Types of Data

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Basic Concepts in Statistics

- **Population:** The entire group of interest from which data is collected.
- **Sample:** A subset of the population used to represent the whole.
- **Variable:** A characteristic or property being measured or observed.
- **Data:** The values collected from the population or sample.
- **Descriptive Statistics:** Methods to summarize and describe data.
- **Inferential Statistics:** Methods to make predictions or inferences about a population based on sample data.

Data

- Different types of data are classified based on their characteristics.
- Understanding data types is crucial for choosing appropriate analysis methods.

Qualitative data

- It can't be expressed as a number and can't be measured. It consist of words, pictures, and symbols.

- Also called categorical data because the information can be sorted by category.

Examples of qualitative data

- Colors e.g. the color of the eyes
- Holiday destination
- Names
- Ethnicity

There are 2 general types of qualitative data: **nominal** data and **ordinal** data

Nominal data

- Nominal data is used just for labeling variables, without any type of quantitative value.

- The nominal data just name a thing without applying it to order. It could just be called "labels."

Examples of nominal data

- Gender
- Hair color
- Marital status
- Ethnicity

Note that there is no intrinsic ordering to the variables:

Eye color is a nominal variable having a few categories (Blue, Green, Brown) and there is no way to order these categories from highest to lowest.

Ordinal data

- Ordinal data shows where a number is in order. This is the crucial difference from nominal types of data.
- Ordinal data is data which is placed into some kind of order by their position on a scale. Ordinal data may indicate superiority.
- You cannot do arithmetic with ordinal numbers because they only show sequence.
- Ordinal variables are considered as "in between" qualitative and quantitative variables.

Ordinal data

- In other words, the ordinal data is qualitative data for which the values are ordered.
- In comparison with nominal data, the second one is qualitative data for which the values cannot be placed in an ordered.
- We can also assign numbers to ordinal data to show their relative position. But we cannot do math with those numbers. For example: "first, second, third. . . etc."

Examples of ordinal data

- The first, second and third person in a competition.
- Rating classes: A, B, C, and etc.
- Status: low, medium and high.

Quantitative data

- Quantitative data seems to be the easiest to explain. It answers key questions such as "how many, "how much" and "how often".
- Quantitative data can be expressed as a number or can be quantified. Simply put, it can be measured by numerical variables.
- Quantitative data are easily amenable to statistical manipulation and can be represented by a wide variety of statistical types of graphs and charts such as line, bar graph, scatter plot, and etc.

Examples of quantitative data

- Scores on tests and exams e.g. 85, 67, 90 and etc.
- The weight of a person or a subject.
- Your shoe size.
- The temperature in a room.

There are 2 general types of quantitative data: **discrete** data and **continuous** data.

Discrete data

- Discrete data is a count that involves only integers. The discrete values cannot be subdivided into parts.
- For example, the number of children in a class is discrete data. You can count whole individuals. You can't count 1.5 kids.
- To put in other words, discrete data can take only certain values. The data variables cannot be divided into smaller parts.
- (Most of the times) It has a limited number of possible values e.g. days of the month.

Examples of discrete data

- The number of students in a class.
- The number of workers in a company.
- The number of goal, passes or shoots in a football game.
- The number of test questions you answered correctly.

Ordering and plotting data

Frequency

The number of times an event or value occurs in a dataset.

Frequency Table

A table that displays the frequencies of different values or categories in a dataset.

Frequency

- **Absolute frequency**: number of times that a value appears. It is represented as f_i where the subscript represents each of the values. The sum of the absolute frequencies is equal to the total number of data, represented as N.

$$f_1 + f_2 + \ldots, f_n = N$$

or equivalentely

$$\sum_{i=1}^{n} f_i = N$$

- **Relative frequency**: the result of dividing the absolute frequency of a certain value by the total number of data. It is represented as n_i. The sum of the relative frequencies is equal to 1. We can prove this easily by factorizing

$$n_i = \frac{f_i}{N}$$

Frequency

- **Cumulative frequency**: the sum of absolute frequencies of all the values equal to or less than the considered value (only for ordinal data). This is represented as F_i.

- **Relative cumulative frequency**: the result of dividing the cumulative frequency by the total number of information, which is represented by N_i.

Creating a Frequency Table

1. Identify the values or categories in your dataset.
2. Count how many times each value or category appears.
3. Organize the data into a table.

Example: Rating class modelling

Our sample comprises 25 European corporations operating in the Energy sector.

Corporation	**Country**	**Rating class**
ItaEnergy	Italy	D
GoEng	Germany	A
Ena	France	B
SolarEn	Italy	A
⋮	⋮	⋮
PowerFS	Spain	C

Table: Simulated Rating Class Data

Example: Rating class analysis

We can summarize the information with a frequency table!

Rating class	$\mathbf{f}_i$
A	5
B	8
C	3
D	2
E	7

Table: Frequency Table of Ratings

Example: Rating class analysis

Rating class	$\mathbf{f}_i$	$\mathbf{n}_i$
A	5	$5/25 = 0.20$
B	8	$8/25 = 0.32$
C	3	$3/25 = 0.12$
D	2	$2/25 = 0.08$
E	7	$7/25 = 0.28$

Table: Frequency Table of Ratings

Rating class modelling: Barplot Absolute Frequency

Rating class modelling: Barplot Relative Frequency

Example: Rating class analysis Absolute Frequencies

Rating class	$\mathbf{f}_i$	$\mathbf{n}_i$
A	5	$5/25 = 0.20$
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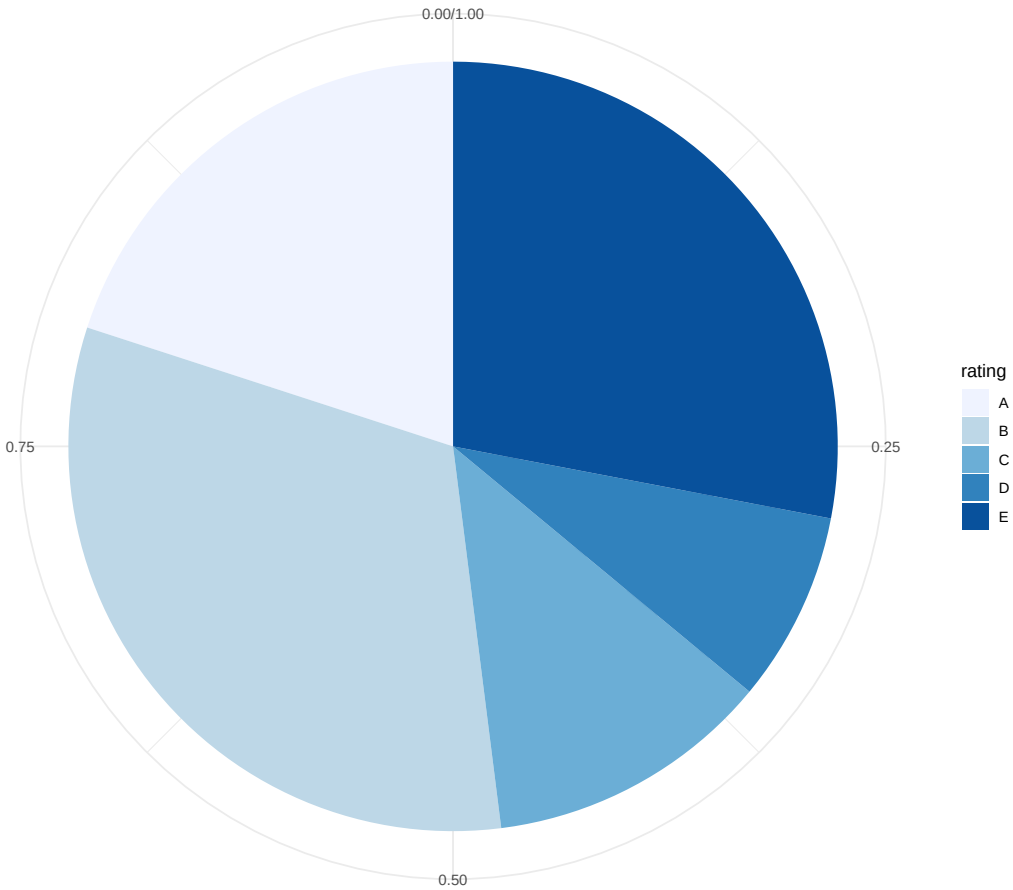
Table: Frequency Table of Ratings

Example: Rating class analysis Absolute Frequencies

Rating class	$\mathbf{f}_i$	$\mathbf{n}_i$	$\mathbf{F}_i$	$\mathbf{N}_i$
A	5	$5/25 = 0.20$	5	0.2
B	8	$8/25 = 0.32$	13	0.52
C	3	$3/25 = 0.12$	16	0.64
D	2	$2/25 = 0.08$	18	0.72
E	7	$7/25 = 0.28$	25	1

Table: Frequency Table of Ratings

Rating class modelling: Pie chart



Example: Crimes in Italian municipalities in 2022

	Municipality	**Crime**	**date**
1	Rome	robbery	01/01/2022
2	Milan	murder	01/01/2022
3	Florence	brawl	01/01/2022
4	Naples	robbery	01/01/2022
⋮	⋮	⋮	⋮
2183043	Pavia	domestic violence	31/12/2022
2183044	Rome	brawl	31/12/2022
2183045	Rome	theft	31/12/2022

Table: Simulated Crime data

NOTE: The data shown is not real

Example: Crimes in Italian municipalities in 2022

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- In Italy there are 7901 municipalities: no, it doesn't make much sense.
- What can we do?

Example: Crimes in Italian municipalities in 2022

	Municipality	**Area**	**Number of Crimes**
1	Abano Terme	North	9
2	Abbadia Cerreto	North	7
3	Abbadia Lariana	North	13
3	Abbadia San Salvatore	Center	3
⋮	⋮	⋮	⋮
7899	Zumpano	South	4
7900	Zungoli	South	12
7901	Zungri	South	7

Table: Crime data

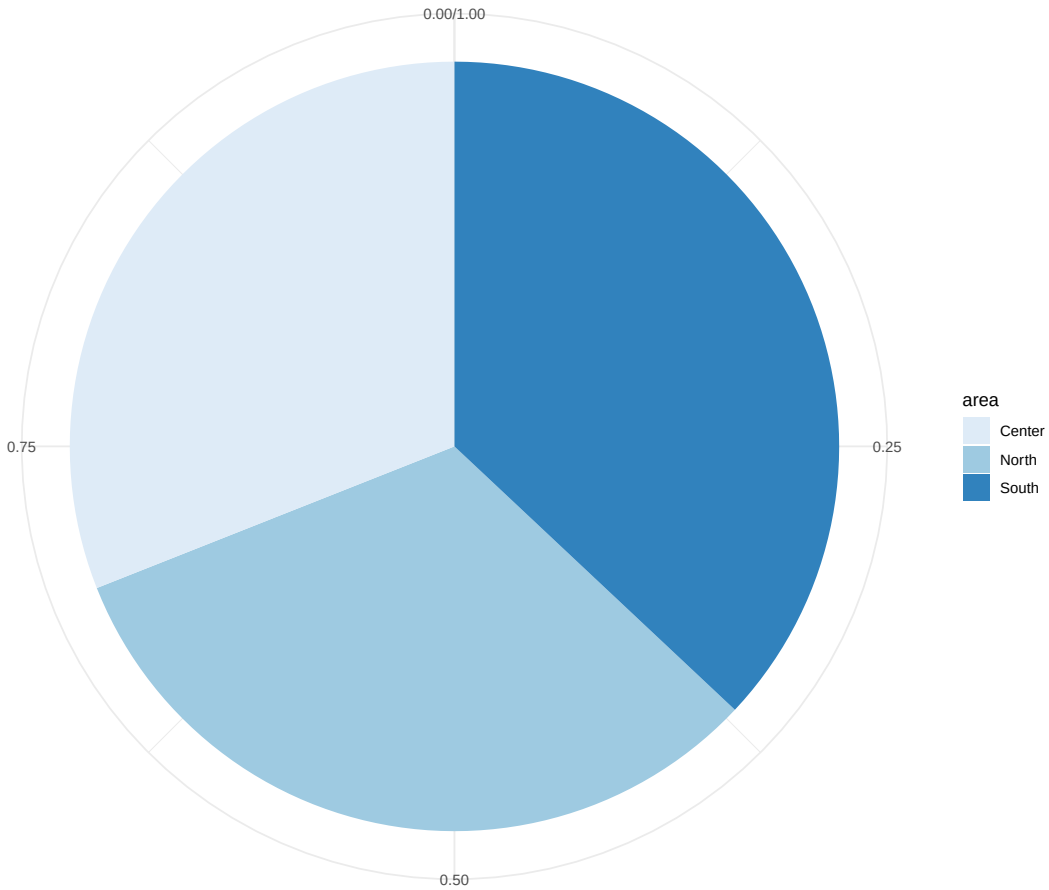
NOTE: The data shown is not real

Example: Crimes in Italy in 2022

Rating class	$\mathbf{f}_i$	$\mathbf{n}_i$
North	698574	0.32
Center	676744	0.31
South	807727	0.37

Table: Frequency Table of Crimes in Italy

Example: Crimes in Italy in 2022



Continuous data

- Continuous data is information that could be meaningfully divided into finer levels. It can be measured on a scale or continuum and can have almost any numeric value.
- For example, you can measure your height at very precise scales — meters, centimeters, millimeters and etc.
- You can record continuous data at so many different measurements – width, temperature, time, and etc. This is where the key difference from discrete types of data lies.
- The continuous variables can take any value between two numbers. For example, between 50 and 72 meters, there are infinite of possible lengths.

Examples of continuous data

- Time (Waiting time).
- Height and Weight.
- Stock Price.
- Income, Inflation and other economic variables.

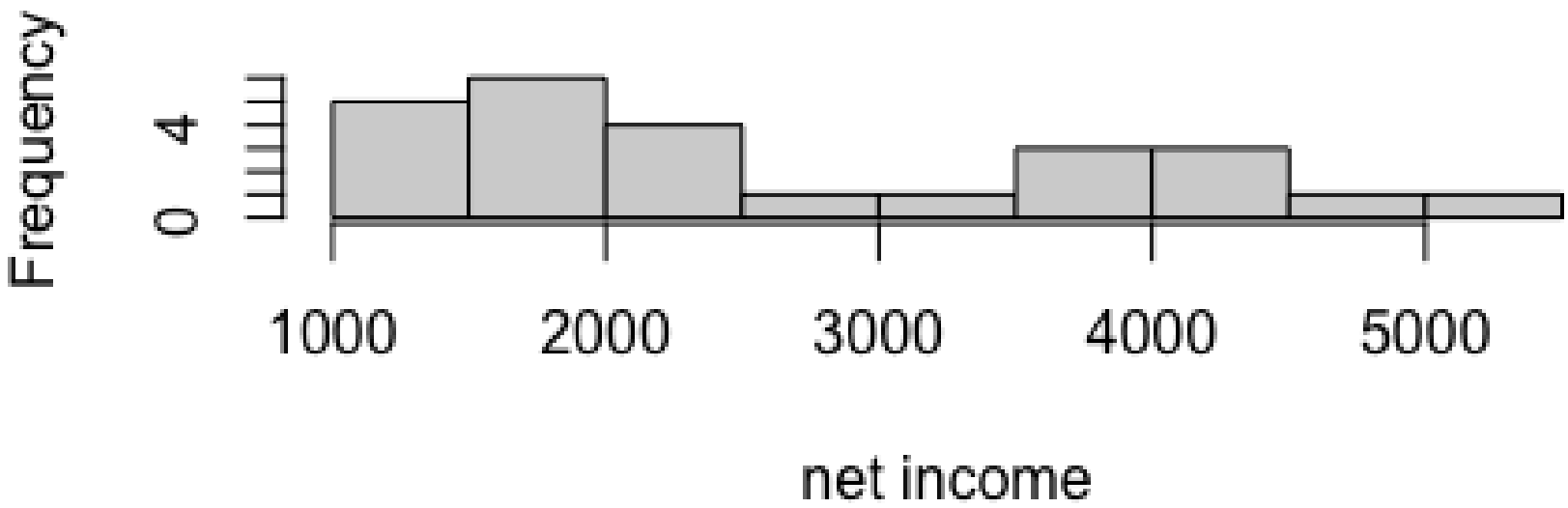
Example: Net Income analysis

Corporation	Country	Rating class	Net Income (M)
ItaEnergy	Italy	D	1400
GoEng	Germany	A	4300
Ena	France	B	3300
SolarEn	Italy	A	4570
⋮	⋮	⋮	⋮
PowerFS	Spain	C	2700

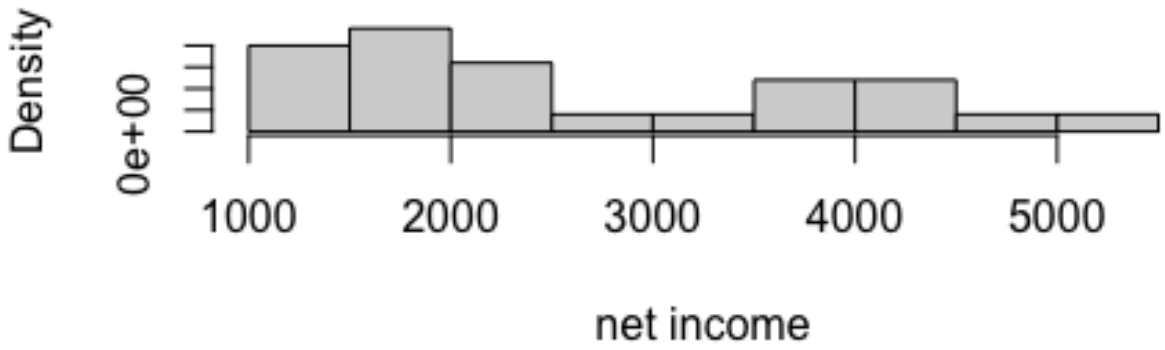
Table: Simulated Rating Class Data

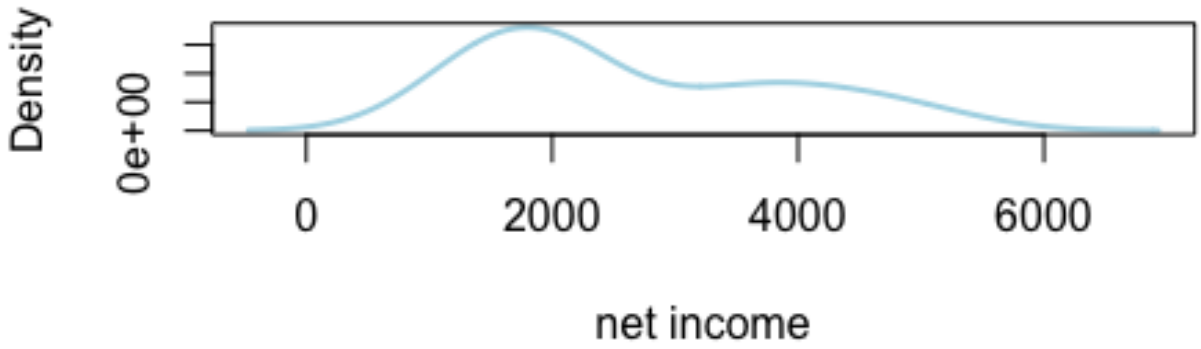
We want to analyse the net income.

Example: Net Income analysis



Example: Net Income analysis





Example: Net Income analysis

What if we want to summarise the **Net Income** distribution?

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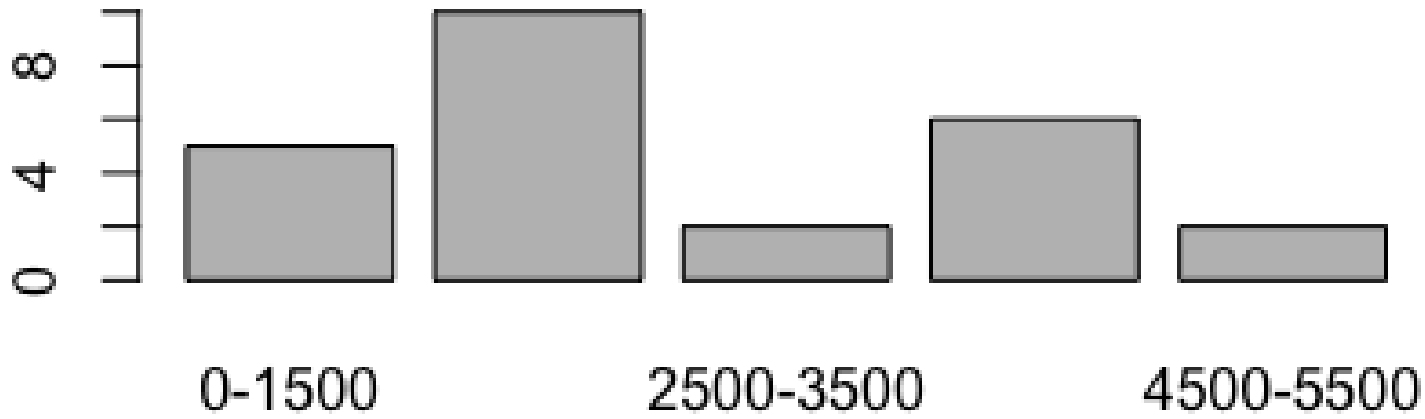
What if we want to summarise the **Net Income** distribution?

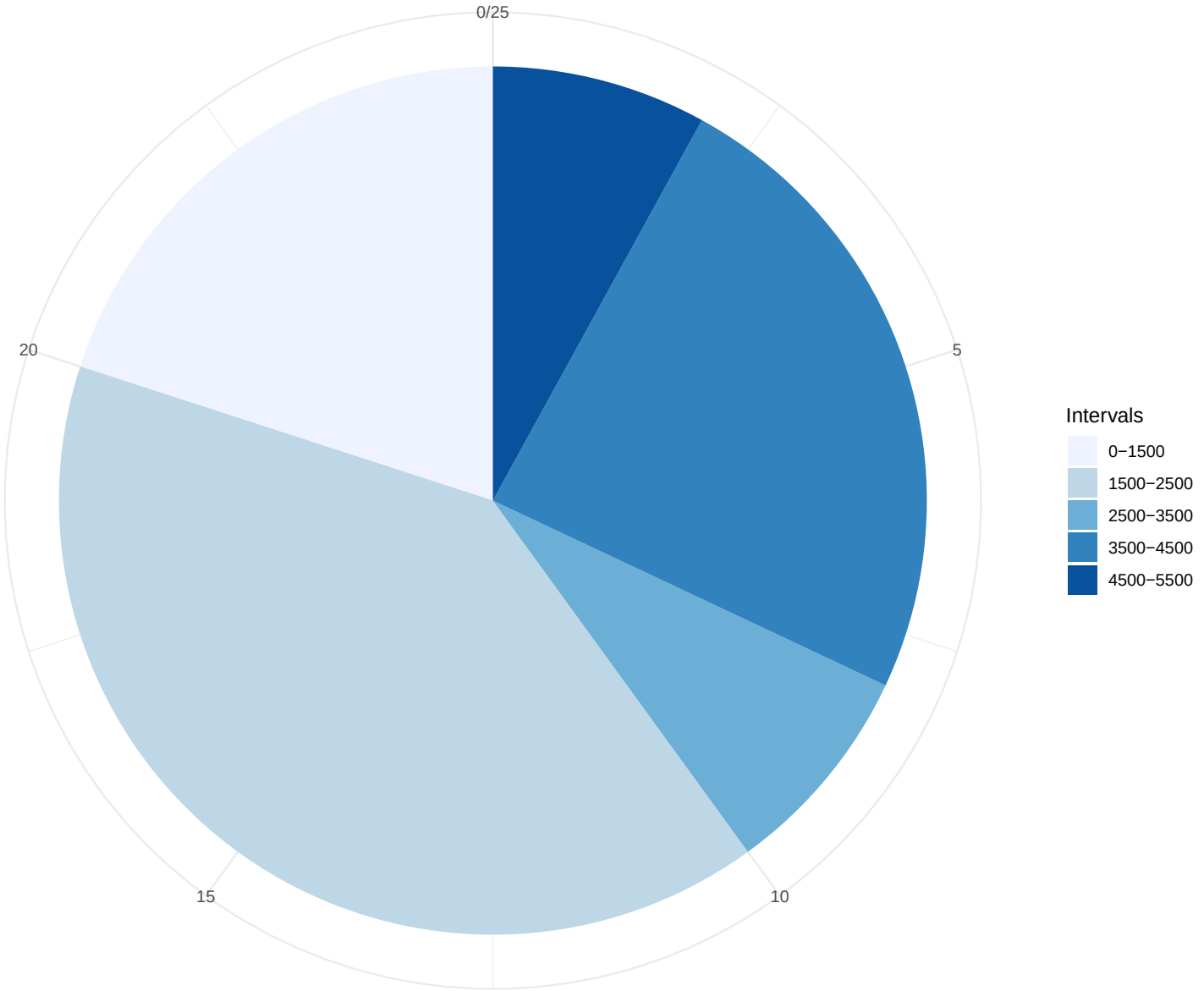
We can split in intervals the **Net Income** values perform the analysis.

Net Income range (M)	**Number of Corporations**
$[0, 1500]$	5
$]1500, 2500]$	10
$]2500, 3500]$	2
$]3500, 4500]$	6
$[4500, 5500]$	2

Net Income analysis: Pie Chart



Net Income analysis: barplot



Summary on the type of data

- Type of data:
  - Qualitative:
    - ★ Nominal
    - ★ Ordinal
  - Quantitative
    - ★ Discrete
    - ★ Continuous
- Frequency distributions: visual displays that organise and present frequency counts so that the information can be interpreted more easily.