Chapter 2
REVIEW OF LITERATURE

2.0 LITERATURE SURVEY

This chapter deals with the survey of literature related to the advanced studies and work carried out by various researchers in the areas of replacement models, Markov chains, inflation and forecasting.

2.1 Fundamentals Of Replacement Modeling, Markov Process, Inflation, And Forecasting Techniques

The replacement problems are concerned with the situations that arise when the efficiency of items decreases, failure or breakdown occurs. Sharma(2003)[1], Kanti Swarup(1992)[2] and Hiller et al(20010[3] have listed out replacement policies for items that deteriorate gradually when money value does not change with time and when money value does change with time. They also listed out Replacement model for items that fails suddenly and completely.

Markov processes are a special class of mathematical models that are often applicable to decision problems associated with dynamic systems. The general theory concerning Markov Process was developed by Kolomogorov and Feller.

Indeed there is a plethora of definitions on inflation in the literature. The layman, however, understands the phenomenon of sizeable and rapid increase in general price level of products and services in a particular economic domain as Inflation. According to Irwing Fisher “Inflation occurs when the supply of money actively
bidding goods and services increases faster than the available supply of goods. Inflation leads to Inflationary spiral. When prices rise, workers demand higher wages. Higher wages leads to higher costs. Higher costs lead to leads to higher prices.

2.2 STUDY OF REPLACEMENT MODELS THAT CONSIDERS REPAIRS AND INFLUENCE OF ECONOMIC VARIABLES SUCH AS INFLATION, MONEY VALUE ETC. ON REPLACEMENT DECISIONS

Several researchers investigated the optimal age replacement models to tailor the models for different real time situations to reduce the cost.

Chein et al (2007) [4] presented an optimal age-replacement policy with minimal repair based on cumulative repair cost limit. In their study the complete repair cost data was considered with an aim to evaluate whether to repair the unit or to replace. This model considers the costs of equipment downtime and storing spare parts or items.

Nuthall et al (1983)[5] studied the impact of inflation on tractor replacement costs along with the impact of some other parameters viz. financing method and increased or decreased hours of use.

Thomas Archibald et al (1996)[7] proposed Modified Block-Replacement Policy (MBRP) of BERG & Epston (1976) in two ways, considering discrete time framework for multi-component systems. Both the ways increase the practical value of MBRP. In MBRP, the failed components are replaced immediately and preventive maintenance takes place at regular intervals.
Isha Bagai et al (1994)[8] studied improvement and deterioration in performance for a repairable system with minimal repairs under non-homogeneous Poisson process. This study also discussed the optimal age replacement policy in which items are replaced on failure or at predetermined time.


Nadamuni Reddy and Uma Sankar (1997)[25] have developed replacement model considering combined influence of assumed inflation and cost of money. In that model they have considered real increase in value of money by considering Fisherman’s relation and replacement age is computed as the period where weighted annual real cost becomes minimum.

2.3 PREDICTION OF INFLATION USING FORECASTING TECHNIQUES

Michael Berlemann (2002)[16] in his discussion paper discussed the need for forecasting of inflation, and distinguished two conventional - Econometric and Expectations – approaches that are used for predicting the inflation. He attempted to forecast inflation via electronic market. Electronic market that was considered is a virtual market organized on internet and is based on the real-money transactions. The forecast results obtained from the prototype (electronic) market ascertained that electronic market instrument is one of the promising forecasting devices.
Ard den Reijer et al (2004)[20] developed two forecasting models in their study to forecast inflation for Netherlands and the euro area. The yearly change in Harmonized Index of consumer prices (HICP) was considered as inflation.

Naveen Kilari and Nadhamuni Reddy C (2009)[23] discussed the results of applying Time-series and Causal forecasting techniques to the forecasting of inflation for Computer and Computer Based System in India. In particular they developed a regression forecasting model with trigonometric function to accommodate the cyclical fluctuations of real time inflation pattern. The inflation (based on WPI) for Computer and Computer based system over a period of time is studied, forecasted and compared with actual values for the known periods by employing various forecasting techniques to identify the underlying model that best fits the time series data. Also an attempt is made to predict inflation for Computer and Computer based system for the forthcoming time periods by the developed Regression model with trigonometric function, which yielded relatively minimal errors.

2.4: STUDY OF HIGHER ORDER MARKOV CHAIN AND ITS APPLICATIONS

Bruce Craig et al (1997)[27] summarized the appropriate techniques to estimate the transition matrix for discrete-time homogeneous Markov chains in various combinations of observation intervals and the cycle length.

David Epstein et al (2005)[28] proposed the technique necessary to estimate and interpret higher order Markov models. They used
higher order Markov models in political science to study the
democratic transitions and observed that three state model with an
intermediary ‘partial democracy’ state has better explanatory power
than the two state model.

Zhenqing Li et al (2006)[29] explored a mechanism for
calculating high-order transition probability matrix of finite Markov
chain. By the application of theory and methods of stochastic process
and computer algebra the given problem is converted into a matrix
equation in order to arrive at the solution. Also they tried to solve the
higher order Transition Probability Matrix of the Markov Chain using
computer-aided program.

Sutawanir et al (2008)[30] studied the spectral representation
of transition probabilities. As the calculation of transition probabilities
of Markov Process with higher number of states is much time
consuming one, they applied spectral decomposition technique for
computing transition probabilities for a multi state Markov process.

Liana Cazacioc et al (1999)[31] applied Markov chain models to
forecast the weather states at some future time using information
given by the current state. They have studied applications of Markov
chain model considering two states for daily precipitation in summer
and winter seasons. They computed and evaluated the sets of
transitional probabilities for 1st, 2nd and 3rd order Markov chains.

Lawrence Saul et al (1999)[32] and Andre Berchtold et al
(2002)[33] discussed mixed memory Markov models and Mixture
transition distribution models respectively for higher order Markov models.

Avik Ghosh et al (2010)[34] applied higher order two-state Markov chain Models to simulate the rainfall trends over Gangetic West Bengal in India during monsoon season. They observed that the climatological probabilities predicted using high order Markov chains are almost similar to the values predicted using first order Markov chain.

Stelios et al (1980)[35] applied Markov process for modeling manpower supply of around 1000 engineers in a large chemical company. In their work they developed Markov chain based manpower model to predict future organizational manpower loss and gain position wise distribution for different hiring quotas.

Jainming et al (2003)[36] used Markov Chain model in their novel networked traffic parameter forecasting method. They simplified the traffic network in Beijing city by System Clustering analysis and used Markov chain model to predict the traffic parameter.

Ying-Zi Li et al (2009)[37] applied Markov chain based forecasting for Power generation of Grid connected Photovoltaic system. Forecast results showed that Markov chain based forecast of power generation is accurate and has practical value. Moreover, they could not see much significance of forecast for power generation when the order of Markov chain is too high.

Shamsad et al (2005)[38] used first and second order transition probability matrices of Markov chain to predict the time series of wind
speed values. In their work they used hourly wind speed time series data of two stations in Malaysia for stochastic generation of wind speed data. A satisfactory relation was found between the actual and the generated wind speed time series data. A second order Markov model has shown a slight improvement in the wind speed behavior.

2.5 Block Replacement Modeling Under The Influence Of Inflation Using Higher Order Markov Process

Until now, the use of Markov models in replacement decisions can be hardly found. Whatever available is at nascent stage with predominantly assumed data. Researchers started considering macro economic variables in replacement theory recently.

Nadhamuni Reddy and Uma Sankar (1997) [25] developed group replacement model for a group of pressure gauges in a filling plant. The model has used the concept of First order Markov models for computing the transition probabilities for different states at various time periods. The replacement decision is carried out based on minimum average cost using mostly hypothetical data.

In the present research work the author has applied Markov models to a subject area of particular interest: Replacement decision in Computer and Computer based system with real time data. The study considered four different states (working, minor repair, major repair and break-down) in block replacement policy and replacement decision is made based on minimum average annual cost.

Conventional models are available to evaluate different replacement strategies for a combination of similar machine tools of
different ages considering and without considering money value. Here net present value criterion based on nominal interest rates does not reflect the real increase in the value of money.

In the present work, the author developed replacement model considering combined influence of forecasted inflation obtained from real time data for computer and computer based system and cost of money. In this model they have considered real increase in value of money by considering Fisherman’s relation.

Moreover, as changes in economic conditions are gradual and won’t be sudden in stable economies, it is thought that maximum weightage maybe given to the most recent data and less weightage may be given to the old data and when trends are determined using the developed model, they will be reliable. Hence the model is intensified further by using “Weighted Moving Transition Probabilities” (WMTP) technique and the decision is derived. WMTP technique, a parsimonious model that approximates the higher order Markov chain is introduced to consider the spread of sizeable data instead of single period’s past data.

2.6 BUSINESS PROCESS REENGINEERING (BPR)

Peter O’Neill et al (1999)[43] and Bernardo (2002)[44] discussed the Business Process Reengineering (BPR) and reviewed the literature related to the BPR. They compiled the definitions of and various perceptions about BPR; and tried to demystify the confusion on the concept of BPR. They also discussed the BPR tools and techniques, distinguished BPR against Total Quality Management (TQM). They also highlighted the role of Information Technology (IT) in BPR.
In the current study the author attempted to reengineer the computer hardware networking process by using Thin-client technology to reduce the cost of hardware and maintenance. The developed block replacement model using higher order Markov chain is extended to accommodate the reengineering cost. Also a cost analysis is made to evaluate the block replacement model with reengineering and the best block replacement strategy is arrived.

**Summary of past research:** The summary of the past research is shown in the Table 2.1.

<table>
<thead>
<tr>
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<th>Contribution</th>
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Table 2.1: Summary of the past research
**Research gaps:** Until now, the use of Markov models in replacement decisions can be hardly found. Whatever available is at nascent stage that to limited to the first order Markov chain with predominantly assumed data. There is no much focus on higher order Markov Chain approach.

Though the models are available for group replacement strategies, there can be hardly found the models for block replacement policies.

In the replacement models explored so far, only single repairable state is considered. But in practicality, multi repairable states of different magnitude exist. Hence in the present study four different states (working, minor repair, major repair and break-down) are considered for block replacement policy.

Conventional models are available to evaluate different replacement strategies for a combination of similar machine tools of different ages considering and without considering money value. Here net present value criterion based on nominal interest rates does not reflect the real increase in the value of money. In this study the author has considered real increase in value of money by considering Fisherman’s relation.