

# Statistical modelling: practical 2

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## 1 Simple linear regression

1. CONSIDER THE data in table 1 for ice cream sales at Luigi Minchella's ice cream parlour.

- Perform a linear regression of  $y$  on  $x$ . Should temperature be included in the model?
- Calculate the sample correlation coefficient  $r$ . Perform a hypothesis test, where  $H_0 : \rho = 0$  and  $H_1 : \rho \neq 0$ .<sup>1</sup> Compare this  $p$ -value to the  $p$ -value for testing if  $\beta_1 = 0$ .
- Construct a graph of the data. Add a dashed red line indicating the line of best fit.
- Using the text function, add the text  $r = 0.983$  to your plot.
- Plot the standardised residuals against the fitted values. Does the graph look random?
- Construct a q-q plot of the standardised residuals.

<sup>1</sup> See section 2.5 in your notes.

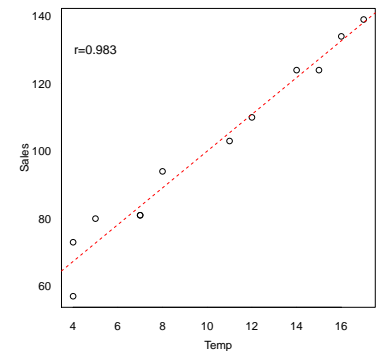


Figure 1: Scatterplot with the earnings data. Also shows the line of best fit (question 1c).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$x, ^\circ\text{C}$	4	4	7	8	12	15	16	17	14	11	7	5
$y, \text{£000's}$	73	57	81	94	110	124	134	139	124	103	81	80

Table 1: Monthly sales data from Luigi Minchella's ice cream parlour.

2. IN A STUDY of the effect of temperature  $x$  on yield  $y$  of a chemical process, the data in table 2 was obtained.

- Perform a linear regression of  $y$  on  $x$ .
- Calculate the sample correlation coefficient  $r$ .
- Plot the data and add the line of best fit to your plot.
- Plot the Studentized residuals against the fitted values.
- Construct a q-q plot of the Studentized residuals.

$x$	25	26	27	28	29	30	31	32	33	34	35	36
$y$	10	16	13	17	20	18	19	23	25	22	29	26

Table 2: Twelve measurements from a study of temperature on yield.

## 2 Multiple linear regression

1. THE DATA (below) are from 101 consecutive patients attending a combined thyroid-eye clinic. The patients have an endocrine disorder, Graves' Ophthalmopathy, which affects various aspects of their eyesight. The ophthalmologist measures various aspects of their eyesight and constructs an overall index of how the disease affects their eyesight. This is the Ophthalmic Index (OI) given in the dataset. The age of the patient and their sex are also recorded. In practice, and as this is a chronic condition which can be ameliorated but not cured, the OI would be monitored at successive clinic visits to check on the patient's progress. However, these data are obtained at presentation. We are interested in how OI changes with age and gender. The data can be obtained from

```
library("nclRmodelling")
data(gravest)
```

- Fit the multivariate regression model predicting OI from age and gender.
  - Examine the Studentized residual plots. Is there anything that would suggest you have a problem with your model? What do you do?
2. DR PHIL comes to see you with his data. He believes that IQ can be predicted by the number of years education. Dr Phil does not differentiate between primary, secondary and tertiary education. He has four variables:
- IQ - the estimated IQ of the person (the response variable);
  - AgeBegin - the age of the person when they commenced education;
  - AgeEnd - the age of the person when they finished education;

- `TotalYears` - the total number of years a person spent in education.

The data can be obtained from:

```
data(drphil)
```

Read the data into R and fit the linear regression model:

$$IQ = \beta_0 + \beta_1 AgeBegin + \beta_2 AgeEnd + \beta_3 TotalYears + \epsilon$$

Explain what is wrong with this model? Suggest a possible remedy.

### 3 One way ANOVA tables

1. A PILOT STUDY was developed to investigate whether music influenced exam scores. Three groups of students listened to 10 minutes of Mozart, silence or heavy metal before an IQ test. The results of the IQ test are as follows

Mozart	109	114	108	123	115	108	114
Silence	113	114	113	108	119	112	110
Heavy Metal	103	94	114	107	107	113	107

- (a) Construct a one-way ANOVA table. Are there differences between treatment groups?
- (b) Check the standardised residuals of your model.
- (c) Perform a multiple comparison test to determine where the difference lies.

THE FOLLOWING SECTIONS use the results of the Olympic heptathlon competition, Seoul, 1988. To enter the data into R, use the following commands

```
data(hep)
## Remove the athletes names and final scores.
hep_s = hep[, 2:8]
```

### 4 Hierarchical clustering

USING THE HEPTATHLON data set, carry out a clustering analysis. Try different distance methods and clustering functions.

Table 3: Results from the study on how music affects examination performance.

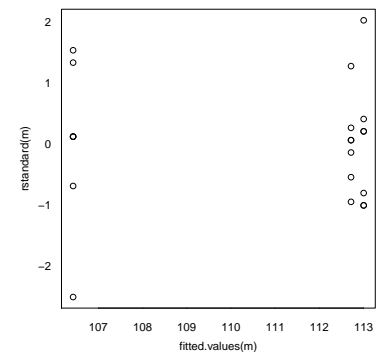


Figure 2: Model diagnostics for the music data.

## 5 *Principal components analysis*

1. Calculate the correlation matrix of the hep data set.
2. Carry out a PCA on this data set.<sup>2</sup>
  - Keep score in your PCA analysis. What happens and why? Do you think you should remove score?
  - Do you think you need to scale the data?
  - Construct a biplot of the data.

<sup>2</sup> Remember to remove the athletes names.

## 6 *Survival analysis*

This final section, is meant to give you a taste at other statistical techniques available. R has many packages<sup>3</sup> available. To install a package, we use the command

<sup>3</sup> A package is just an “add-on” that provides new functionality.

```
install.packages("survival")
```

Once the package is installed, we load it using library function

```
library(survival)
```

The data set we will use is the lung data set<sup>4</sup> - this comes with the survival package. To load this data set, we use the command

<sup>4</sup> Survival in patients with advanced lung cancer from the North Central Cancer Treatment Group. Performance scores rate how well the patient can perform usual daily activities.

```
data(lung)
```

We then use the dim function to extract the number of rows and columns

```
dim(lung)

## [1] 228 10
```

This creates a data frame with the following columns

- inst: Institution code
- time: Survival time in days
- status: censoring status 1=censored, 2=dead
- age: Age in years
- sex: Male=1 Female=2
- ph.ecog: ECOG performance score (0=good 5=dead)
- ph.karno: Karnofsky performance score (bad=0-good=100) rated by physician
- pat.karno: Karnofsky performance score as rated by patient
- meal.cal: Calories consumed at meals

- `wt.loss`: Weight loss in last six months

To begin, we create a `Surv` object:<sup>5</sup>

<sup>5</sup> Look at `?Surv` for further details.

```
Surv(lung$time, lung$status)
```

We can fit a Kaplan-Meier curve using the `survfit` function:

```
survfit(Surv(lung$time, lung$status) ~ 1)
```

and also plot survival curve

```
plot(survfit(Surv(lung$time, lung$status) ~ 1))
```

To fit the model using an additional covariate, we just alter the formula

```
plot(survfit(Surv(lung$time, lung$status) ~ lung$sex))
```

**Task:** Load the heart data set:<sup>6</sup>

<sup>6</sup> Look at the help page: `?heart`

```
data(heart)
```

and make a `Surv` object

```
Surv(heart$start, heart$stop, heart$event)
```

Why are there three arguments in the above function? Construct a Kaplan-Meier plot. Look at the `coxph` function. Try fitting a cox proportional hazard function.

### *Solutions*

Solutions are contained within this package:

```
library("nclRmodelling")
vignette("solutions2", package = "nclRmodelling")
```