

**University of Sri Jayewardenepura
Faculty of Graduate Studies.**



**Identification of Main Factors Affecting
Production of the
National Paper Company.**

**This dissertation is submitted by
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As a partial fulfillment of the requirements for the
M.Sc Degree in Statistics.**

Approval

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DECLARATION

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ABSTRACT

This study concentrates on the production loss and quality of the paper produced by National Paper Company in Sri Lanka. It has two mills that are located at Embilipitiya and Valachchenai. Most of the products in the two mills are different and each product is produced as a batch, according to their stock level. Both mills produce various grades of paper (offset, white writing, printing, duplicating, bank & bond etc.) Different raw materials (long fibre, sort fibre, broke, waste paper etc.) mixture is used to produce different grades of paper and online quality measurements (weight, thickness, tensile, strength, etc.) are recorded to check the quality of each grade of paper.

The first chapter describes the background information about the paper production, variables of interest, objectives and Statistical technique required for this study.

The second chapter contains statistical analysis with related theories. Using the Analysis of Variance techniques we found that, mean loss rates are same for other than the duplicating grade paper and which has the greater mean loss rate compare to other grade of papers.

Multiple regression analysis was done to find the significant factors for the amount of loss of the offset paper. According to this analysis, amount of loss increases with amount of raw materials (amount of broke and amount of long fibre) increase. Using the loss function (regression equation of amount of loss on amount of long fibre and amount of broke), we derived a linear programming model, to find a best mixture that minimizes the value of the offset grade paper. This was solved by a computer program, and we found a raw materials ratio, (Broke:Sort fibre:Long fibre) 34:247:12 which minimizes the value of the offset grade paper.

Univariate mean comparison was used to compare the mean loss rates on the duplicating grade paper in two mills. It indicates mean loss rates of duplicating grade paper is same in the two mills.

Finally, comparison of multivariate means was used to compare the quality of duplicating grade paper in two mills. We found the quality of duplicating grade paper is different in the two mills. Thickness and tensile of duplicating grade paper is higher for Embilipitiya product.

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Chapter 1.

Introduction.

Introduction.

1 .1 Background information.

The National Paper Company has been involved in the production of various grades of paper since late 1950's. It is a government organisation which has two mills, located at Embilipitiya and Valachchenai.

In the early days, locally produced raw materials (for example a type of fibre extract from the local wood) were used for the production. But later, the company started using imported raw material because they were cheaper than local raw materials. Use of imported raw materials also stopped the pollution occurred in preparation of some local raw materials. In addition to imported raw materials, locally available waste paper is also used as a raw material.

Most of the products in the two mills are different and each product is produced as a batch according to their stock level. Different raw materials mixture is used to produce different grades of paper and online quality measurements are recorded to check the quality of each grade paper. Embilipitiya mill produces five grades of paper namely Offset, White writing, Printing, Duplicating, and Bank & Bond while the Valachchenai mill produces Cartridge, Mainfold, Duplicating, and Wrapper.

1.2 Data.

This study is carried out using the secondary data obtained from publications, monthly production reports, quality reports and the cost statements of the National Paper Company. Data on the following variables are recorded.

1.2.1 Loss Rate (per ton).

Production loss of each grade of paper is recorded for every batch.

Loss = total weight of input raw materials – weight of finish production; measured in tons.

Loss rate = loss/total weight of input

1.2.2 Amount of raw materials.

1). Amount of raw materials in tons.

- a) Broke (damage paper in the production)
- b) Sort Fibre (an imported raw material)
- c) Long Fibre (an imported raw material)
- d) Cheme Thermo Mechanical Pulp (CTMP) (an imported raw material)
- e) Black and White News Print (news paper without ink)
- f) Waste Paper.

2) Amount of additives (raw materials related to the quality of the paper) in Kg.

- a) Alum (a chemical used for strength & filling)
- b) Rosin (a chemical used for ink resistance)
- c) Clay (a chemical used for smoothing & filling)

1.2.3 Quality Measurements.

- 1). Weight of the paper (gm^{-2})
- 2). Thickness of the paper (mm)
- 3). Burst Strength of the paper (Nmg^{-1})
- 4). Tear indexes ($\text{mNm}^2\text{g}^{-1}$)
- 5). Tensile strength (Nmg^{-1})
- 6). Ink resistance (sizing) of the paper (s^{-1})

1.3 Objectives.

The objectives of this study are

- a) to compare the means of loss rates of different grades of paper,
- b) to identify the factors those are significantly related with the loss,
- c) to compare the mean losses in two mills,
- d) to examine whether the qualities of paper produced by the two mills are same,
- e) to identify the factors, which are possibly related with the quality of paper.

1.4 Methods used in the study.

The following statistical techniques are used in the study.

1.4.1 Analysis of Variance (one way with unequal number of replications).

A one way analysis of variance with unequal number of replications is done to check the equality of mean losses of different grades of paper. Here, the loss rate is considered as the response variable. The grade of paper is taken as a factor with five levels (five grades). In order to use the analysis of variance techniques we have to check whether each response variable follows a normal distribution with constant variance. This is usually done with the residuals.

Kolmogrov-Smirnov test is used to check the normality of the residuals and Bartlett test [3] is used to check the equality of the variances of residuals at different levels of the factors.

1.4.2 Multiple Regression Model.

Multiple linear regression models are used to identify factors that are related with the loss. Amount of loss is considered as the response variable. It is suspected that the loss depends on the amount of raw material. Therefore, the amounts of raw materials are used as the explanatory variables in the regression. In order to use the regression, response variable should follow the normal distribution with constant variance. This is usually done with residuals.

The selling price of paper could be reduced if the production cost is reduced. Therefore, if the regression is significant we will try to find out the best proportion of raw materials, which will lead to the minimum loss and thereby minimize the cost.

1.4.3 t test - Comparison of two univariate means based on independent samples.

Both mills are producing a common grade paper namely duplicating paper. An independent sample t-test is done to compare the mean loss rates of duplicating paper in the two mills. Kolmogrov-Smirnov test and F test are used to check the normality and equality of the variances of loss rates in the two mills.

1.4.4 Hotelling's T^2 Test - Comparison of multivariate means based on independent samples.

An independent sample Hotelling's T^2 test is done to compare the quality of paper in the two mills. Both mills produce a common grade (duplicating) paper and check the quality of the paper. In our analysis, quality measurements are considered as multivariate

1.4.5 Multivariate Multiple Regression Analysis.

Multivariate multiple regression analysis is done to identify the factors that are possibly related with the quality of paper. Here, quality measurements are taken as multivariate response variables and amounts of raw materials per ton are taken as explanatory variables.

1.5 Computer Packages used for the study.

Statistical Packages MINITAB and STATISTICA were used for analysis.

Chapter 2.
Statistical Analysis.