	6	2.2544	2.9508	3.3933	4.5329	7.3094	8.6398	10.8592
5	7	2	6	2.5899	3.2533	3.6558	4.5019	6.5121	7.5774	9.3785
5	7	3	6	2.6969	3.4488	3.9043	5.0036	7.5340	8.7874	10.9087
5	7	4	3	2.7374	3.5623	4.0738	5.4883	8.6113	10.0337	12.4169

Table 3. Unity values for (n, u_1, u_2, v_1, v_2) when i = 3

u_1	u_2	v_1	v_2	0.99	0.95	0.90	0.50	0.10	0.05	0.01
0	2	0	1	0.2070	0.3990	0.5789	0.8630	2.7589	3.7848	5.3945
0	3	0	1	0.2075	0.3995	0.5799	0.8710	2.7589	3.7848	5.3945
0	3	0	2	0.2080	0.4000	0.5809	0.3710	2.7594	3.7848	5.3945
0	4	0	3	0.2080	0.4000	0.5809	0.8730	2.7594	3.7848	5.3945
1	2	0	1	0.4569	0.7544	0.9850	1.3385	2.9859	3.9313	5.4400
1	3	0	1	0.5009	0.7994	1.0285	1.3645	2.9874	3.9313	5.4400
1	3	1	2	0.5269	0.8750	1.1495	1.8634	4.3463	5.5331	7.4273
1	4	1	2	0.5324	0.8840	1.1600	1.8689	4.3463	5.5331	7.4273
1	4	1	3	0.5334	0.8870	1.1655	1.8814	4.3463	5.5331	7.4273
1	5	1	2	0.5329	0.8850	1.1615	1.8709	4.3463	5.5331	7.4273
1	5	1	4	0.5339	0.8885	1.1680	1.8884	4.3468	5.5331	7.4273
2	3	1	2	0.8550	1.3070	1.6240	2.3454	4.5363	5.6491	7.4603
2	4	1	3	0.9675	1.4055	1.7124	2.3814	4.5373	5.6491	7.4603
2	5	1	3	0.9910	1.4300	1.7364	2.3954	4.5378	5.6491	7.4603
2	6	1	3	0.9945	1.4350	1.7419	2.4009	4.5383	5.6496	7.4603
2	6	1	5	0.9955	1.4370	1.7449	2.4044	4.5383	5.6496	7.4603
2	7	1	4	0.9960	1.4375	1.7454	2.4049	4.5388	5.6496	7.4603
2	7	1	6	0.9960	1.4380	1.7464	2.4069	4.5388	5.6496	7.4603
2	7	2	3	1.0150	1.5025	1.8544	2.8808	5.7788	7.0852	9.1951
2	7	2	5	1.0170	1.5080	1.8674	2.9048	5.7793	7.0852	9.1951
3	4	1	3	1.2670	1.7874	2.1284	2.8358	4.7964	5.8332	7.5324
3	4	2	3	1.3200	1.9159	2.3114	3.3478	5.9524	7.1877	9.2231
3	5	1	2	1.4234	1.9129	2.2384	2.8878	4.8009	5.8347	7.5324
3	5	2	3	1.4919	2.0504	2.4244	3.3813	5.9529	7.1882	9.2231
3	6	1	2	1.4719	1.9569	2.2794	2.9128	4.8044	5.8352	7.5324
3	6	1	5	1.4789	1.9649	2.2869	2.9158	4.8044	5.8952	7.5233
3	6	2	5	1.5509	2.1099	2.4824	3.4108	5.9534	7.1882	9.2231
3	7	2	4	1.5609	2.1194	2.4909	3.4148	5.9534	7.1887	9.2231
3	8	3	6	1.5779	2.1859	2.6069	3.9098	7.1378	8.5428	10.8342
4	6	2	3	2.0039	2.6134	2.9974	3.8968	6.1910	7.3493	9.2806
4	6	2	5	2.0149	2.6229	3.0094	3.9018	6.1910	7.3493	9.2806
4	7	3	6	2.1554	2.8214	3.2523	4.4189	7.3019	8.6383	10.8592
5	7	2	6	2.5189	3.1613	3.5578	4.4119	6.4831	7.5654	9.3775
5	7	3	6	2.6239	3.3443	3.7893	4.9076	7.5225	8.7844	10.9087
5	7	4	6	2.6674	3.4578	3.6553	5.3953	8.6073	10.0327	11.8169

Table 4. Operating Ration values for (n, u_1, u_2, v_1, v_2) when i = 1

u_1	u_2	v_1	v_2	α=0.01 β=0.01	α=0.01 β=0.05	α=0.01 β=0.10	α=0.05 β=0.05	α=0.05 β=0.01	α=0.05 β=0.10
0	2	0	1	21.8851	15.3865	11.2928	11.2062	7.8786	5.7824
0	3	0	1	21.8147	15.3387	11.2651	11.1370	7.8308	5.7511
0	3	0	2	21.8011	15.3683	11.3460	11.0887	7.8168	5.7709
0	4	0	3	21.8076	15.4119	11.4207	11.0852	7.8341	5.8053
1	2	0	1	10.7546	7.7940	5.9676	6.4531	4.6767	3.5807
1	3	0	1	8.98057	6.5217	5.0165	5.7346	4.1645	3.2034
1	3	1	2	11.6539	8.6913	6.8528	7.1236	5.3126	4.1888
1	4	1	2	11.2616	8.3995	6.6259	6.9018	5.1477	4.0607
1	4	1	3	11.2308	8.3882	6.6386	6.8454	5.1128	4.0464
1	5	1	2	11.2174	8.3680	6.6029	6.8622	5.1191	4.0393
1	5	1	4	11.1833	803682	6.6443	6.7932	5.0832	4.0360
2	3	1	2	8.2285	6.2392	5.0300	5.2877	4.0094	3.2334
2	4	1	3	6.6848	5.0778	4.1118	4.6106	3.5022	2.8360
2	5	1	3	6.3040	4.7924	3.8878	4.4168	3.3577	2.7239
2	6	1	3	6.2297	4.7385	3.8488	4.3659	3.3209	2.6973
2	6	1	5	6.2111	4.7365	3.8589	4.3371	3.3075	2.6946
2	7	1	4	6.2016	4.7256	3.8475	4.3320	3.3010	2.6876
2	7	1	6	6.2003	4.7345	3.8624	4.3252	3.3027	2.6943
2	7	2	3	7.5296	5.8073	4.7535	5.1449	3.9680	3.2480
2	7	2	5	7.4995	5.7974	4.7672	5.0868	3.9322	3.2335
3	4	1	3	5.6497	4.3913	3.6356	3.9429	3.0647	2.5373
3	4	2	3	6.7337	5.2524	4.0983	4.5535	3.5518	2.7713
3	5	1	2	4.7898	3.7300	3.0993	305684	2.7789	2.3090
3	5	2	3	5.5893	4.3613	3.6261	4.0563	3.1651	2.6315
3	6	1	2	4.4712	3.4905	2.9107	3.3985	2.6530	2.2124
3	6	1	5	4.3932	3.4378	2.8745	3.3335	2.6086	2.1812
3	6	2	5	5.1472	4.0258	3.3621	3.7947	2.9676	2.4787
3	7	2	4	5.0533	3.9500	3.2968	3.7580	2.9298	2.4453
3	8	3	6	5.9010	4.6640	3.9198	4.2838	3.3858	2.8456
4	6	2	3	4.2933	3.4101	2.8910	3.2805	2.6057	2.2091
4	6	2	5	4.2312	3.3653	2.8590	3.2225	2.5630	2.3176
5	7	2	6	3.4689	2.8199	2.4408	2.7474	2.2333	1.9331
5	7	3	6	3.8902	3.1423	2.7084	3.0149	2.4353	2.0990
5	7	4	6	4.3772	3.5410	3.0481	3.3348	2.6977	2.3222

Table 5. Operating Ration values for (n, u_1, u_2, v_1, v_2) when i = 2

u_1	u_2	v_1	v_2	α=0.01 β=0.01	α=0.01 β=0.05	α=0.01 β=0.10	α=0.05 β=0.05	α=0.05 β=0.01	α=0.05 β=0.10
0	2	0	1	24.5764	12.693	8.7788	1702454	8.9067	6.1601
0	3	0	1	24.5764	12.6632	8.7575	17.2454	8.8858	6.1451
0	3	0	2	24.5764	12.6335	8.7291	17.2477	8 .8662	6.1216
0	4	0	3	24.5764	12.6188	8.7221	17.2477	8.8558	6.1211
1	2	0	1	11.4169	6.8993	5.3047	8.2527	4.9872	3.8345
1	3	0	1	10.1212	6.3926	5.0046	7.3189	4.6226	3.6190
1	3	1	2	13.1343	7.9522	6.0954	9.7854	5.9246	4.5412
1	4	1	2	12.9173	7.8306	6.0115	9.6238	5.8340	4.4787
1	4	1	3	12.8949	7.7936	5.9704	9.6079	5.8070	4.4485
1	5	1	2	12.8949	7.8100	5.9970	9.6071	5.8187	4.4679
1	5	1	4	12.8734	7.7697	5.9446	9.5921	5.7893	4.4294
2	3	1	2	8.5018	5.5302	4.4526	6.4383	4.1879	3.3719
2	4	1	3	7.2925	5.0306	4.1470	5.5235	3.8102	3.1410
2	5	1	3	7.0513	4.9097	4.0656	5.3413	3.7190	3.0796
2	6	1	3	7.0115	4.8824	4.0447	5.3116	3.6987	3.0640
2	7	1	4	6.9984	4.8665	4.0294	5.3026	3.6873	3.0530
2	7	1	6	6.9951	4.8633	4.0250	5.3006	3.6852	3.0500
2	7	2	3	8.4708	5.7506	4.6843	6.5270	4.4310	3.6094
2	7	2	5	8.4513	5.7113	4.6396	6.5130	4.4014	3.5755
3	4	1	3	5.8187	4.1060	3.4505	4.5088	3.1816	2.6737
3	4	2	3	6.8727	4.7009	3.8933	5.3563	3.6638	3.0343
3	5	1	2	5.0836	3.7885	3.2477	3.9424	2.9380	2.5186
3	5	2	3	5.9351	4.3180	3.6622	4.6260	3.3656	2.8544
3	6	1	2	4.8631	3.6746	3.1678	3.7729	2.8508	2.4576
3	6	1	5	4.8226	3.6453	3.1453	3.7418	2.8283	2.4404
3	7	2	4	5.5797	4.1221	3.5217	4.3498	3.2136	2.7455
3	8	3	6	6.4935	4.6974	3.9535	5.1207	3.7043	3.1177
4	6	2	3	4.4889	3.4437	3.0040	3.5564	2.7284	2.3800
4	6	2	5	4.4512	3.4133	2.9804	3.5268	2.7045	2.3614
5	7	2	6	3.6212	2.8827	2.5653	2.9257	2.3290	2.5479
5	7	3	6	4.0449	3.1630	2.7940	3.2583	2.5479	2.2506
5	7	4	6	4.5360	3.4855	3.0479	3.6654	2.8166	2.4629

Table 6. Operating Ration values for (n, u_1, u_2, v_1, v_2) when i = 3

u_1	u_2	v_1	v_2	α=0.01 β=0.01	α=0.01 β=0.05	α=0.01 β=0.10	α=0.05 β=0.05	α=0.05 β=0.01	α=0.05 β=0.10
0	2	0	1	26.0605	13.5201	9.3171	18.2844	9.4858	6.5370
0	3	0	1	25.9977	13.5032	9.3010	18.2403	9.4740	6.5257
0	3	0	2	25.9352	13.4863	9.2850	18.1964	9.4621	6.5145
0	4	0	3	25.9352	13.4863	9.2850	18.1964	9.4621	6.5145
1	2	0	1	11.9041	7.2102	5.5229	8.6027	5.2106	3.9912
1	3	0	1	10.8586	6.8044	5.2893	7.8471	4.9173	3.8224
1	3	1	2	14.0939	8.4884	6.4613	10.4994	6.3235	4.8134
1	4	1	2	13.9483	8.4019	6.4028	10.3909	6.2591	4.7699
1	4	1	3	13.9222	8.3735	6.3726	10.3715	6.2379	4.7474
1	5	1	2	13.9352	8.3924	6.3946	10.3812	6.2520	4.7637
1	5	1	4	13.9091	8.3594	6.3590	10.3618	6.2274	4.7372
2	3	1	2	8.7255	5.7079	4.5938	6.6071	4.3221	3.4785
2	4	1	3	7.7109	5.3079	4.3564	5.8388	4.0193	3.2987
2	5	1	3	7.5280	5.2170	4.2962	5.7003	3.9504	3.2531
2	6	1	3	7.5015	5.1988	4.2826	5.6808	3.9370	3.2432
2	6	1	5	7.4940	5.1916	4.2753	5.6751	3.9315	3.2376
2	7	1	4	7.4902	5.1898	4.2740	5.6722	3.9301	3.2367
2	7	1	6	7.4902	5.1880	4.2716	5.6722	3.9288	3.2348
2	7	2	3	9.0592	6.1199	4.9583	6.9804	4.7156	3.8205
2	7	2	5	9.0413	6.0976	4.9238	6.9667	4.6984	3.7940
3	4	1	3	5.9450	4.2139	3.5389	4.6039	3.2633	2.7405
3	4	2	3	6.9872	4.8138	3.9902	5.4452	3.7515	3.1096
3	5	1	2	5.2915	3.9375	3.3650	4.0988	3.0500	2.6065
3	5	2	3	6.1817	4.4980	3.8042	4.8179	3.5056	2.9649
3	6	1	2	5.1171	3.8490	3.3044	3.9641	2.9817	2.5599
3	6	1	5	5.0867	3.8287	3.2896	3.9454	2.9696	2.5515
3	6	2	5	5.9466	4.3712	3.7153	4.6346	3.4068	2.8956
3	7	2	4	5.9085	4.3516	3.7027	4.6052	3.3918	2.8859
3	8	3	6	6.8659	4.9563	4.1559	5.4137	3.9080	3.2769
4	6	2	3	4.6311	3.5511	3.0962	3.6674	2.8121	2.4519
4	6	2	5	4.6058	3.5382	3.0838	3.6474	2.8019	2.4421
4	7	3	6	5.0380	3.8488	3.3388	4.0076	3.0617	2.6560
5	7	2	6	3.7228	2.9662	2.6357	3.0034	2.3930	2.1263
5	7	3	6	4.1574	3.2618	2.8787	3.3478	2.6266	2.3181
5	7	4	6	4.4301	3.4174	2.9875	3.7612	2.9014	2.5365