Group 9

May 16th 2024

ANOVA ANALYSIS

Analysis of Data Science Engineer's Salary

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Introduction

This dataset represents salary information for Machine Learning(Data Science) engineers.

For each entry, contains 11 columns, including details such as the level of experience, employment type, job title, salary amount, employee residence, remote work ratio, company location, and company size.

experienc...	employme...	job_title	salary_in_...	employee_...	remote_ra...	company_l...	company_...
MI	FT	Data Scientist	120000	AU	0	AU	S
MI	FT	Data Scientist	70000	AU	0	AU	S
MI	CT	Data Scientist	130000	US	0	US	M
MI	CT	Data Scientist	110000	US	0	US	M
MI	FT	Data Science Manager	240000	US	0	US	M
MI	FT	Data Science Manager	180000	US	0	US	M
SE	FT	Business Intelligence Engineer	202800	US	0	US	M
SE	FT	Business Intelligence Engineer	115000	US	0	US	M

This information allows for analysis of salary trends, employment patterns, and other factors affecting machine learning engineer salaries in various locations and company settings.

Data Preprocessing

- We drop job_title(not important).
- We drop salary, salary_currency(USD as measurement).
- We drop those entries with company location not in US(US consists of 87.8%).

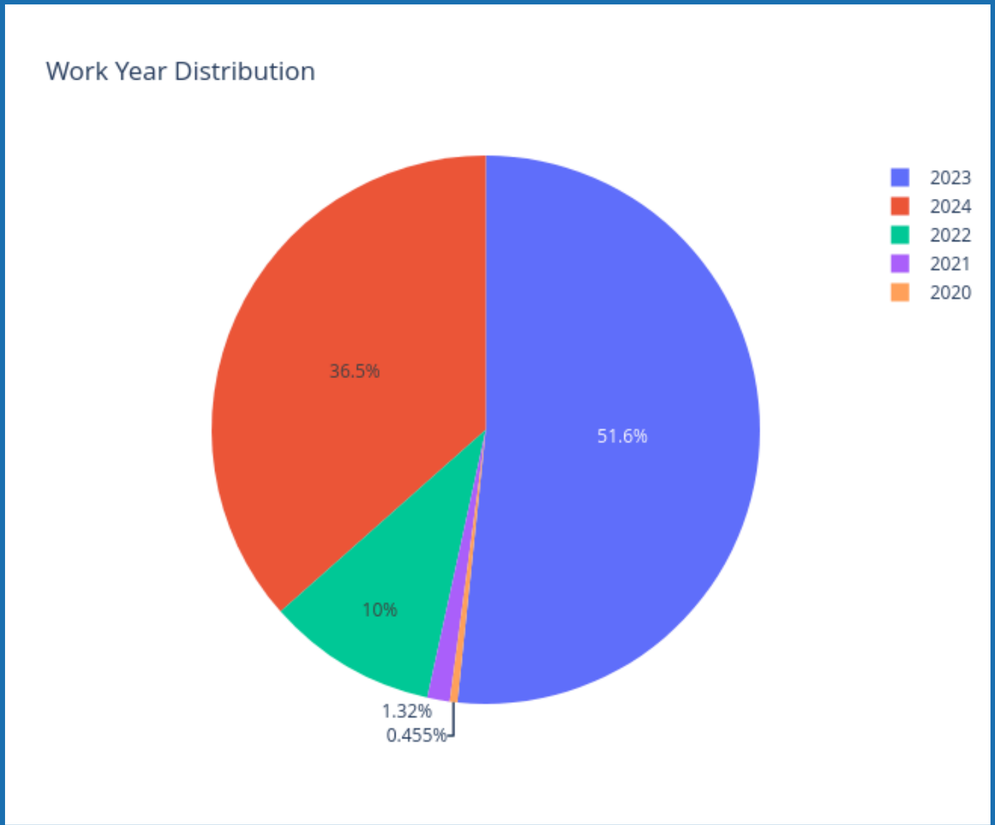
Total 16494 entries, 7 categorical features.

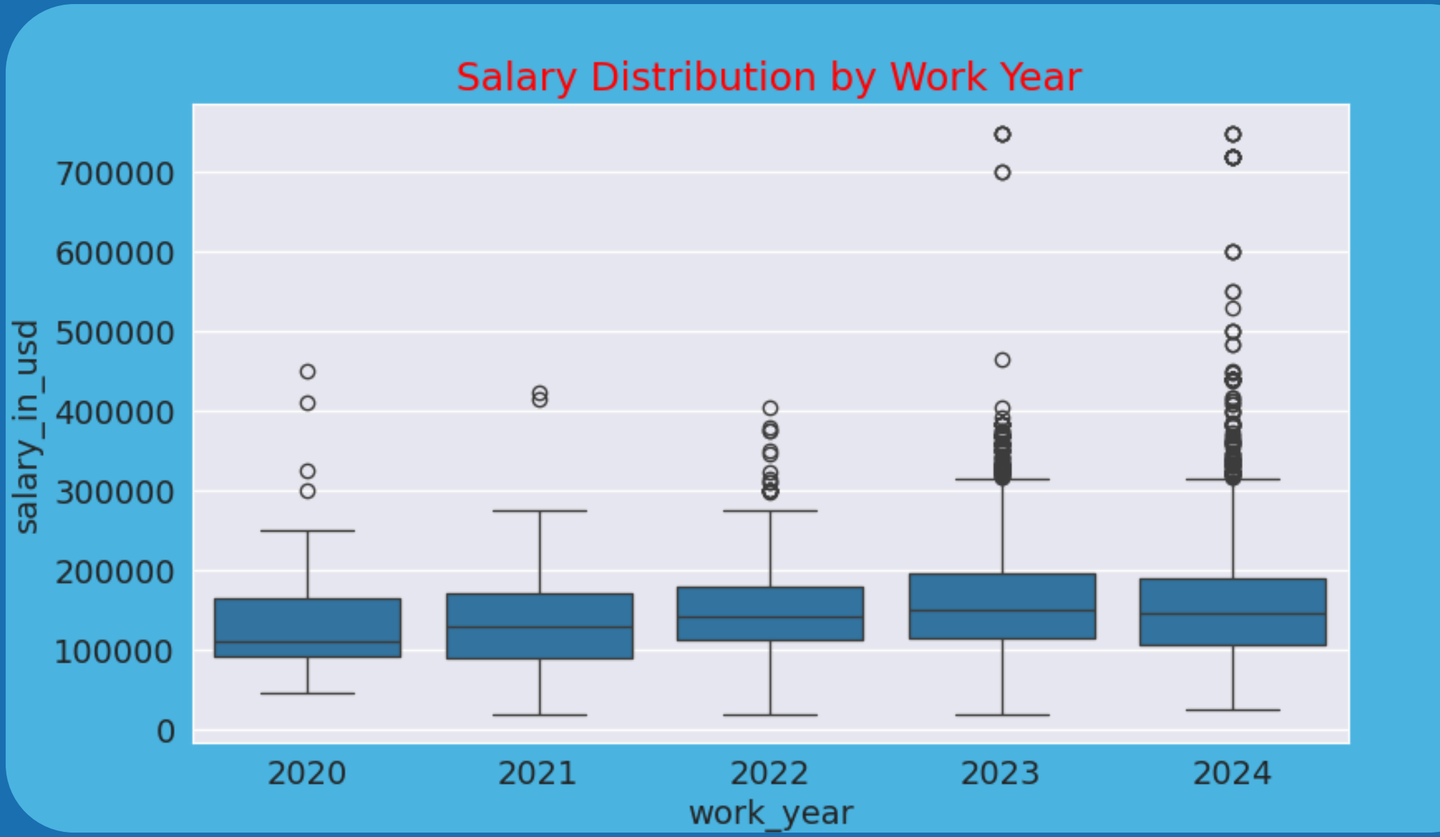
```
RangeIndex: 16494 entries, 0 to 16493
Data columns (total 11 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   work_year           16494 non-null  int64
 1   experience_level    16494 non-null  category
 2   employment_type     16494 non-null  category
 3   job_title           16494 non-null  category
 4   salary              16494 non-null  int64
 5   salary_currency     16494 non-null  category
 6   salary_in_usd       16494 non-null  int64
 7   employee_residence  16494 non-null  category
 8   remote_ratio        16494 non-null  int64
 9   company_location    16494 non-null  category
 10  company_size        16494 non-null  category
dtypes: category(7), int64(4)
memory usage: 656.4 KB
None
```

14478 entries, 4 categorical features.

```
Index: 14478 entries, 2 to 16492
Data columns (total 7 columns):
 #   Column              Non-Null Count  Dtype
---  ------              --------------  -----
 0   work_year           14478 non-null  int64
 1   experience_level    14478 non-null  category
 2   employment_type     14478 non-null  category
 3   salary_in_usd       14478 non-null  int64
 4   employee_residence  14478 non-null  category
 5   remote_ratio        14478 non-null  int64
 6   company_size        14478 non-null  category
dtypes: category(4), int64(3)
memory usage: 512.3 KB
None
```

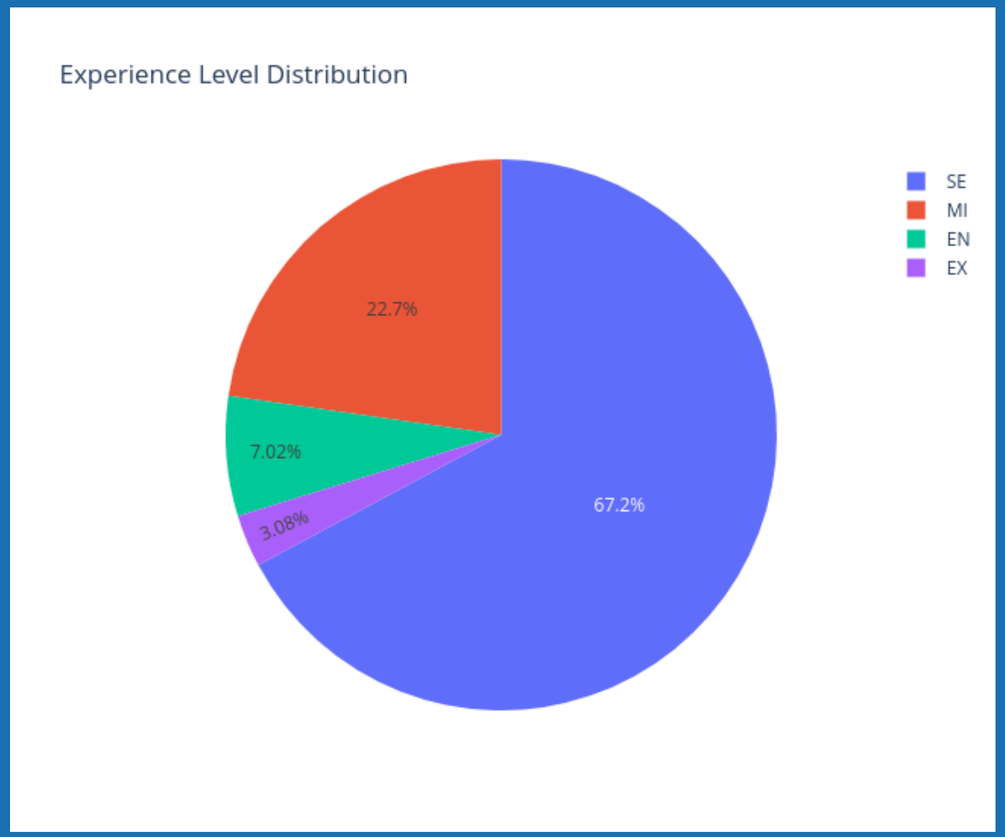
Visualization - Work Year

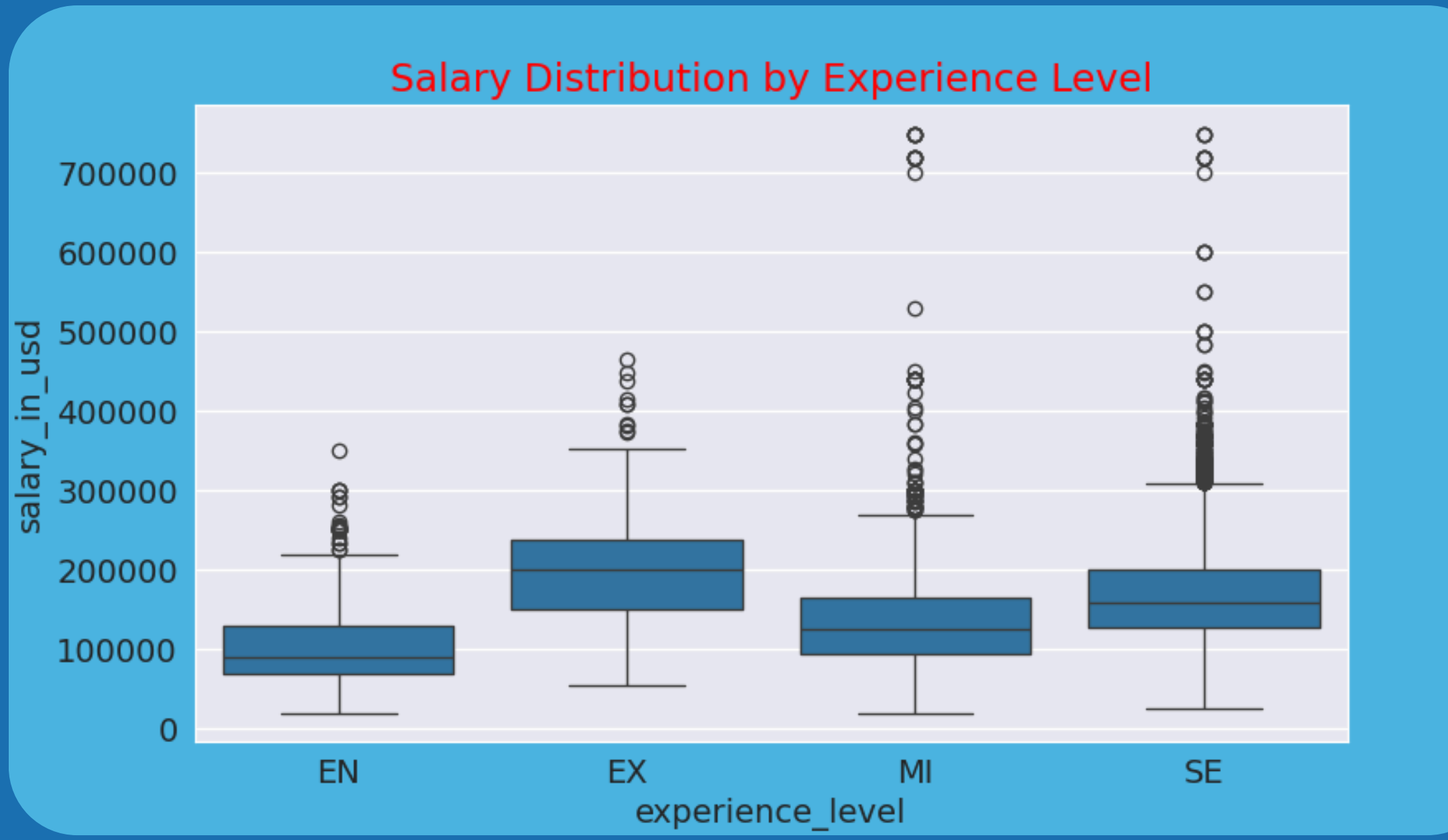




Visualization - Experience Level

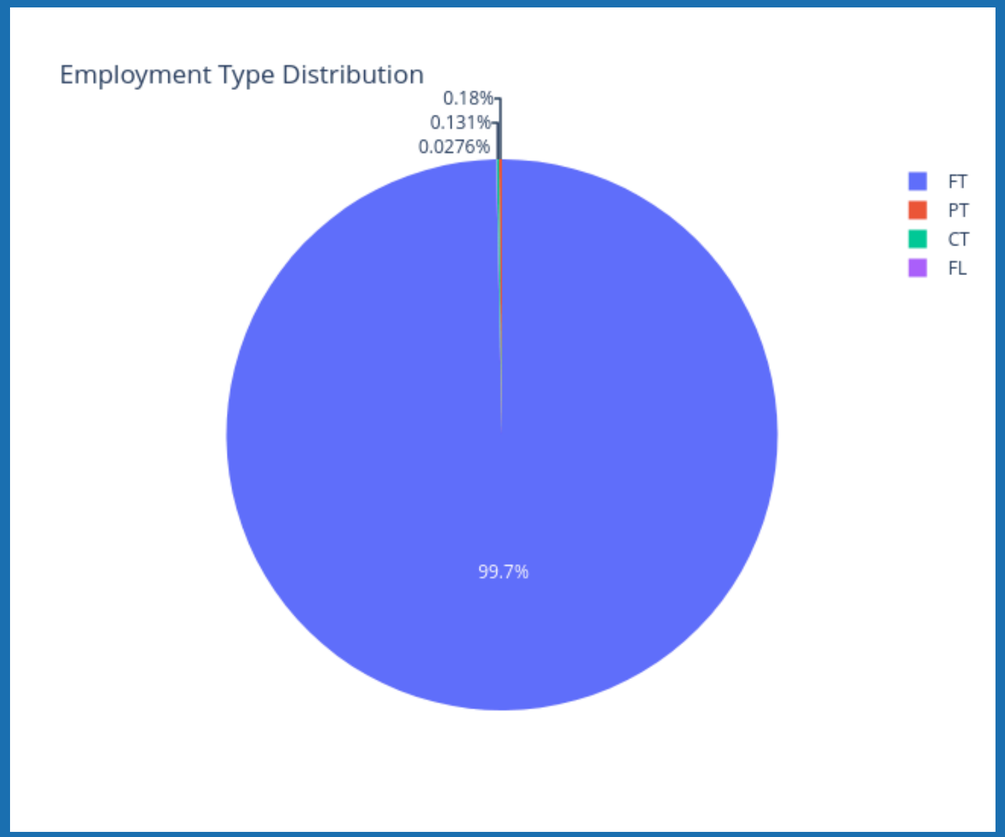
EN: Entry Level **SE: Senior Level**
MI: Mid Level **EX: Executive Level**

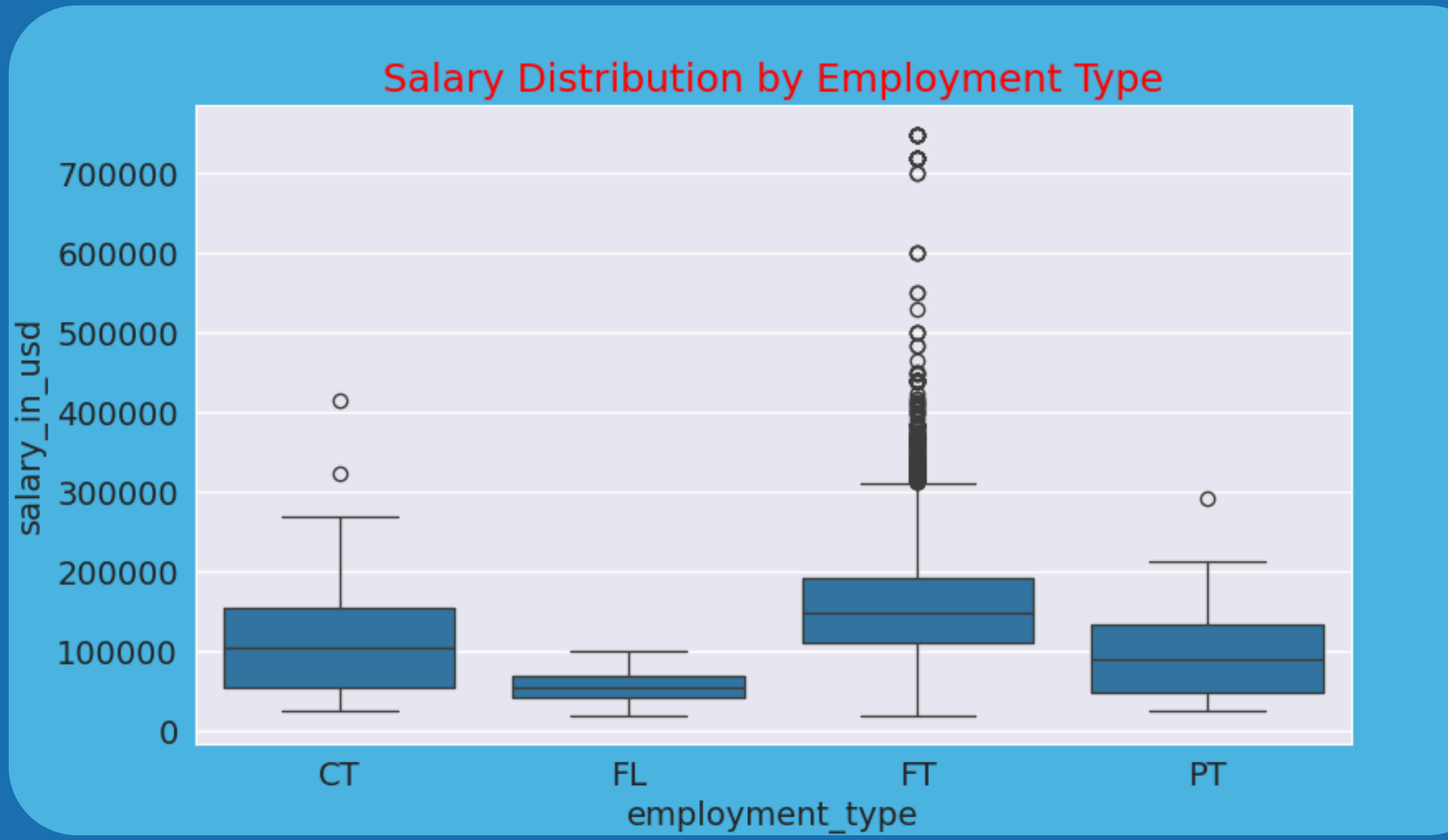




Visualization - Employment Type

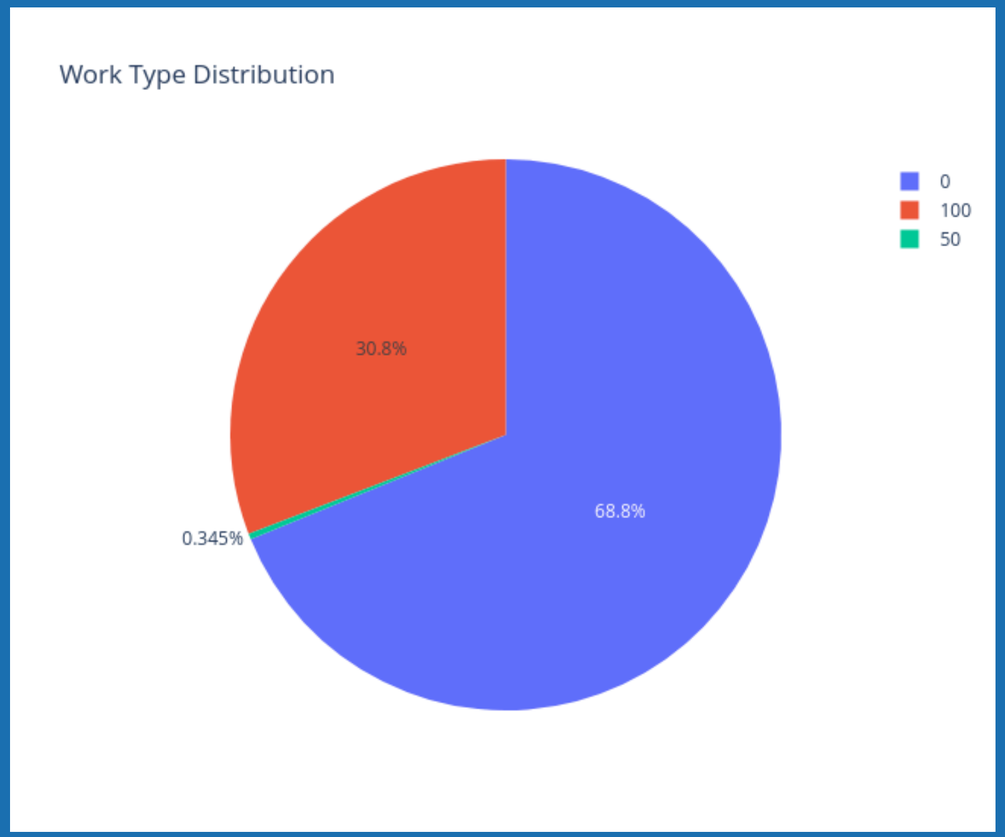
FL: Freelancer
CT: Contract basis
PT: Part Time
FT: Full Time





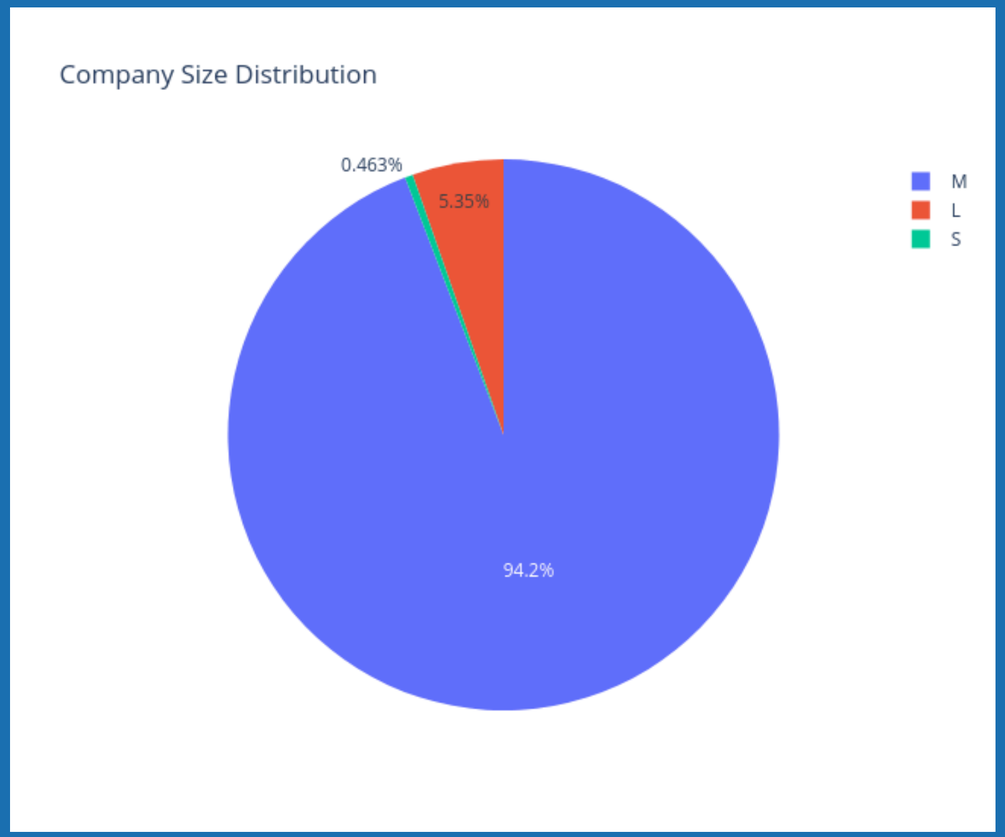
Visualization - Work Type

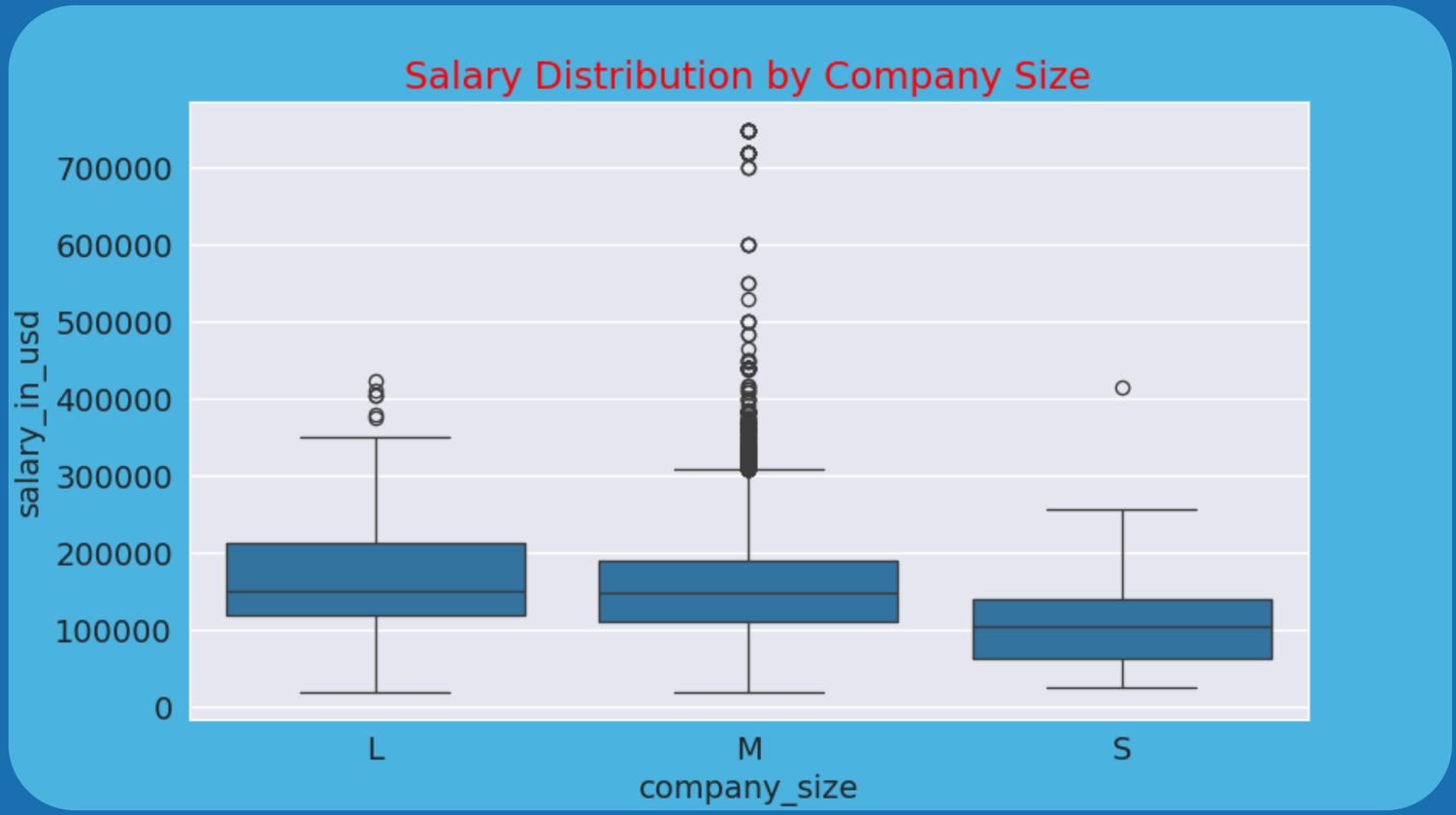
0: Office Work
50: Hybrid
100: Work from Home



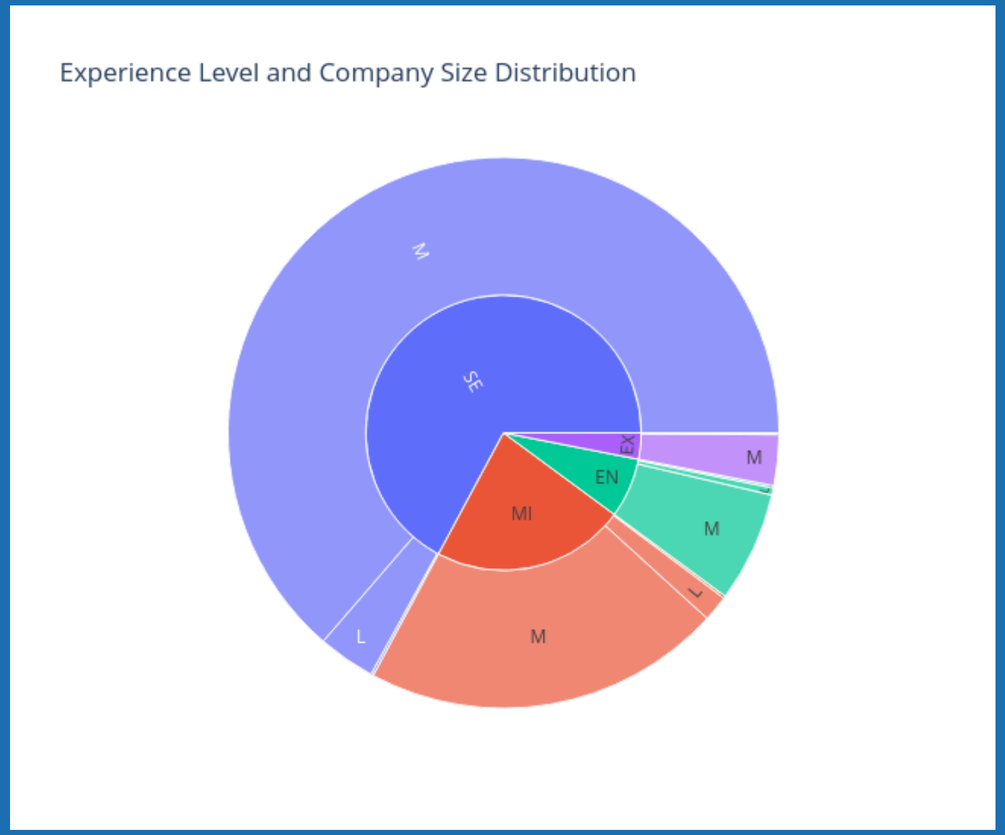
Visualization - Company Size

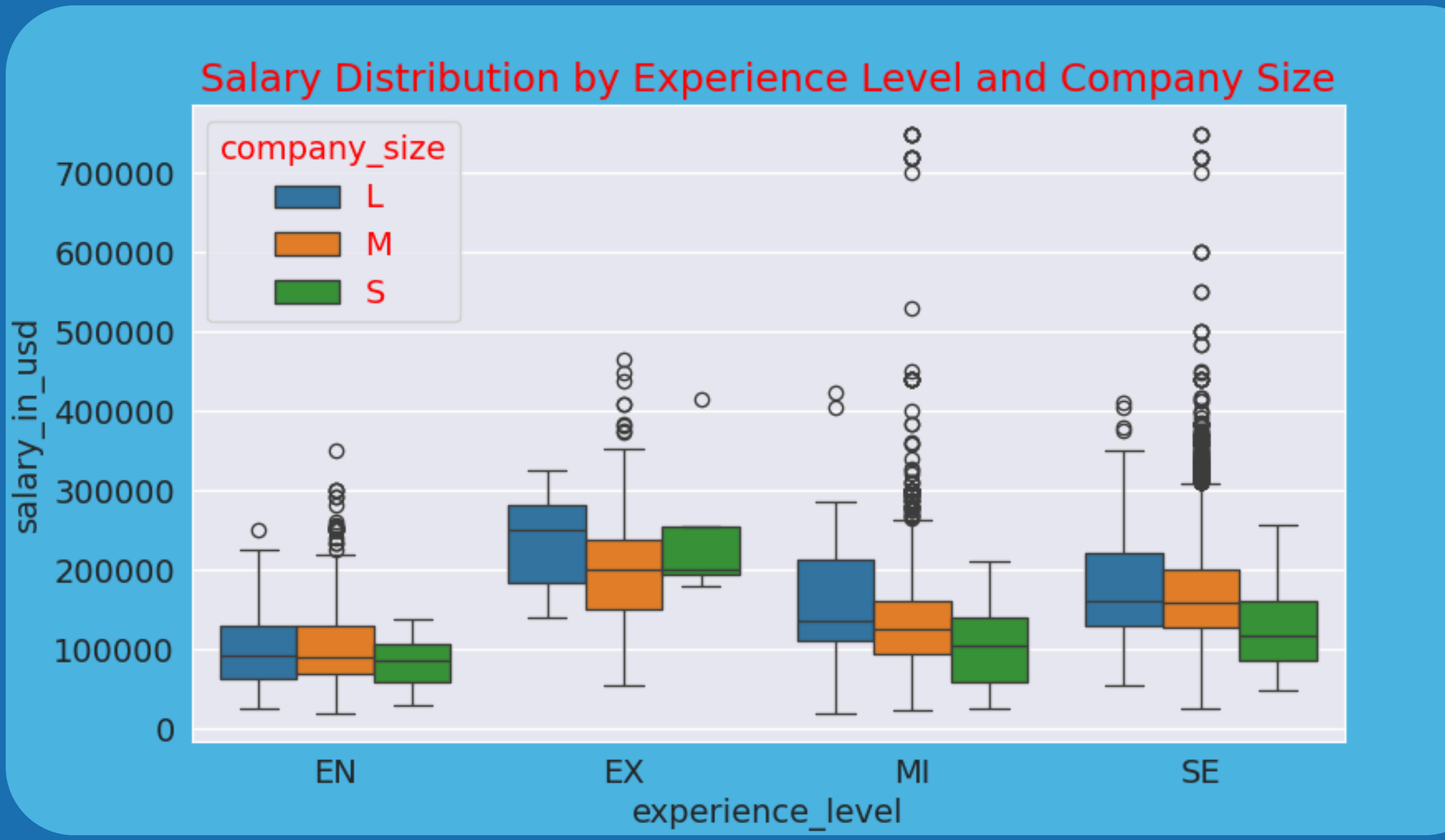
S: Small
M: Medium
L: Large





Visualization - Company Size ~ Experience Level





Hypothesis Setting

- Want to know that if there is an impact on salary by
  - company size
  - experience level

- Company size
  - Set $H_0 : \mu_1 = \mu_2 = \mu_3$ against $H_1 : H_0$ is NOT true

- Experience level
  - Set $H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$ against $H_1 : H_0$ is NOT true

Introduction - Summarization

Company Size

company_size <fctr>	group_size <int>	mean_salary <dbl>	var_salary <dbl>
L	775	163876.5	4180752190
M	13636	156768.4	4318185977
S	67	114857.2	4259542012

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	163877	2358	69.486	< 2e-16
data$company_sizeM	-7108	2424	-2.932	0.00338
data$company_sizeS	-49019	8361	-5.863	4.64e-09

<--- Raw data

company_size <fctr>	group_size <int>	mean_salary <dbl>	var_salary <dbl>
L	769	162034.2	3772159152
M	13343	151866.3	3049765625
S	66	110294.4	2908749533

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	162034	2004	80.856	< 2e-16
processed_data$company_sizeM	-10168	2061	-4.934	8.16e-07
processed_data$company_sizeS	-51740	7128	-7.259	4.11e-13

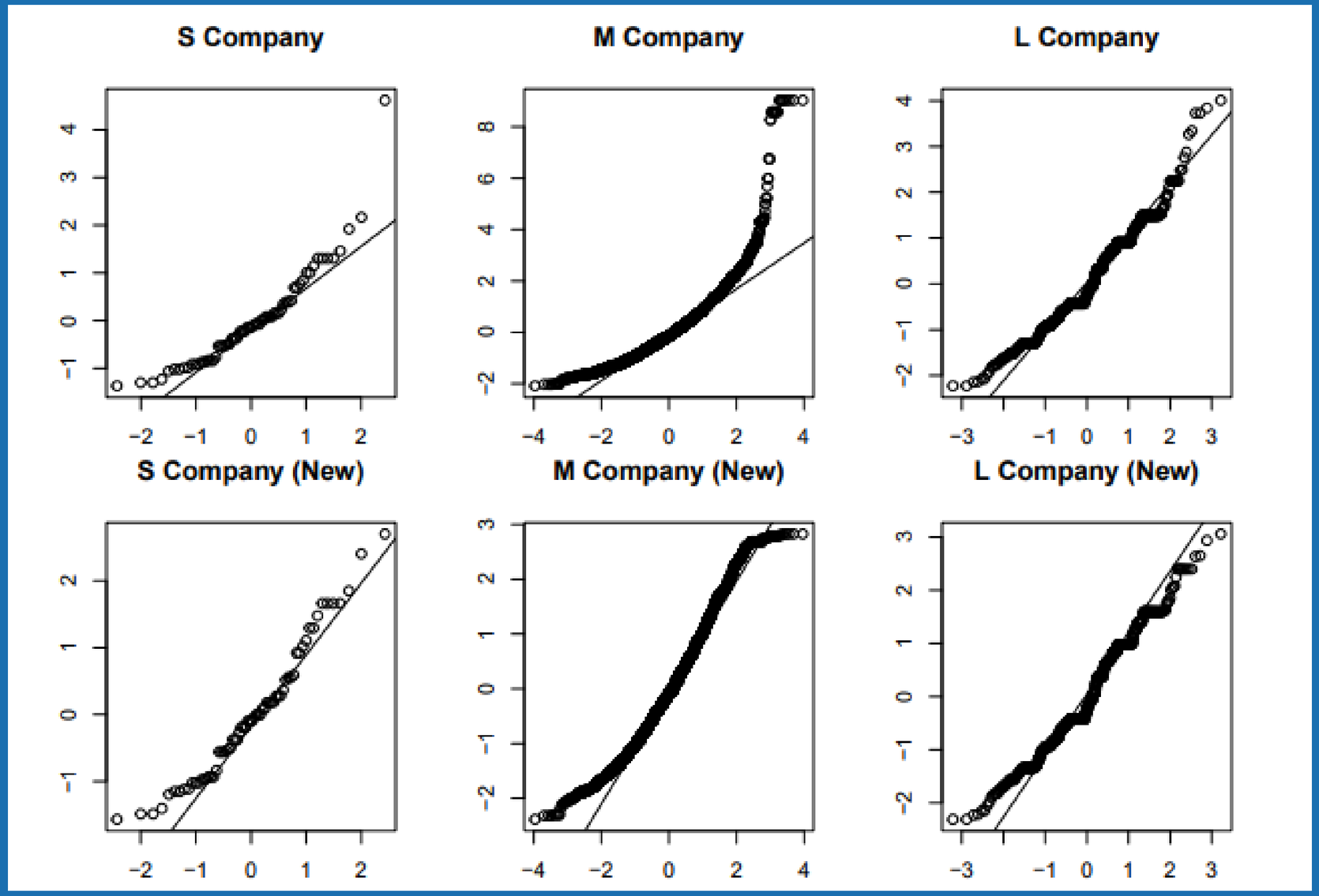
<--- Processed data

remove the outlier that outside

[Q1 - 1.5 IQR , Q3+1.5 IQR]

Model Diagnostics - Normality

Company Size



<--- Raw data

<--- Processed data

remove the outlier that outside
[Q1 - 1.5 IQR , Q3+1.5 IQR]

Model Diagnostics - Homogeneity

Company Size

```
Levene's Test for Homogeneity of Variance (center = mean)
         Df F value   Pr(>F)
group     2  4.7596 0.008582 **
      14475
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

<--- Raw data

```
Levene's Test for Homogeneity of Variance (center = mean)
         Df F value    Pr(>F)
group     2  20.242 1.666e-09 ***
      14175
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

<--- Processed data

remove the outlier that outside

[Q1 - 1.5 IQR , Q3+1.5 IQR]

ANOVA

Company Size

```
                Df    Sum Sq   Mean Sq F value   Pr(>F)
company_size     2 1.563e+11 7.817e+10   18.14 1.36e-08 ***
Residuals    14475 6.240e+13 4.311e+09
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

<--- Raw data

```
                Df    Sum Sq   Mean Sq F value   Pr(>F)
company_size     2 1.917e+11 9.587e+10   31.05 3.52e-14 ***
Residuals    14175 4.378e+13 3.088e+09
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

<--- Processed data

remove the outlier that outside [Q1 - 1.5 IQR , Q3+1.5 IQR]

Introduction - Summarization

Experience Level

experience_level <fctr>	group_size <int>	mean_salary <dbl>	var_salary <dbl>
EN	1017	102587.1	2216775262
EX	446	200829.7	4753351772
MI	3291	135429.4	4232276146
SE	9724	167913.8	3877693626

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	102587	1950	52.60	<2e-16
data$experience_levelEX	98243	3532	27.81	<2e-16
data$experience_levelMI	32842	2232	14.72	<2e-16
data$experience_levelSE	65327	2050	31.87	<2e-16

<--- Raw data

experience_level <fctr>	group_size <int>	mean_salary <dbl>	var_salary <dbl>
EN	992	98559.14	1591651109
EX	436	196034.46	3813384376
MI	3224	129911.32	2304660037
SE	9501	163198.42	2824313693

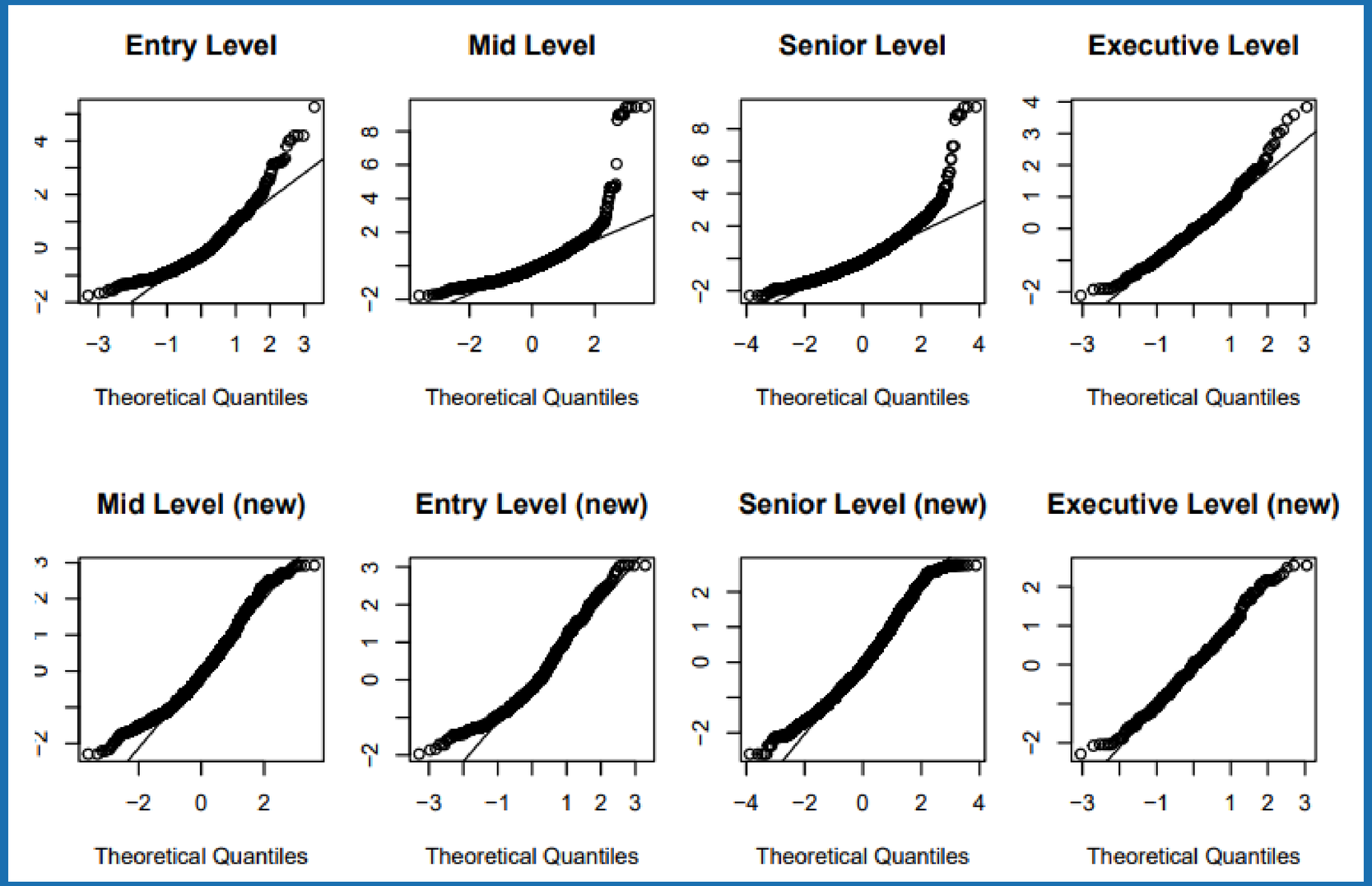
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	98559	1634	60.30	<2e-16
processed_data$experience_levelEX	97475	2958	32.95	<2e-16
processed_data$experience_levelMI	31352	1869	16.77	<2e-16
processed_data$experience_levelSE	64639	1718	37.63	<2e-16

<--- Processed data

remove the outlier that outside [Q1 - 1.5 IQR , Q3+1.5 IQR]

Model Diagnostics - Normality

Experience Level



<--- Raw data

<--- Processed data

remove the outlier that outside [Q1 - 1.5 IQR , Q3+1.5 IQR]

Model Diagnostics - Homogeneity

Experience Level

```
Levene's Test for Homogeneity of Variance (center = mean)
         Df F value    Pr(>F)
group     3  26.702 < 2.2e-16 ***
      14474
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

<--- Raw data

```
Levene's Test for Homogeneity of Variance (center = mean)
         Df F value    Pr(>F)
group     3  55.746 < 2.2e-16 ***
      14149
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

<--- Processed data

remove the outlier that outside
[Q1 - 1.5 IQR , Q3+1.5 IQR]

ANOVA

Experience Level

```
                    Df    Sum Sq   Mean Sq F value Pr(>F)
experience_level     3 6.557e+12 2.186e+12     565 <2e-16 ***
Residuals        14474 5.599e+13 3.869e+09
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

<--- Raw data

```
                    Df    Sum Sq   Mean Sq F value Pr(>F)
experience_level     3 6.443e+12 2.148e+12   810.4 <2e-16 ***
Residuals        14149 3.750e+13 2.650e+09
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

<--- Processed data

remove the outlier that outside
[Q1 - 1.5 IQR , Q3+1.5 IQR]

Conclusion

- **The size of a company has an impact on salaries.**
  - **The difference between the size “M” and “L” is smaller than the difference between “S” and the others.**
- **The experience level has a significant impact on salaries.**
- **Kick out the outliers may lead to**
  - **increase the normality.**
  - **worsen the homogeneity of variance.**
  - **make the results of ANOVA more significant.**

Reference

- **Dataset: Machine Learning Engineer Salary in 2024**
- **Article reference: Data Scientist Job Salaries Analysis**

Group 9

May 16th 2024

THANKS FOR LISTENING