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RESEARCH ARTICLE

RELIABILITY AND PROFIT ANALYSIS OF A TWO NON-IDENTICAL UNITS OPERATING SYSTEM UNDER ABNORMAL WEATHER CONDITIONS

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ABSTRACT

The present paper deals with the system model having two non-identical units A and B arranged in parallel configuration. Initially both the units are operative. The unit A does not work in bad weather conditions and unit A takes some activation time before starting its operation after disappearance of bad weather conditions and repair. Unit A gets priority for repair and activation over unit B. A single repair facility is always available with the system to repair a failed unit and for activation. All the failure time distributions are taken to be negative exponential. All the repair time distributions are taken as arbitrary. Distribution of occurrence and disappearance of bad weather conditions and time required for activation are also taken as exponential.

INTRODUCTION

Two unit parallel system models have been studied by many authors under different set of assumptions including Goel and Gupta (1984), Gupta and Goel (1990), Gupta and Shivakar (2010). But it has been found that operation of a system is also effected due to changing environmental conditions. Keeping in this view, reliability models systems operation under controlled weather conditions have been developed by several authors including Dhillon and Natesan (1983), Malik and Barak (2007), Gupta (1985). Malik and Pawar (2010) studied the reliability and economic measures of a system in abnormal weather conditions under different set of assumptions.

In the present study we investigate and analyze a system model having two non-identical units A and B arranged in parallel configuration. Initially both the units are operative. The unit A does not work in bad weather conditions and unit A takes some activation time before starting its operation after disappearance of bad weather conditions and repair. Unit A gets priority for repair and activation over unit B. A single repair facility is always available with the system to repair a failed unit and for activation. All the failure time distributions are taken to be negative exponential. All the repair time distributions are taken as arbitrary. Distribution of occurrence and disappearance of bad weather conditions and time required for activation are also taken as exponential.

Using the regenerative point technique the following important reliability characteristics of interest are obtained:

a) Transition probabilities and mean sojourn times.
b) Reliability and Mean time to system failure.
c) Point wise and steady-state availabilities of the system.
d) Expected up time of the system.
e) Expected busy time of the repairman during (0, t] and in the steady-state.
f) Expected number of repairs by repairman during (0, t] and in the steady-state.
g) Net expected profit incurred by the system during (0, t] and in the steady-state.

System Description and Assumptions

a) The system consists of two non-identical units A and B. Initially both the units are operative.
b) The unit A does not work in bad weather conditions and unit A takes some activation time before starting its operation after disappearance of bad weather conditions and repair.
c) Unit A gets priority for repair and activation over unit B.
d) A single repair facility is always available with the system to repair a failed unit and for activation.
e) All the failure time distributions are taken to be negative exponential.
f) All the repair time distributions are taken as arbitrary.

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g) Distribution of occurrence and disappearance of bad weather conditions and time required for activation are also taken as exponential.

Notations and Symbols

$\alpha_i (i = 1,2)$: Failure rate of unit **A/B** respectively.
α_3 : Rate of occurrence of bad weather conditions.
β_1 : Rate of disappearance of bad weather conditions.
β_2 : Rate of completion of activation of unit **A**.
$G_i(.)\ (i = 1,2)$: C.d.f. of repair time of unit **A/B** respectively**.**
m_1 : mean repair time of unit **A**.

Symbols for the states of the system

$A_O/A_r/A_a$: Unit **A** is operative/ under repair/ under activation.
$B_O/B_r/B_{wr}$: Unit **B** is operative/ under repair/ waiting for repair.
A_{bwc} : Unit **A** is not working due to bad weather conditions.

With the help of the above symbols, the possible states of the system are:

$S_0 = [A_O, B_O]$ $\quad S_1 = [A_r, B_O]$
$S_2 = [A_O, B_r]$ $\quad S_3 = [A_{dwc}, B_O]$
$S_4 = [A_a, B_O]$ $\quad S_5 = [A_r, B_{wr}]$
$S_6 = [A_{dwc}, B_r]$ $\quad S_7 = [A_a, B_{wr}]$

The transition diagram along with all transitions is shown in Fig. 1.

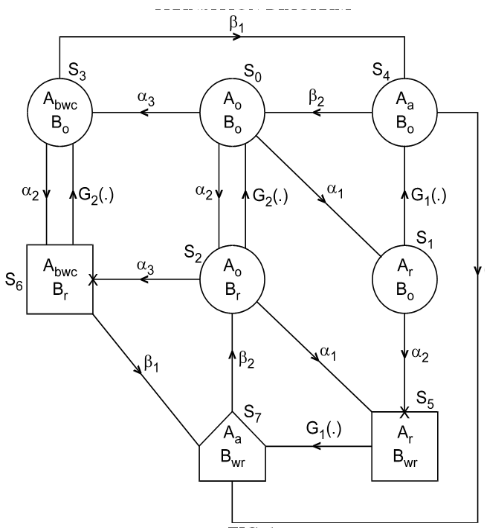

Figure 1 Transition Diagram

Transition Probabilities and Sojourn Times

Let $T_0 (\equiv 0), T_1, T_2$ .... denotes the regenerative epochs and X_n denotes the state visited at epoch T_{n^+} i.e just after the transition at T_n. Then $\{X_n, T_n\}$ constitute a Markov-Renewal process with state space E, set of regenerative states and

$$Q_{ij}(t) = P[X_{n+1} = j, T_{n+1} - T_n \le t | X_n = i]$$

is the semi Markov kernel over E.
Thus steady state transition probabilities can be obtained as follows:

$$p_{ij} = \lim_{t\to\infty} Q_{ij}(t)$$

So that,

$$p_{01} = \frac{\alpha_1}{(\alpha_1+\alpha_2+\alpha_3)} \qquad p_{02} = \frac{\alpha_2}{(\alpha_1+\alpha_2+\alpha_3)}$$
$$p_{03} = \frac{\alpha_3}{(\alpha_1+\alpha_2+\alpha_3)} \qquad p_{14} = \tilde{G}_1(\alpha_2)$$
$$p_{17}^{(5)} = [1 - \tilde{G}_1(\alpha_2)] \qquad p_{20} = \tilde{G}_2(\alpha_1 + \alpha_3)$$
$$p_{23}^{(6)} = \frac{\alpha_3}{(\alpha_1+\alpha_3-\beta_1)}[\tilde{G}_2(\beta_1) - \tilde{G}_2(\alpha_1 + \alpha_3)] \qquad p_{25} = \frac{\alpha_1}{(\alpha_1+\alpha_3)}[1 - \tilde{G}_2(\alpha_1 + \alpha_3)]$$
$$p_{27}^{(6)} = \frac{\alpha_3}{(\alpha_1+\alpha_3-\beta_1)}\left\{[1 - \tilde{G}_2(\beta_1)] - \frac{\beta_1}{(\alpha_1+\alpha_3)}[1 - \tilde{G}_2(\alpha_1 + \alpha_3)]\right\}$$
$$p_{34} = \frac{\beta_1}{(\alpha_2+\beta_1)} \qquad p_{36} = \frac{\alpha_2}{(\alpha_2+\beta_1)}$$
$$p_{40} = \frac{\beta_2}{(\alpha_2+\beta_2)} \qquad p_{47} = \frac{\alpha_2}{(\alpha_2+\beta_2)}$$
$$p_{63} = \tilde{G}_2(\beta_1) \qquad p_{67} = [1 - \tilde{G}_2(\beta_1)]$$
$$p_{57} = p_{72} = 1 \qquad \textbf{(1-16)}$$

It can be easily seen that the following results hold good:

$$p_{01} + p_{02} + p_{03} = 1 \qquad p_{14} + p_{17}^{(5)} = 1$$
$$p_{20} + p_{23}^{(6)} + p_{25} + p_{27}^{(6)} = 1 \qquad p_{34} + p_{36} = 1$$
$$p_{40} + p_{47} = 1 \qquad p_{63} + p_{67} = 1$$
$$p_{57} = p_{72} = 1 \qquad \textbf{(17-23)}$$

Mean sojourn times

The mean sojourn time in state S_i denoted by Ψ_i is defined as the expected time taken by the system in state S_i before transiting to any other state. To obtain mean sojourn time Ψ_i, in state S_i, we observe that as long as the system is in state S_i, there is no transition from S_i to any other state. If T_i denotes the sojourn time in state S_i then mean sojourn time Ψ_i in state S_i is:

$$\Psi_i = E[T_i] = \int P(T_i > t)dt \qquad \textbf{(24)}$$

Thus

$$\Psi_0 = \int e^{-(\alpha_1+\alpha_2+\alpha_3)t}\, dt = \frac{1}{(\alpha_1+\alpha_2+\alpha_3)}$$
$$\Psi_1 = \int e^{-\alpha_2 t}\, \overline{G}_1(t)dt = \frac{1}{\alpha_2}[1 - \tilde{G}_1(\alpha_2)]$$
$$\Psi_2 = \int e^{-(\alpha_1+\alpha_3)t}\, \overline{G}_2(t)dt = \frac{1}{(\alpha_1+\alpha_3)}[1 - \tilde{G}_2(\alpha_1 + \alpha_3)]$$
$$\Psi_3 = \int e^{-(\alpha_2+\beta_1)t}dt = \frac{1}{(\alpha_2+\beta_1)}$$
$$\Psi_4 = \int e^{-(\alpha_2+\beta_2)t}dt = \frac{1}{(\alpha_2+\beta_2)}$$
$$\Psi_5 = \int \overline{G}_1(t)dt = m_1$$
$$\Psi_6 = \int e^{-\beta_1 t}\overline{G}_2(t)dt = \frac{1}{\beta_1}[1 - \tilde{G}_2(\beta_1)]$$
$$\Psi_7 = \int e^{-\beta_2 t}dt = \frac{1}{\beta_2} \qquad \textbf{(25-32)}$$

Analysis of Reliability and MTSF

Let the random variable T_i be the time to system failure when system starts up from state $S_i \in E_i$, the the reliability of the system is given by

$$R_i(t) = P[T_i > t]$$

To determine, $R_i(t)$ we assume that the failed states (S_5, S_6) and down state S_7 of the system as absorbing. Using the simple probabilistic arguments, one can easily develop the recurrence relations among $R_i(t)$; i = 0, 1, 2, 4. Taking the Laplace Transforms of these relations and simplifying the resulting set of algebraic equations for, $R_0^*(s)$ we get after omitting the arguments 's' for brevity.

$$R_0^*(s) = N_1(s)/D_1(s) \quad \textbf{(33)}$$

where,

$$N_1(s) = Z_0^* + q_{01}^*(Z_1^* + q_{14}^* Z_4^*) + q_{03}^*(Z_3^* + q_{34}^* Z_4^*) + q_{02}^*\left(Z_2^* + q_{23}^{(6)*} Z_3^* + q_{23}^{(6)*} q_{34}^* Z_4^*\right)$$

and

$$D_1(s) = \left[1 - (q_{01}^* q_{14}^* + q_{03}^* q_{34}^*) q_{40}^* - q_{02}^*\left(q_{20}^* + q_{23}^{(6)*} q_{34}^* q_{40}^*\right)\right]$$

where, $Z_0^*, Z_1^*, Z_2^*, Z_4^*$ are the Laplace transform of

$Z_0(t) = e^{-(\alpha_1+\alpha_2+\alpha_3)t}$ $\quad Z_1(t) = e^{-\alpha_2 t}\,\bar{G}_1(t)$ $\quad Z_2(t) = e^{-(\alpha_1+\alpha_3)t}\,\bar{G}_2(t)$ $Z_3(t) = e^{-(\alpha_2+\beta_1)t}$ $\quad Z_4(t) = e^{-(\alpha_2+\beta_2)t}$

Taking inverse Laplace Transform of **(36),** we get reliability of the system.

To get MTSF, we use the well known formula

$$E(T_0) = \int R_0(t)dt = \lim_{s\to 0} R_0^*(s) = N_1(0)/D_1(0) \quad \textbf{(34)}$$

where,

$$N_1(0) = \Psi_0 + p_{01}(\Psi_1 + p_{14}\Psi_4) + p_{03}(\Psi_3 + p_{34}\Psi_4) + p_{02}\left(\Psi_2 + p_{23}^{(6)}\Psi_3 + p_{23}^{(6)} p_{34}\Psi_4\right)$$

And

$$D_1(0) = \left[1 - (p_{01}p_{14} + p_{03}p_{34})p_{40} - p_{02}\left(p_{20} + p_{23}^{(6)} p_{34}p_{40}\right)\right]$$

Here we use the relations $q_{ij}^*(0) = p_{ij}$ and $\lim_{s\to 0} Z_i^*(s) = \int Z_i(t)dt = \Psi_i$.

Availability Analysis

Define $A_i(t)$ as the probability that the system is up at epoch't' when it initially started from regenerative state S_i . Using the definition of $A_i(t)$ and probabilistic concepts, the recurrence relations among $A_i(t)$ where i = 0, 1, 2, 3, 4, 5, 7 can easily be developed.

Using the technique of L.T., the value of $A_i(t)$ in terms of their L.T. are as follows:

$$A_0^*(s) = N_2(s)/D_2(s) \quad \textbf{(35)}$$

where,

$$N_2(s) = [Z_0^* + q_{01}^*(Z_1^* + q_{14}^* Z_4^*) + q_{03}^*(Z_3^* + q_{34}^* Z_4^*)]D_1 + \left[Z_2^*(1 - q_{36}^* q_{63}^*) + q_{23}^{(6)*}(Z_3^* + q_{34}^* Z_4^*)\right]D_2 \quad \textbf{(36)}$$

And

$$D_2(s) = [(1 - q_{01}^* q_{14}^* q_{40}^*)(1 - q_{36}^* q_{63}^*) - q_{03}^* q_{34}^* q_{40}^*]D_1 - \left[q_{20}^*(1 - q_{36}^* q_{63}^*) + q_{23}^{(6)*} q_{34}^* q_{40}^*\right] D_2 \quad \textbf{(37)}$$

where,

$$D_1 = \left[1 - q_{72}^*\left(q_{25}^* q_{57}^* + q_{27}^{(6)*}\right)\right](1 - q_{36}^* q_{63}^*) - q_{23}^{(6)*} q_{72}^*(q_{34}^* q_{47}^* + q_{36}^* q_{67}^*)$$

$$D_2 = \left[q_{02}^* + q_{01}^* q_{72}^*\left(q_{14}^* q_{47}^* + q_{17}^{(5)*}\right)\right](1 - q_{36}^* q_{63}^*) + q_{03}^* q_{72}^*(q_{34}^* q_{47}^* + q_{36}^* q_{67}^*)$$

The steady state availability of the system will be up in the long run is given by

$$A_0 = \lim_{t\to\infty} A_0(t) = \lim_{s\to 0} s\,A_0^*(s) = \lim_{s\to 0} \frac{sN_2(s)}{D_2(s)} = \lim_{s\to 0} N_2(s) \lim_{s\to 0} \frac{s}{D_2(s)}$$

As $s \to 0$, the above equation becomes indeterminate form. Hence on using L'Hospital's rule, A_0 becomes

$$A_0 = N_2(0)/D_2'(0) \quad \textbf{(38)}$$

where,

$$N_2(0) = [\Psi_0 + p_{01}(\Psi_1 + p_{14}\Psi_4)(1 - p_{36}p_{63}) + p_{03}(\Psi_3 + p_{34}\Psi_4)]D_3 + \left[\Psi_2(1 - p_{36}p_{63}) + p_{23}^{(6)}(\Psi_3 + p_{34}\Psi_4)\right]D_4 \quad \textbf{(39)}$$

where,

$$D_3 = \left[1 - \left(p_{25} + p_{27}^{(6)}\right)\right](1 - p_{36}p_{63}) - p_{23}^{(6)}(p_{34}p_{47} + p_{36}p_{67})$$

$$D_4 = \left[p_{02} + p_{01}\left(p_{14}p_{47} + p_{17}^{(5)}\right)\right](1 - p_{36}p_{63}) + p_{03}(p_{34}p_{47} + p_{36}p_{67})$$

And

$$D_2'(0) = A\Psi_0 + p_{01}A\Psi_1 + B\Psi_2 + C\Psi_3 + D\Psi_4 + p_{25}Em_1 + F\Psi_6 + (E - p_{02}A)\Psi_7 \quad \textbf{(40)}$$

where,

$$A = p_{20}(1 - p_{36}p_{63}) + p_{23}^{(6)} p_{34}p_{40}$$
$$B = \left[p_{02} + p_{01}\left(p_{14}p_{47} + p_{17}^{(5)}\right)\right](1 - p_{36}p_{63}) + p_{03}(p_{34}p_{47} + p_{36}p_{67})$$
$$C = p_{03}p_{63}\left(p_{20} - p_{23}^{(6)} p_{40}\right)$$
$$D = p_{20}[p_{01}p_{14}(1 - p_{36}p_{63}) + p_{03}p_{34}]$$
$$E = [(1 - p_{01}p_{14}p_{40})(1 - p_{36}p_{63}) - p_{03}p_{34}p_{40}]$$
$$F = p_{03}p_{36}\left(p_{20} - p_{23}^{(6)} p_{34}p_{40}\right)$$

The expected up time of the system during $(0, t]$ is given by

$$\mu_{up}(t) = \int_0^t A_0(u)\,du$$

So that,

$$\mu_{up}^*(s) = A_0^*(s)/s. \quad \textbf{(41)}$$

Busy Period Analysis

Define $B_i(t)$ as the probability that the system having started from regenerative state $S_i \in E$ at time $t = 0$, is under repair at time t due to failure of the unit. Using the definition of $B_i(t)$ and probabilistic concepts, the recurrence relations among $B_i(t)$ where i = 0, 1, 2, 3, 4, 5, 7 can easily be developed.

Using the technique of L.T., the value of $B_i(t)$ in terms of their L.T. are as follows:

$$B_0^*(s) = N_3(s)/D_2(s) \quad \textbf{(42)}$$

where,

$$N_3(s) = \left\{q_{01}^*\left[Z_1^* + q_{14}^* Z_4^* + \left(q_{14}^* q_{47}^* + q_{17}^{(5)*}\right)Z_7^*\right](1 - q_{36}^* q_{63}^*) + q_{03}^*[q_{34}^* Z_4^* + q_{36}^* Z_6^* + (q_{34}^* q_{47}^* + q_{36}^* q_{67}^*)Z_7^*]\right\}D_1 + \left\{\left[Z_2^* + q_{25}^* Z_5^* + \left(q_{25}^* q_{57}^* + q_{27}^{(6)*}\right)Z_7^*\right](1 - q_{36}^* q_{63}^*) + q_{23}^{(6)*}[q_{34}^* Z_4^* + q_{36}^* Z_6^* + (q_{34}^* q_{47}^* + q_{36}^* q_{67}^*)Z_7^*]\right\}D_2 \quad \textbf{(43)}$$

In the steady state, the probability that the repairman will be busy is given by

$$B_0 = \lim_{t\to\infty} B_0(t) = \lim_{s\to 0} s\,B_0^*(s) = N_3(0)/D_2'(0) \quad \textbf{(44)}$$

also as $s \to 0$, $q_{ij}^*(s)/_{s=0} = q_{ij}^*(0) = p_{ij}$ and $\lim_{s\to 0} Z_i^*(s) = \int Z_i(t)dt = \Psi_i$

where,

$N_3(0) = \{p_{01}[\Psi_1 + p_{14}\Psi_4 + (p_{14}p_{47} + p_{17}^{(5)})\Psi_7](1 - p_{36}p_{63}) + p_{03}[p_{34}\Psi_4 + p_{36}\Psi_6 + (p_{34}p_{47} + p_{36}p_{67})\Psi_7]\}D_3 + \{[\Psi_2 + p_{25}m_1 + (p_{25} + p_{27}^{(6)})\Psi_7](1 - p_{36}p_{63}) + p_{23}^{(6)}[p_{34}\Psi_4 + p_{36}\Psi_6 + (p_{34}p_{47} + p_{36}p_{67})\Psi_7]\}D_4$ **(45)**

The expected busy period of the repairman during (0, t] is given by

$\mu_b(t) = \int_0^t B_0(u)\,du$ So that, $\mu_b^*(s) = B_0^*(s)/s.$ **(46)**

Expected Number of Visits

Let us define $V_i(t)$ as the expected number of visits by the repairman during the time interval $(0,t]$ when the system initially starts from regenerative state S_i. Using the definition of $V_i(t)$ and probabilistic concepts, the recurrence relations among $V_i(t)$ where i = 0, 1, 2, 3, 4, 5, 7 can easily be developed.

Using the technique of L.T., the value of $V_i(t)$ in terms of their L.T. are as follows:

$\tilde{V}_0(s) = N_4(s)/D_4(s)$ **(47)**

where,

$N_4(s) = [(\tilde{Q}_{01} + \tilde{Q}_{02} + \tilde{Q}_{03})(1 - \tilde{Q}_{36}\tilde{Q}_{63}) + \tilde{Q}_{03}(\tilde{Q}_{34} + \tilde{Q}_{36})]D_5 + [\tilde{Q}_{20}(1 - \tilde{Q}_{36}\tilde{Q}_{63}) + \tilde{Q}_{23}^{(6)}(\tilde{Q}_{34} + \tilde{Q}_{36})]D_6$ **(48)**

where,

$D_5 = [1 - \tilde{Q}_{72}(\tilde{Q}_{27}^{(6)} + \tilde{Q}_{25}\tilde{Q}_{57})](1 - \tilde{Q}_{36}\tilde{Q}_{63}) - \tilde{Q}_{23}^{(6)}\tilde{Q}_{72}(\tilde{Q}_{34}\tilde{Q}_{47} + \tilde{Q}_{36}\tilde{Q}_{67})$

$D_6 = [\tilde{Q}_{02} + \tilde{Q}_{01}\tilde{Q}_{72}(\tilde{Q}_{17}^{(5)} + \tilde{Q}_{14}\tilde{Q}_{47})](1 - \tilde{Q}_{36}\tilde{Q}_{63}) + \tilde{Q}_{03}\tilde{Q}_{72}(\tilde{Q}_{34}\tilde{Q}_{47} + \tilde{Q}_{36}\tilde{Q}_{67})$

$D_4(s)$ can be written on replacing q_{ij}^* by $\tilde{Q}_{ij}$ in $D_2(s)$.

In the steady state, the expected number of repairs per unit time is given by

$V_0 = \lim_{t\to\infty}\frac{V_0(t)}{t} = \lim_{s\to 0} s\,\tilde{V}_0(s) = N_4(0)/D_2'(0)$

And also as $s \to 0, q_{ij}^*(s)/_{s=0} = q_{ij}^*(0) = p_{ij}$ and $\lim_{s\to 0} Z_i^*(s) = \int Z_i(t)dt = \Psi_i$

where,

$N_4(0) = [(p_{01} + p_{02} + p_{03})(1 - p_{36}p_{63}) + p_{03}(p_{34} + p_{36})]D_3 + [p_{20}(1 - p_{36}p_{63}) + p_{23}^{(6)}(p_{34} + p_{36})]D_4$ **(49)**

Profit Function Analysis

Profit function P(t) can easily be obtained for the system model under study with the help of characteristics obtained earlier. The expected total profits incurred during $(0,t]$ are:

P(t) = Expected total revenue in (0, t]− Expected total expenditure in (0, t]

$= K_0\mu_{up}(t) - K_1\mu_b(t) - K_2V_0(t)$ **(50)**

where,

K_0 is revenue per unit up time.

K_1 is the cost per unit time for which repair man is busy in repair of the failed unit.

K_2 is per unit repair cost.

The expected total profits per unit time, in steady state, is

$P_1 = \lim_{t\to\infty}[P_1(t)/t] = \lim_{s\to 0} s^2 P_1^*(s)$

$P_2 = \lim_{t\to\infty}[P_2(t)/t] = \lim_{s\to 0} s^2 P_2^*(s)$

So that,

$P_1 = K_0A_0 - K_1B_0 - K_2V_0$ **(51)**

Particular Case

If the repair time distributions are taken as negative exponential i.e

$G_i(t) = 1 - e^{-\lambda_i t}$ where, $(i = 1,2)$

Then the changed transition probabilities and mean sojourn times are as follows:

$p_{14} = \frac{\lambda_1}{(\alpha_2+\lambda_1)}$ $p_{17}^{(5)} = \frac{\alpha_2}{(\alpha_2+\lambda_1)}$ $p_{20} = \frac{\lambda_2}{(\alpha_1+\alpha_3+\lambda_2)}$

$p_{25} = \frac{\alpha_1}{(\alpha_1+\alpha_3+\lambda_2)}$ $p_{23}^{(6)} = \frac{\alpha_3\lambda_2}{(\beta_1+\lambda_2)(\alpha_1+\alpha_3+\lambda_2)}$ $p_{27}^{(6)} = \frac{\alpha_3\beta_1}{(\beta_1+\lambda_2)(\alpha_1+\alpha_3+\lambda_2)}$

$p_{63} = \frac{\lambda_2}{(\beta_1+\lambda_2)}$ $p_{67} = \frac{\beta_1}{(\beta_1+\lambda_2)}$ $\Psi_1 = \frac{1}{(\alpha_2+\lambda_1)}$

$\Psi_2 = \frac{1}{(\alpha_1+\alpha_3+\lambda_2)}$ $\Psi_5 = \frac{1}{\lambda_1}$ $\Psi_6 = \frac{1}{(\beta_1+\lambda_2)}$

GRAPHICAL STUDY OF THE SYSTEM MODEL AND CONCLUSION

For more concrete study of system behavior, we plot MTSF and Profit function with respect to α_3 (rate of occurrence of bad weather conditions) for different values of β_1(rate of disappearance of bad weather conditions).

Behaviour of MTSF w.r.t. α_3 for different values of β_1

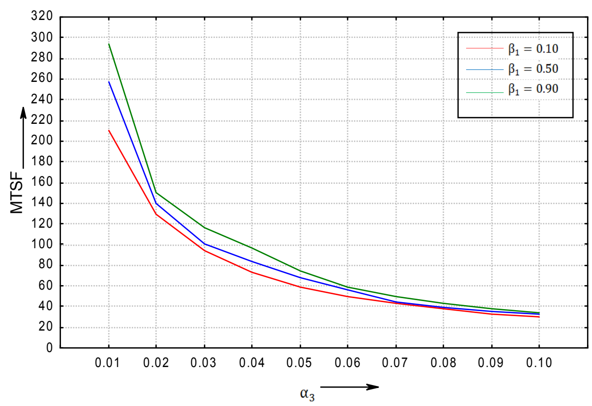

Fig.2

Behaviour of Profit Function w.r.t. α_3 for different values of β_1

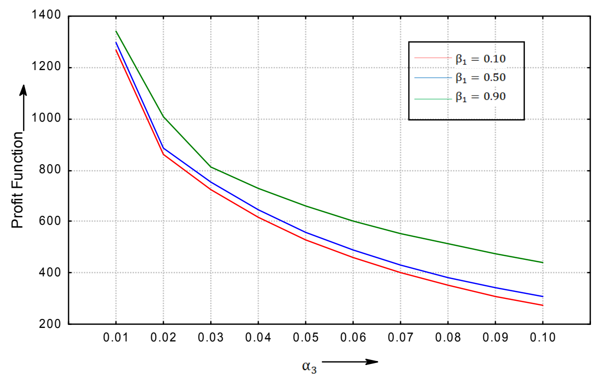

Fig.3

Fig. 2 shows the variations in MTSF in respect of α_3 for different values of β_1 as 0.10, 0.50 and 0.90 while the other parameters are fixed as $\lambda_1 = 0.07$, $\lambda_2 = 0.05$, $\alpha_1 = 0.05$, $\alpha_2 = 0.02$, $\beta_2 = 0.04$. It is observed from the graph that MTSF decreases with the increase in bad weather conditions rate α_3 and for higher values of β_1, the MTSF is higher i.e., the normal weather conditions resulting in longer lifetime of the system.

Fig. 3 represents the change in profit function w.r.t. α_3 for different values of β_1 as 0.10, 0.50 and 0.90 while the other parameters are fixed as $\lambda_1 = 0.07$, $\lambda_2 = 0.05$, $\alpha_1 = 0.05$, $\alpha_2 = 0.02$, $\beta_2 = 0.04$, $K_0 = 1000$, $K_1 = 300$, $K_2 = 250$. From the graph it is seen that profit function decrease with the increase in bad weather conditions rate α_3 and increase with the increase in β_1. Thus the better understanding of weather conditions results in better system performance.

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