

# 1 Notations

$\mathbf{X}$  denote a  $n \times p$  matrix whose  $(i, j)$ th element is  $x_{ij}$  That is,

$$\mathbf{X}_{n \times p} = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{np} \end{pmatrix} \quad (1.1)$$

Transpose of  $\mathbf{X}$ ,

$$\mathbf{X}_{p \times n}^T = \begin{pmatrix} x_{11} & x_{21} & \cdots & x_{n1} \\ x_{12} & x_{22} & \cdots & x_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ x_{1p} & x_{2p} & \cdots & x_{np} \end{pmatrix} \quad (1.2)$$

$x_i$  is a vector of length  $p$  containing the  $p$  variable for the  $i$ th observation. That is,

$$x_i = \begin{pmatrix} x_{i1} \\ x_{i2} \\ \vdots \\ x_{ip} \end{pmatrix} \quad (1.3)$$

Transpose of  $x_i$

$$x_i^T = \begin{pmatrix} x_{i1} & x_{i2} & \cdots & x_{ip} \end{pmatrix} \quad (1.4)$$

The columns of  $\mathbf{X}$ , which we write as  $\mathbf{x}_1, \mathbf{x}_2, \dots, \mathbf{x}_p$ . Each is a vector of length  $n$ . That is,

$$\mathbf{x}_j = \begin{pmatrix} x_{1j} \\ x_{2j} \\ \vdots \\ x_{nj} \end{pmatrix} \quad (1.5)$$

Using the notation above, the matrix  $\mathbf{X}$  can be written as

$$\mathbf{X} = (\mathbf{x}_1 \ \mathbf{x}_2 \ \cdots \ \mathbf{x}_p) \quad (1.6)$$

Or,

$$\mathbf{X} = \begin{pmatrix} x_1^T \\ x_2^T \\ \vdots \\ x_n^T \end{pmatrix} \quad (1.7)$$

$y_i$  denote the  $i$ th response.  $\mathbf{y}$  for all  $n$  response in vector form as,

$$\mathbf{y} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix} \quad (1.8)$$