CHAPTER-VIII

COMPARATIVE ANALYSIS OF THE STUDIED MODELS
Chapter-VIII

Comparative Analysis of the Studied Models

In the preceding chapters, various models have been discussed for one/two-unit cold standby sophisticated systems wherein unit(s) have two/three operational stages considering various different aspects including the concepts of warranty, inspection, minor/major faults, on-line/off-line repair and replacement. All the models studied in the thesis cannot be good in all the situations. Some of them may be better in some of the situations while others may be better in some other situations. To judge which of the models is better in what situation, the comparative study of the models discussed in the preceding chapters, taking two at a time, has been made in the present chapter on the basis of their profits through graphs. Various conclusions have been drawn about the models observing the trends of the graphs as well as the cut-off points.

Comparison between the Models Discussed in Chapter-III

In Chapter-III two models for a single unit sophisticated system under warranty having different operational modes/stages have been discussed. Comparative study of these models with respect to profits obtained, respectively, for the system user and the system provider, is made here for the particular case assuming all the general distributions as exponential as mentioned already in the concerned models. The numerical values assumed/given to various rates/costs have been mentioned along with the graphs.

Fig. 8.1 shows the behaviour of difference between the profits of the system user i.e. \( P_{12} - P_{11} \), with respect to revenue per unit time \( (C_0) \) for different values of improvement rate \( (\eta_1) \).

It can be concluded from the graph that

(i) The difference \( P_{12} - P_{11} \) increases as the revenue per unit time increases. Also, the difference becomes higher for higher values of improvement rate \( (\eta_1) \).
(ii) For \( \eta_1 = 2 \), \( P_{12} - P_{11} > 0 \) or \(< 0 \) according as \( C_0 > 0 \) = or \(< 390.979 \). Hence Model-II is better or equally good or worse than the Model-I for the system user if \( C_0 > 0 \) = or \(< 390.979 \).

(iii) For \( \eta_1 = 3 \), \( P_{12} - P_{11} > 0 \) or \(< 0 \) according as \( C_0 > 0 \) = or \(< 356.2714 \). Hence Model-II is better or equally good or worse than the Model-I for the system user if \( C_0 > 0 \) = or \(< 356.2714 \).

(iv) For \( \eta_1 = 4 \), \( P_{12} - P_{11} > 0 \) or \(< 0 \) according as \( C_0 > 0 \) = or \(< 314.2009 \). Hence Model-II is better or equally good or worse than the Model-I for the system user if \( C_0 > 0 \) = or \(< 314.2009 \).

**Fig. 8.2** depicts the behaviour of difference between the profits of the system provider i.e. \( P_{22} - P_{21} \) with respect to cost per visit (\( C_7 \)) of the repairman for different values of deterioration rate (\( \eta_2 \)).

It can be seen from the graph that:

(i) The difference \( P_{22} - P_{21} \) decreases as \( C_7 \) increases. Also, the difference becomes lower for higher values of deterioration rate (\( \eta_2 \)).
DIFFERENCE IN PROFITS OF SYSTEM PROVIDER ($P_{22}-P_{21}$) VERSUS COST PER VISIT ($C_7$) FOR DIFFERENT VALUES OF DETERIORATION RATE ($\eta_2$)

**Fig. 8.2**

(ii) For $\eta_2 = 2.8$, $P_{22}-P_{21} > or = or < 0$ according as $C_7 < or = or > 484.7725$.

Hence Model-II is better or equally good or worse than the Model-I for the system provider if $C_7 < or = or > 484.7725$.

(iii) For $\eta_2 = 2.9$, $P_{22}-P_{21} > or = or < 0$ according as $C_7 < or = or > 446.2985$.

Hence Model-II is better or equally good or worse than the Model-I for the system provider if $C_7 < or = or > 446.2985$.

(iv) For $\eta_2 = 4$, $P_{22}-P_{21} > or = or < 0$ according as $C_7 < or = or > 413.0571$.

Hence Model-II is better or equally good or worse than the Model-I for the system provider if $C_7 < or = or > 413.0571$

**Comparison between the Models Discussed in Chapter-IV**

Two models for a single unit sophisticated system under warranty having three operational stages with the possibility of occurrence of minor/major faults have been discussed in the Chapter-IV. Comparative study of the models is done on the basis of
profits incurred to the system for the particular cases mentioned in the concerned models. Assumed numerical values have been shown along with the graphs.

**Fig 8.3** shows the behaviour of difference between the profits of the system user i.e. $P_{12} - P_{11}$ with respect to revenue per unit time ($C_o$) for different values of deterioration rate ($\eta_2$).

![Graph](image)

**Fig. 8.3**

It can be seen from the graph that

(i) The difference $P_{12} - P_{11}$ increases with the increase in the values of $C_o$. Also, the difference becomes higher for higher values of $\eta_2$.

(ii) For $\eta_2 = 1$, $P_{12} - P_{11} > = or < 0$ according as $C_o > = or < 532.1186$. Hence Model-II is better or equally good or worse than the Model-I for the system user whenever $C_o > = or < 532.1186$.

(iii) For $\eta_2 = 1.5$, $P_{12} - P_{11} > = or < 0$ according as $C_o > = or < 514.0539$. Hence Model-II is better or equally good or worse than the Model-I for the system user whenever $C_o > = or < 514.0539$. 
For $\eta_2 = 2$, $P_{12} - P_{11} > 0$ according a $C_0 > 0$ or $< 504.1694$. Hence Model-II is better or equally good or worse than the Model-I for the system user whenever $C_0 > 0 = 0 < 504.1694$

**Fig. 8.4** shows the behaviour of difference between the profits of the system user i.e. $P_{12} - P_{11}$ with respect to failure rate ($\lambda_3$) for different values of deterioration rate ($\eta_2$).

**DIFFERENCE OF PROFITS OF SYSTEM USER ($P_{12} - P_{11}$) VERSUS FAILURE RATE ($\lambda_3$) FOR DIFFERENT VALUES OF DETERIORATION RATE ($\eta_2$)**

It can be observed from the graph that:

(i) The difference $P_{12} - P_{11}$ increases with the increase in the values of $\lambda_3$. Also, the difference becomes higher for lower values of $\eta_2$.

(ii) For $\eta_2 = 0.35$, $P_{12} - P_{11} > 0 = 0 < 0$ according as $\lambda_3 > 0 = 0 < 1.9653$. Hence Model-II is better or equally good or worse than the Model-I for the system user if $C_0 > 0 = 0 < 1.9653$. 

**Fig. 8.4**

![Graph showing the relationship between difference in profits and failure rate for different deterioration rates.](image)
(iii) For $\eta_2 = 0.37$, $P_{12} - P_{11} > \text{or} = \text{or} < 0$ according as $\lambda_3 > \text{or} = \text{or} < 2.3434$.
Hence Model-II is better or equally good or worse than the Model-I for the system user if $\lambda_3 > \text{or} = \text{or} < 2.3434$.

(iv) For $\eta_2 = 0.39$, $P_{12} - P_{11} > \text{or} = \text{or} < 0$ according as $\lambda_3 > \text{or} = \text{or} < 2.8237$.
Hence Model-II is better or equally good or worse than the Model-I for the system user if $\lambda_3 > \text{or} = \text{or} < 2.8237$.

**Fig. 8.5** depicts the behaviour of difference between the profits of the system provider i.e. $P_{22}-P_{21}$ with respect to failure rate ($\lambda_2$) during Stage-II for different values of improvement rate ($\eta_1$).

It can be seen from the graph that:

(i) The difference $P_{22}-P_{21}$ decreases as $\lambda_2$ increases. Also, the difference becomes higher for higher values of $\eta_1$.

(ii) For $\eta_1 = 3$, $P_{22}-P_{21} > \text{or} = \text{or} < 0$ according as $\lambda_2 < \text{or} = \text{or} > 0.3789$.
Hence Model-II is better or equally good or worse than the Model-I for the system provider if $\lambda_2 < \text{or} = \text{or} > 0.3789$. 
(iii) For $\eta_1 = 3.5$, $P_{22} - P_{21} >$ or $= or < 0$ according as $\lambda_2 < $ or $= or > 0.5805$.

Hence Model-II is better or equally good or worse than the Model-I for the system provider if $\lambda_2 < $ or $= or > 0.5805$.

(iv) For $\eta_1 = 4$, $P_{22} - P_{21} >$ or $= or < 0$ according as $\lambda_2 < $ or $= or > 0.7826$.

Hence Model-II is better or equally good or worse than the Model-I for the system provider if $\lambda_2 < $ or $= or > 0.7826$.

**Comparison between the Models Discussed in Chapter-V**

Two models for a single unit sophisticated system under warranty having three stages of operation with two types of service facility have been discussed in the Chapter-V.

**Fig. 8.6.** depicts the behaviour of difference between the profits of the system user i.e. $P_{12}-P_{11}$ with respect to failure rate ($\lambda_2$) during Stage-II for different values of improvement rate ($\eta_1$).

![Graph of Difference in Profits of System User](image-url)
It can be seen from the graph that:

(i) The difference $P_{12} - P_{11}$ increases as $\lambda_2$ increases. Also, the difference becomes higher for higher values of $\eta_1$.

(ii) For $\eta_1 = 3$, $P_{12} - P_{11} > 0$ or $\leq 0$ according as $\lambda_2 > 0$ or $\leq 0.6578$.
Hence Model-II is better or equally good or worse than the Model-I for the system user if $\lambda_2 > 0$ or $\leq 0.6578$.

(iii) For $\eta_1 = 3.5$, $P_{12} - P_{11} > 0$ or $\leq 0$ according as $\lambda_2 > 0$ or $\leq 0.5591$.
Hence Model-II is better or equally good or worse than the Model-I for the system user if $\lambda_2 > 0$ or $\leq 0.5591$.

(iv) For $\eta_1 = 4$, $P_{12} - P_{11} > 0$ or $\leq 0$ according as $\lambda_2 > 0$ or $\leq 0.4745$.
Hence Model-II is better or equally good or worse than the Model-I for the system user if $\lambda_2 > 0$ or $\leq 0.4745$.

Fig. 8.7 shows the behaviour of difference between the profits of the system user i.e. $P_{12} - P_{11}$ with respect to revenue per unit time ($C_0$) for different values of improvement rate ($\eta_1$).
It can be observed from the graph that:

(i) the difference $P_{12} - P_{11}$ decreases as the revenue per unit time increases. Also, the difference becomes higher for higher values of $\eta_1$.

(ii) for $\eta_1 = 1$, $P_{12} - P_{11}$ is $=$ or $< 0$ according as $C_0 < = or > 277.1029$. Hence Model-II is better or equally good or worse than the Model-I for the system user if $C_0 < = or > 277.1029$.

(iii) for $\eta_1 = 1.5$, $P_{12} - P_{11}$ is $=$ or $< 0$ according as $C_0 < = or > 281.0811$. Hence Model-II is better or equally good or worse than the Model-I for the system user if $C_0 < = or > 281.0811$.

(iv) for $\eta_1 = 2$, $P_{12} - P_{11}$ is $=$ or $< 0$ according as $C_0 < = or > 283.9595$. Hence Model-II is better or equally good or worse than the Model-I for the system user if $C_0 < = or > 283.9595$.

Fig. 8.8. shows the behaviour of difference between the profits of the system provider i.e. $P_{22} - P_{21}$ with respect to failure rate ($\lambda_2$) during Stage-II for different values of improvement rate ($\eta_1$).

**Fig. 8.8**
It can be concluded from the graph that

(i) the difference $P_{22} - P_{21}$ decreases as $\lambda_2$ increases. Also, the difference becomes higher for higher values of $\eta_1$.

(ii) for $\eta_1 = 6$, $P_{22} - P_{21} > 0$ or $= 0$ according as $\lambda_2 < 0$ or $= 0$. Hence Model-II is better or equally good or worse than Model-I for the system provider if $\lambda_2 < 0$ or $= 0$.

(iii) for $\eta_1 = 7$, $P_{22} - P_{21} > 0$ or $= 0$ according as $\lambda_2 < 0$ or $= 0$. Hence Model-II is better or equally good or worse than the Model-I for the system provider if $\lambda_2 < 0$ or $= 0$.

(iv) for $\eta_1 = 8$, $P_{22} - P_{21} > 0$ or $= 0$ according as $\lambda_2 < 0$ or $= 0$. Hence Model-II is better or equally good or worse than Model-I for the system provider if $\lambda_2 < 0$ or $= 0$.

Fig. 8.9 shows the behaviour of difference between the profits of the system provider i.e. $P_{22} - P_{21}$ with respect to fixed profit (SP-CP) for different values of failure rate ($\lambda_2$) during Stage-II.
It can be seen from the graph that:

(i) the difference $P_{22} - P_{21}$ decreases as $SP - CP$ increases. Also, the difference becomes lower for higher values of $\lambda_2$.

(ii) for $\lambda_2 = 0.05$, $P_{22} - P_{21} > 0$ or $= 0$ or $< 0$ according as $SP - CP < 0 = or > 419.7905$. Hence Model-II is better or equally good or worse than Model-I for the system provider if $SP - CP < 0 = or > 419.7905$.

(iii) for $\lambda_2 = 0.08$, $P_{22} - P_{21} > 0$ or $= 0$ or $< 0$ according as $SP - CP < 0 = or > 321.5096$. Hence Model-II is better or equally good or worse than the Model-I for the system provider if $SP - CP < 0 = or > 321.5096$.

(iv) for $\lambda_2 = 0.11$, $P_{22} - P_{21} > 0$ or $= 0$ or $< 0$ according as $SP - CP < 0 = or > 278.1914$. Hence Model-II is better or equally good or worse than Model-I for the system provider if $SP - CP < 0 = or > 278.1914$.

Comparison between the Models Discussed in Chapter-VI and Chapter-VII

Models discussed in Chapter-VI and Chapter-VII deals with two-unit cold standby sophisticated system where in units have three stages of operation. In the model given in Chapter-VI repair on FCFS pattern is considered whereas in the model given in Chapter-VII priority for operation as well as repair to a unit at second stage has been taken into consideration. Comparative study of the models is done on the basis of profit incurred to the system for the particular cases mentioned in the concerned models. Assumed numerical values have been shown along with the graphs. Graphs have been plotted for making comparison between the Models of the Chapter-VI and Chapter-VII by varying rates /costs.

Fig. 8.10 depicts the behaviour of difference between the profits i.e. $P_7 - P_6$ with respect to failure rate ($\lambda_2$) of the unit during Stage-II for different values deterioration rate ($\eta_2$).
DIFFERENCE IN PROFITS ($P_7-P_6$) VERSUS FAILURE RATE ($\lambda_2$) FOR DIFFERENT VALUES OF DETERIORATION RATE ($\eta_2$)

It can be observed from the graph that:

(i) the difference $P_7-P_6$ decreases with the increase in the values of $\lambda_2$. Also, the difference becomes lower for higher values of $\eta_2$.

(ii) for $\eta_2 = 0.5$, $P_7-P_6 > 0$ or $< 0$ according as $\lambda_2 < 0 = 0 > 0.2588$. Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $\lambda_2 < 0 = 0 > 0.2588$.

(iii) for $\eta_2 = 0.51$, $P_7-P_6 > 0$ or $< 0$ according as $\lambda_2 < 0 = 0 > 0.2018$. Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $\lambda_2 < 0 = 0 > 0.2018$.

(iv) for $\eta_2 = 0.52$, $P_7-P_6 > 0$ or $< 0$ according as $\lambda_2 < 0 = 0 > 0.1494$. Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $\lambda_2 < 0 = 0 > 0.1494$.

Fig. 8.11 reveals the behaviour of difference between the profits i.e. $P_7-P_6$ with respect to revenue per unit up time ($C_0$) for different values of improvement rate ($\eta_1$).
It can be concluded from the graph that:

(i) the difference $P_7 - P_6$ increases as $C_0$ increases. Also, the difference becomes lower for higher values of $\eta_1$.

(ii) for $\eta_1 = 0.8$, $P_7 - P_6 > 0$ or $= 0$ according as $C_0 > 0$ or $= 0 < 726.8788$. Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $C_0 > 0$ or $= 0 < 726.8788$.

(iii) for $\eta_1 = 0.9$, $P_7 - P_6 > 0$ or $< 0$ according as $C_0 > 0$ or $< 773.7183$. Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $C_0 > 0$ or $< 773.7183$.

(iv) for $\eta_1 = 1$, $P_7 - P_6 > 0$ or $< 0$ according as $C_0 > 0$ or $< 822.7881$.

Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $C_0 > 0$ or $< 822.7881$.

Fig. 8.12 depicts the behaviour of difference between the profits i.e. $P_7 - P_6$ with respect to failure rate ($\lambda_1$) during Stage-I of the unit for different values of improvement rate ($\eta_1$).
It can be observed from the graph that:

(i) the difference $P_7 - P_6$ increases with the increase in the values of $\lambda_1$. Also, the difference becomes lower for higher values of $\eta_1$.

(ii) for $\eta_1 = 2$, $P_7 - P_6 > or = or < 0$ according as $\lambda_1 > or = or < 1.0843$. Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $\lambda_1 > or = or < 1.0843$.

(iii) for $\eta_1 = 2.5$, $P_7 - P_6 > or = or < 0$ according as $\lambda_1 > or = or < 1.2250$. Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $\lambda_1 > or = or < 1.2250$.

(iv) for $\eta_1 = 3$, $P_7 - P_6 > or = or < 0$ according as $\lambda_1 > or = or < 1.3466$. Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $\lambda_1 > or = or < 1.3466$.

Fig. 8.13 depicts the behaviour of difference between the profits i.e. $P_7 - P_6$ with respect to cost ($C_3$) for different values of deterioration rate ($\eta_2$).
It can be concluded from the graph that

(i) the difference $P_7 - P_6$ increases with the increase in the values of $C_3$

Also, the difference becomes lower for higher values of $\eta_2$.

(ii) for $\eta_2 = 0.06$, $P_7 - P_6 > \text{or} = \text{or} < 0$ according as $C_3 > \text{or} = \text{or} < 329.3925$.

Hence Model of Chapter-VII is better or equally good or worse than the Model of Chapter-VI whenever $C_3 > \text{or} = \text{or} < 329.3925$.

(iii) for $\eta_2 = 0.07$, $P_7 - P_6 > \text{or} = \text{or} < 0$ according as $C_3 > \text{or} = \text{or} < 411.8087$.

Hence Model of Chapter VII is better or equally good or worse than the Model of Chapter VI whenever $C_3 > \text{or} = \text{or} < 411.8087$.

(iv) for $\eta_2 = 0.08$, $P_7 - P_6 > \text{or} = \text{or} < 0$ according as $C_3 > \text{or} = \text{or} < 457.3104$.

Hence Model of Chapter VII is better or equally good or worse than the Model of Chapter VI whenever $C_3 > \text{or} = \text{or} < 457.3104$.