Data Analysis Course

Preparing data for analysis

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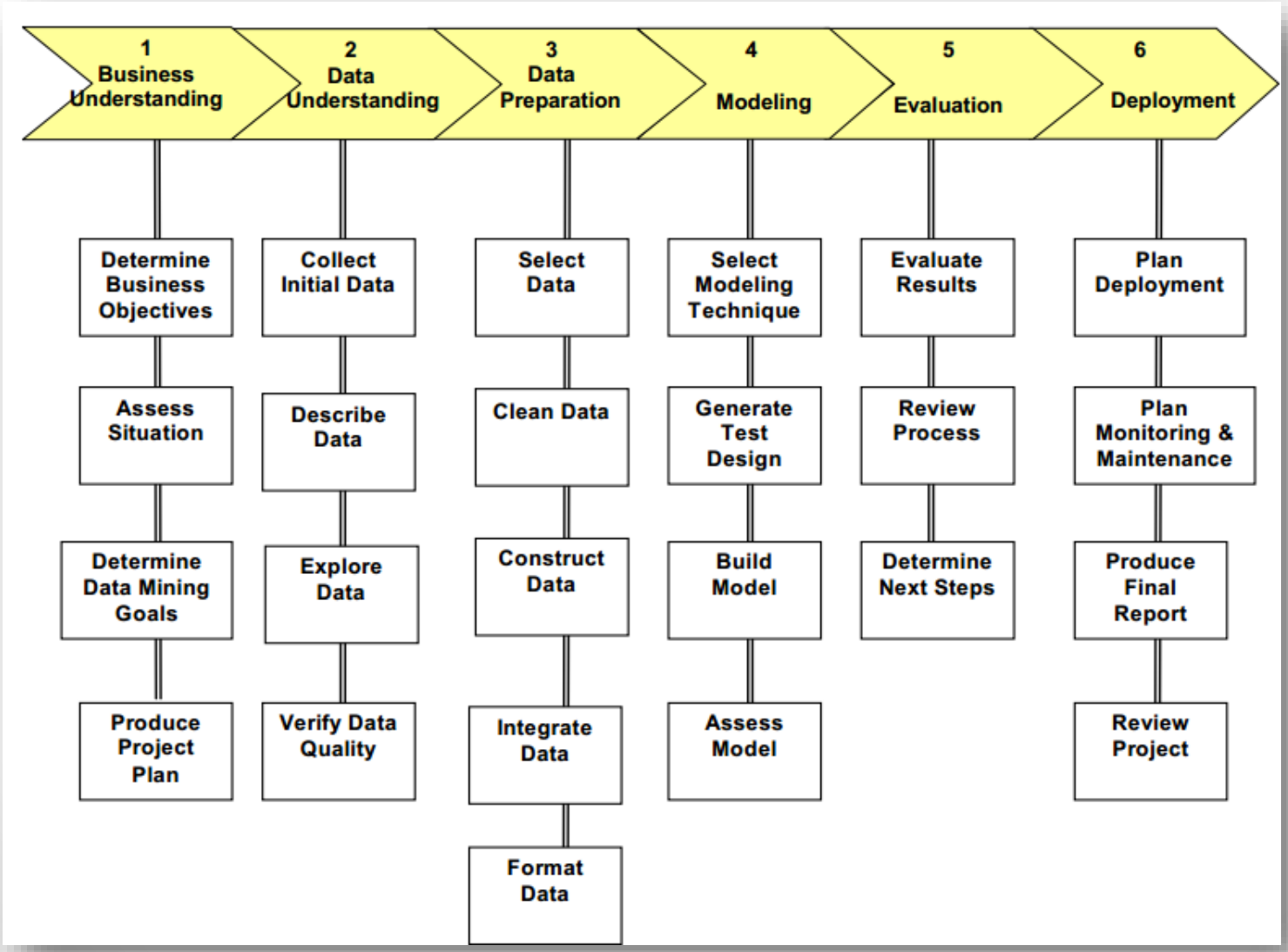
Contents

- Need of data exploration
- Data Exploration
- Data Validation
- Data Sanitization
  - Missing Value Treatment
  - Outlier Treatment Identification & Treatment

Main steps in statistical data analysis



Remember…

Data in the real world is dirty

Incomplete: lacking attribute values, lacking certain attributes of interest, or containing only aggregate data. e.g., occupation=“ ”

- Incomplete data may come from
  - “Not applicable” data value when collected.
  - Different considerations between the time when the data was collected and when it is analyzed.
  - Human/hardware/software problems

Noisy: Containing errors or outliers. e.g., Salary=“-10”

- Noisy data (incorrect values) may come from
  - Faulty data collection instruments
  - Human or computer error at data entry
  - Errors in data transmission

Inconsistent: containing discrepancies in codes or names

- e.g., Age=“42” Birthday=“03/07/1997”, Was rating “1,2,3”, now rating “A, B, C”,e.g., discrepancy between duplicate records
- Inconsistent data may come from
  - Different data sources
  - Functional dependency violation (e.g., modify some linked data)

Missing values and Outliers

- How to identify the missing values?
- What are outliers?
- Sometimes outlier finding it self is the aim of the analysis

Data & Objective

- **Loans data**: Historical data are provided on 250,000 borrowers.
- The objective is to build a model that borrowers can use to help make the best financial decisions.

Variable Name	Description	Type
SeriousDlqin2yrs	Person experienced 90 days past due delinquency or worse	Y/N
RevolvingUtilizationOfUnsecuredLines	Total balance on credit cards and personal lines of credit except real estate and no installment debt like car loans divided by the sum of credit limits	percentage
age	Age of borrower in years	integer
NumberOfTime30-59DaysPastDueNotWorse	Number of times borrower has been 30-59 days past due but no worse in the last 2 years.	integer
DebtRatio	Monthly debt payments, alimony,living costs divided by monthy gross income	percentage
MonthlyIncome	Monthly income	real
NumberOfOpenCreditLinesAndLoans	Number of Open loans (installment like car loan or mortgage) and Lines of credit (e.g. credit cards)	integer
NumberOfTimes90DaysLate	Number of times borrower has been 90 days or more past due.	integer
NumberRealEstateLoansOrLines	Number of mortgage and real estate loans including home equity lines of credit	integer
NumberOfTime60-89DaysPastDueNotWorse	Number of times borrower has been 60-89 days past due but no worse in the last 2 years.	integer
NumberOfDependents	Number of dependents in family excluding themselves (spouse, children etc.)	integer

Basic contents of the data

- What are total number of observations
- What are total number of fields
- Each field name, Field type, Length of field
- Format of field, Label

Basic Contents –Check points

- Are all variables as expected (variables names)
- Are there some variables which are unexpected say q9 r10?
- Are the data types and length across variables correct
- For known variables is the data type as expected (For example if age is in date format something is suspicious)
- Have labels been provided and are sensible

If anything suspicious we can further investigate it and correct accordingly

Lab: Basic contents of the data

- Import Data_explore.csv into SAS
- What are basic contents of the data
- Verify the check list
- Any suspicious variables?
- What is var1?
- Are all the variable names correct?

Proc Contents-SAS

- SAS code : proc contents data=<<data name>>; run;
- Useful options :
  - **Short** – Outputs the list of variables in a row by row format.

    Code : proc contents data=test **short**; run;
  - **Out=*filename*** - Creates a data set wherein each observation is a variable

Snapshot of the data

Data Snapshot, if possible

- Printing the first few observations all fields in the data set .It helps in better understanding of the variable by looking at it's assigned values.

Checkpoints for data snapshot output:

1. Do we have any unique identifier? Is the unique identifier getting repeated in different records?
2. Do the text variables have meaningful data?(If text variables have absurd data as '&^%*HF' then either the variable is meaningless or the variable has become corrupt or wasn't properly created.)
3. Are there some coded values in the data?(if for a known variable say State we have category codes like 1-52 then we need definition of how they are coded.)
4. Do all the variables appear to have data? (In case variables are not populated with non missing meaningful value it would show in print. We can further investigates using means statistics.)

Proc print in SAS

SAS code : **proc print** data=<<data set>>; run;

- Useful options :

  proc print data=<<data set>> label noobs heading=vertical;

  var <<variable-list>>; by var1; run;

  - Label:The label option uses variable labels as column headings rather than variable names (the default).
  - Obs : Restricts the number of observations in the output
  - Nobs: It omits the OBS column of output.
  - Heading=vertical: It prints the column headings vertically. *This is useful when the names are long but the values of the variable are short.*
  - Var: Specifies the variables to be listed and the order in which they will appear.
  - By: By statement produces output grouped by values of the mentioned variables

Lab: Data exploration & validation

- Print the first 10 observations
  - Do we have any unique identifier?
  - Do the text variables have meaningful data?
  - Are there some coded values in the data?
  - Do all the variables appear to have data

Categorical field frequencies

- Calculate frequency counts cross-tabulation frequencies for Especially for categorical, discrete & class fields
- Frequencies
  - help us understanding the variable by looking at the values it's taking and data count at each value.
  - They also helps us in analyzing the relationships between variables by looking at the cross tab frequencies or by looking at association

Checkpoints for looking frequency table

1. Are values as expected?
2. Variable understanding : Distinct values of a particular variable, missing percentages
3. Are there any extreme values or outliers?
4. Any possibility of creating a new variable having small number of distinct category by clubbing certain categories with others.

Proc Freq in SAS

- SAS code: **Proc FREQ** data =<dataset > <options> ;
  TABLES requests < / options > ; // Gives Frequency Count or Cross Tab
  BY <varl> ; // Grouping output based on varl
  WEIGHT variable < / option > ; //Specifying Weight (if applicable)
  OUTPUT < OUT=SAS-data-set > options ; //Output results to another data set run;
- Useful options :
  - **Order=Freq** - sorts by descending frequency count (default is the unformatted value). Ex: proc freq data=test order=freq; tables X1-X5; run;
  - **Nocol/Norow/Nopercent** - suppresses printing of column, row and cell percentages respectively of a cross tab. Ex : proc freq data=test; tables AGE*bad**/nocol norow nopercent missing**; run;
  - **Missing**- interprets missing values as non-missing and includes them in % and statistics calculations ex : proc freq data=test; tables CHANNEL* BAD **/missing**; run;
  - **Chisq** - performs several chi-square tests. Ex: proc freq data=test; tables channel*bad/chisq; run;

Lab: Frequencies

- Find the frequencies of all class variables in the data
- Are there any variables with missing values?
- Are there any default values?
- Can you identify the variables with outliers?

Descriptive Statistics for continuous fields

- Distribution of numeric variables by calculating
  - N – Count of non missing observations
  - Nmiss – Count of Missing observations
  - Min, Max, Median, Mean
  - Quartile numbers & percentiles– P1, p5,p10,q1(p25),q3(p75), p90,p99
  - Stddev
  - Var
  - Skewness
  - Kurtosis

Descriptive Statistics Checkpoints

- Are variable distribution as expected.
- What is the central tendency of the variable? Mean, Median and Mode across each variable
- Is the concentration of variables as expected ? What are quartiles?
- Indicates variables which are unary I.e stddev=0 ; the variables which are useless for the current objective.
- Are there any outliers / extreme values for the variable?
- Are outlier values as expected or they have abnormally high values - for ex for Age if max and p99 values are 10000. Then should investigate if it's the default value or there is some error in data
- What is the % of missing value associated with the variable?

Proc Univariate on continuous variables

- SAS Code : **PROC UNIVARIATE** data=<dataset>;

  VAR *variable(s)*; run;
- Useful options :
  - **PROC UNIVARIATE** data=<dataset> plot normal;

    HISTOGRAM *<variable(s)> </ option(s)>*;

    By variable;

    VAR *variable(s)*; run;
    - Normal option produces the tests of normality ;
    - Plot option produces the 3 plots of data(stem and leaf plot, box plot, normal probability plot
    - By option is used for giving outputs separated by categories
    - Histogram option gives the distribution of variable in a histogram

Proc Means in SAS

- Proc means data=<data set> < options>;

  Var <variable list >;

  Run;
- If variable list is not mentioned it gives results across all numeric variables
- If options are not specified by default it gives stats like – n , min, max, mean and stddev.
- Useful Options :
  - By : Calculates statistics based on grouping across specified variable;

```
Proc means data=check n nmiss min max;
var age ;
class channel;
run;
```

General Checks

- **Mean=Median?**
- **Counted proportion data.** If data consists of counted proportions, e.g. number of individuals responding out of total number of individuals,
- **Data Sufficiency:** Data Sufficiency involves ensuring that the data has the required attributes to make the prediction as stated by objective
  - **Eg1:** To build a model to predict fraud, the given data doesn't have any key for identifying fraud accounts or those identifiers are erased than there are no accounts which we can identify as 'bad' and build a model to predict the same.
  - **Eg2:** If we are building a response model specifically for internet channel for a "airline card". Then data should have a identifier for 'channel of acquisition' to identify the right data base on which to build the model

Lab: Data exploration & validation

- Find N, Average, sd, minimum & maximum
- Is N same for all the variables?
- Any variables with unusual min & max?
- Identify list of suspicious variables
- Find below statistics for all the doubtful variables
  - N,Mean,Median,Mode
  - Std Deviation
  - Skewness
  - Variance
  - Kurtosis
  - Interquartile Range
  - Quantiles 100% Max, 99%,,95%,,90%, 75% Q3,50% Median,25% Q1,10%,5%,1%,0% Min
- See the variable definitions and possible values
- Identify variables with missing values, default values & outliers

Now what…?

- Some variables contain outliers
- Some variables have default values
- Some variables have missing values

- **RevolvingUtilizationOfUnsecuredL**
- **NumberOfTime30_59DaysPastDueNotW**
- **Montly income has missing values**

- Shall we delete them and go ahead with our analysis?

Missing Values

- Data is not always available E.g., many tuples have no recorded value for several attributes, such as customer income in sales data
- Missing data may be due to
  - Equipment malfunction
  - Inconsistent with other recorded data and thus deleted
  - Data not entered due to misunderstanding
  - Certain data may not be considered important at the time of entry
  - Not register history or changes of the data
  - Missing data may need to be inferred.
- Missing data - values, attributes, entire records, entire sections
- Missing values and defaults are indistinguishable

Missing Value Imputation1

- **Standalone imputation**
  - Mean, median, other point estimates
  - Convenient, easy to implement
  - **Assume:** Distribution of the missing values is the same as the non-missing values.
  - Does not take into account inter-relationships
  - **Eg:** The average of available values is 11.4. Can we replace the missing value in this table by **11.4** ?

X1
11.0
11.1
11.9
10.9
10.8
.
11.5
11.6
11.6
11.4
11
12
11.8
11.4
11.9

Missing Value Imputation2

- Use attribute relationships
- Better imputation
- Two techniques
  - Propensity score (nonparametric). Useful for discrete variables
  - Regression (parametric)

- There are two missing values in x2. What are the most appropriate replacements

X1	X2
-4	-12
2	6
-6	-18
8	24
-1	
-4	-12
-5	-15
4	12
-4	-12
-5	-15
-2	
4	12
10	30
-10	-30
-3	-9

Missing Value Imputation3

- There are two missing values in x2. Find the most appropriate replacements

X1	X2
4	1
5	1
4	1
3	1
3	1
4	1
5	1
3	
31	0
39	0
32	0
37	0
32	0
32	0
32	

Missing Value Imputation4

- What if more than 50% are missing?
- It doesn't make sense to carry out the analysis on 205 or 30% of the whole data and give inferences on overall data
- The best imputation is ignore the actual values and take available or not available info

Default Values Treatment

- Special or default values are values like 999 or 999999 which fall outside the normal range of data .

- **Example:**
  - Number of cards= 99999
  - For instance a no. of bankcards variable usually has values from 0 to 100 but 99999 values in the data represent the population which does not have any trade lines. Including them in the regression as 99999 would skew the regression results, hence we need to treat them accordingly.

- Special or default values also should be treated as we are treating the missing values depending upon the no. of categories and the % of default value.

Outlier Treatment

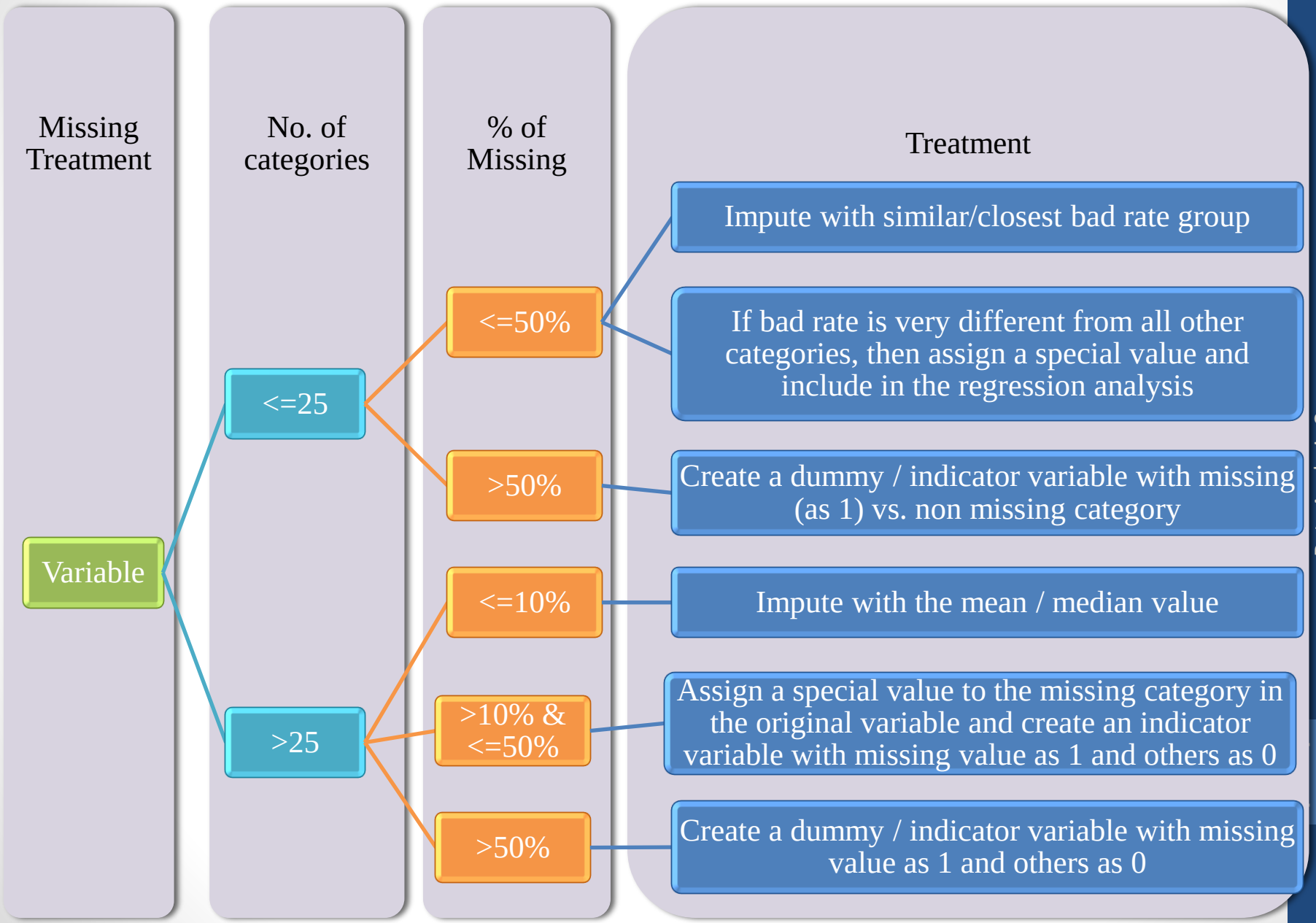
- They can also be taken care of by capping or flooring them to a realistic value / where the trend is being maintained (especially if the % of default value is very less).
- Sometimes outlier finding it self is the aim of the analysis

- Flooring
- Capping
- Treat as a separate segment

- We can cap the data at 40, anything above 40 is 40

Player Age
26
39
37
23
24
27
29
35
29
30
21
25
58
60
39
26
32
21
24
20
35
25
20

Missing Value & Outlier Treatment

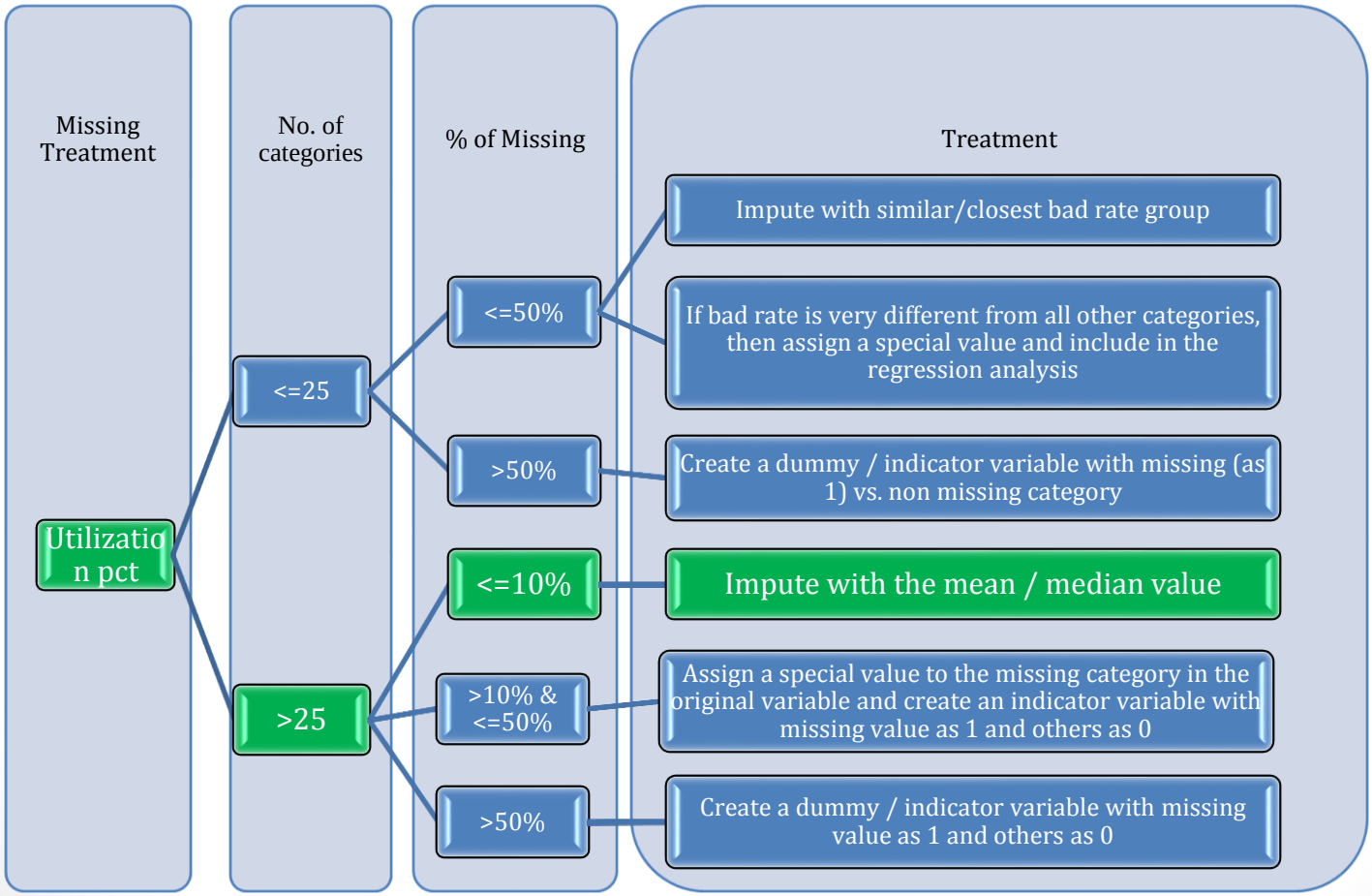


Lab: Data Cleaning step by step

- **Var-1:** Change the variable name to sr_no
- **SeriousDlqin2yrs :** Only training data has data objective variable test data doesn't have objective variable in it. Subset training data & test from overall data
- **Age:** If age <21 make it 21

Lab :Data Cleaning step by step

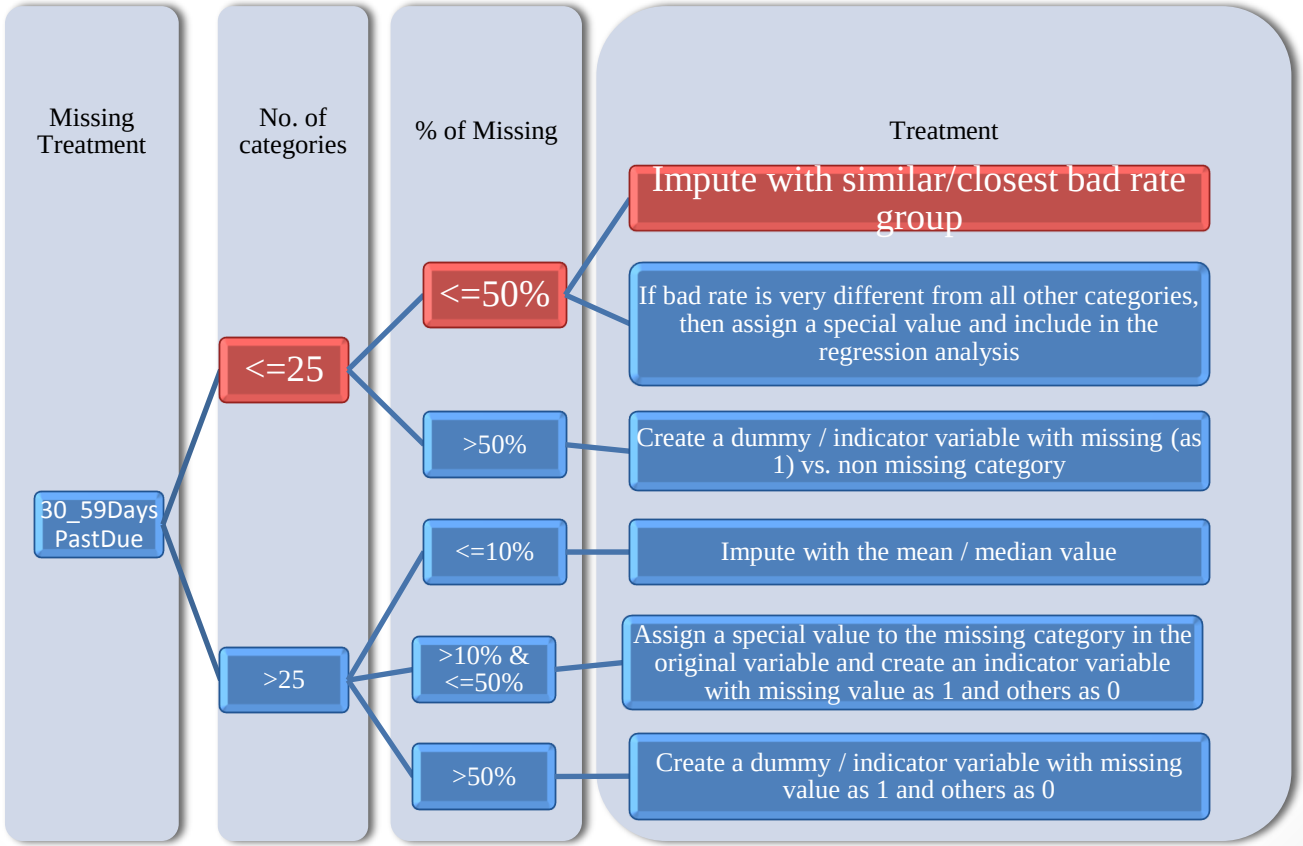
- **RevolvingUtilizationOfUnsecuredL:** What type of variable is this? What are the possible values?
- Replace anything more than 1 with_____?



Lab : Data Cleaning step by step

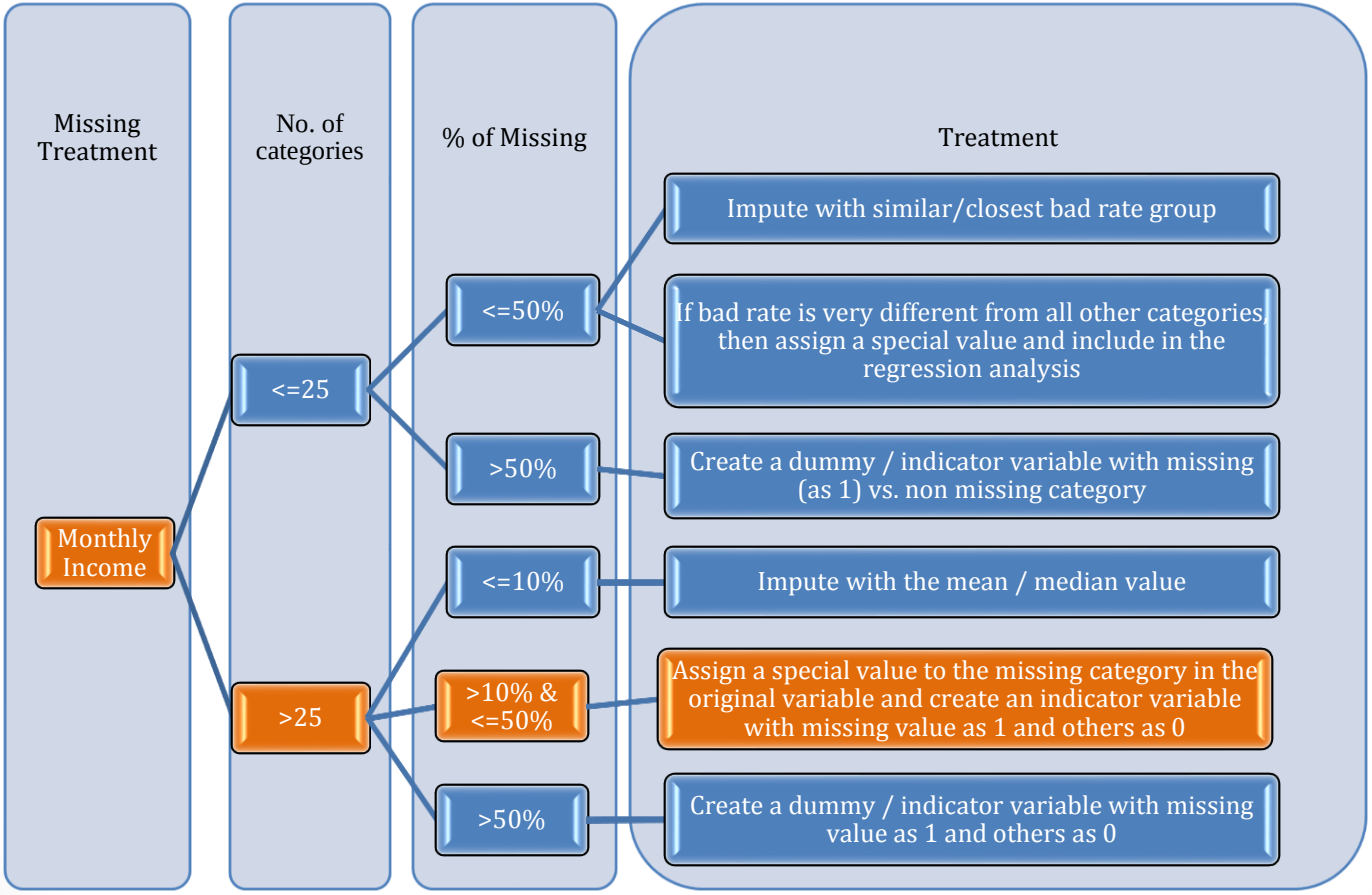
NumberOfTime30_59DaysPastDueNotW

- Find bad rate in each category of this variable
- Replace 96 with _____? Replace 98 with_____?



Lab :Data Cleaning step by step

- Monthly Income



Lab :Data Cleaning step by step

- **Debt Ratio**: Similar Imputation
- **NumberOfOpenCreditLinesAndLoans** : No clear evidence
- **NumberOfTimes90DaysLate:** Imputation similar to NumberOfTime30_59DaysPastDueNotW
- **NumberRealEstateLoansOrLines:** : No clear evidence
- **NumberOfTime60_89DaysPastDueNotW:** Imputation similar to NumberOfTime30_59DaysPastDueNotW
- **NumberOfDependents**: Impute with equal bad rate

Variables & Treatment

Old Var	Type	Treatment	New Var
VAR1	Num	Nothing	
SeriousDlqin2yrs	Num	Nothing	
RevolvingUtilizationOfUnsecuredL	Num	Impute with the mean	Util
age	Num	flooring	age1
NumberOfTime30_59DaysPastDueNotW	Num	Impute with the mean	NumberOfTime30_59DaysPastDue1
DebtRatio	Num	Impute with the median	DebtRatio1
MonthlyIncome	Char	Convert to num & create a dummy var	ind_MonthlyIncome, MonthlyIncome1
NumberOfOpenCreditLinesAndLoans	Num	Impute with median	num_open_lines
NumberOfTimes90DaysLate	Num	Imputing & capping	delq_90
NumberRealEstateLoansOrLines	Num	Capping	num_loans
NumberOfTime60_89DaysPastDueNotW	Num	Capping & Imputing	delq_60to89
NumberOfDependents	Char		
obs_type	Char	Subset training data	Obs_type