

Statistical Analysis

LU7 – ANOVA

Tutorial: One-way ANOVA with JMP Pro 16

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Contents

Introduction	4
Exploratory data analysis and normality	5
ANOVA and associated tests.....	7

List of Tables

Table 1: Data from Example 1 in stacked format	4
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List of Figures

Figure 1: “Distribution” window	5
Figure 2: Partial output of the exploratory analysis of the Cost variable, further options are available in the circled “red arrow” menu	5
Figure 3: Request normality tests from the “red arrow” menu of “Fitted Normal Distribution”	6
Figure 4: “Fit Y by X” window	7
Figure 5: Request ANOVA and associated tests in the “red arrow” menu of “Oneway Analysis of Cost by Institute”	8

Introduction

This tutorial exemplifies the use of JMP Pro 16 to apply the tests associated with the ANOVA process¹ using the data from Example 1:

A governmental department is concerned with the increased costs occurring within the R&D projects that are commissioned to institutes A, B, C and D. It was then decided to analyse the costs associated with different projects, calculating for each one of them the ratio between the incurred final cost and the cost initially indicated in the budget. For each project, the two costs were expressed on a constant basis. Do the four institutes have a distinct global behaviour in relation to the increasing of the costs?

The data must be imported to JMP in stacked format (Table 1).

Table 1: Data from Example 1 in stacked format

Cost	Institute
1	A
0.8	A
1.9	A
1.1	A
2.7	A
1.7	B
2.5	B
3	B
2.2	B
3.7	B
1.9	B
1	C
1.3	C
3.2	C
1.4	C
1.3	C
2	C
3.8	D
2.8	D
1.9	D
3	D
2.5	D

¹ Costa, A. C. (2019). *One-way ANOVA process and nonparametric counterparts*. NOVA Information Management School, Universidade Nova de Lisboa, <https://doi.org/10.13140/RG.2.2.25687.47520/1>.

Exploratory data analysis and normality

After importing the data from Excel, follow these steps to request an exploratory data analysis of the Cost variable for each Institute:

1. Select the Distribution option from the **Analyze menu**.
2. Select the Cost variable and press the “Y, Columns” button, then select the Institute variable and press the “By” button (Figure 1) and click OK.

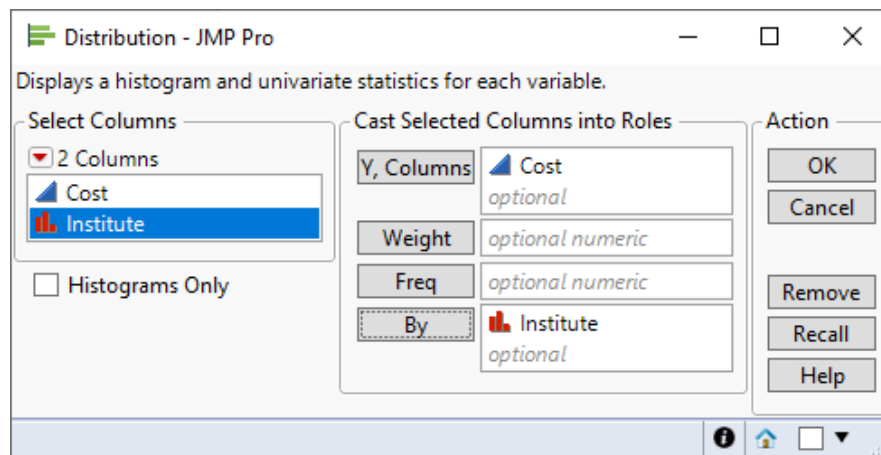


Figure 1: “Distribution” window

The output exhibits descriptive statistics, histograms, and boxplots with outliers, but many other analyses are available in the “red arrow” menu of each Cost analysis (Figure 2).

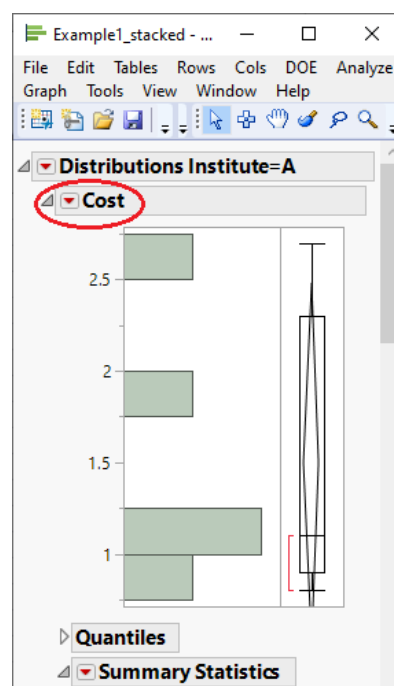


Figure 2: Partial output of the exploratory analysis of the Cost variable, further options are available in the circled “red arrow” menu

To apply normality tests, follow these steps:

1. In the “red arrow” menu of the Cost analysis (Figure 2), select **Continuous fit > Enable Legacy Fitters**.
2. In the “red arrow” menu of the Cost analysis (Figure 2), select **Continuous fit > Fit Normal**.
3. In the “red arrow” menu of “Fitted Normal Distribution” (Figure 3), select the **Goodness of Fit** option. The **Shapiro-Wilk** and the Anderson-Darling tests results will be displayed.

Repeat the previous steps for each group (Institute) of the response variable (Cost).

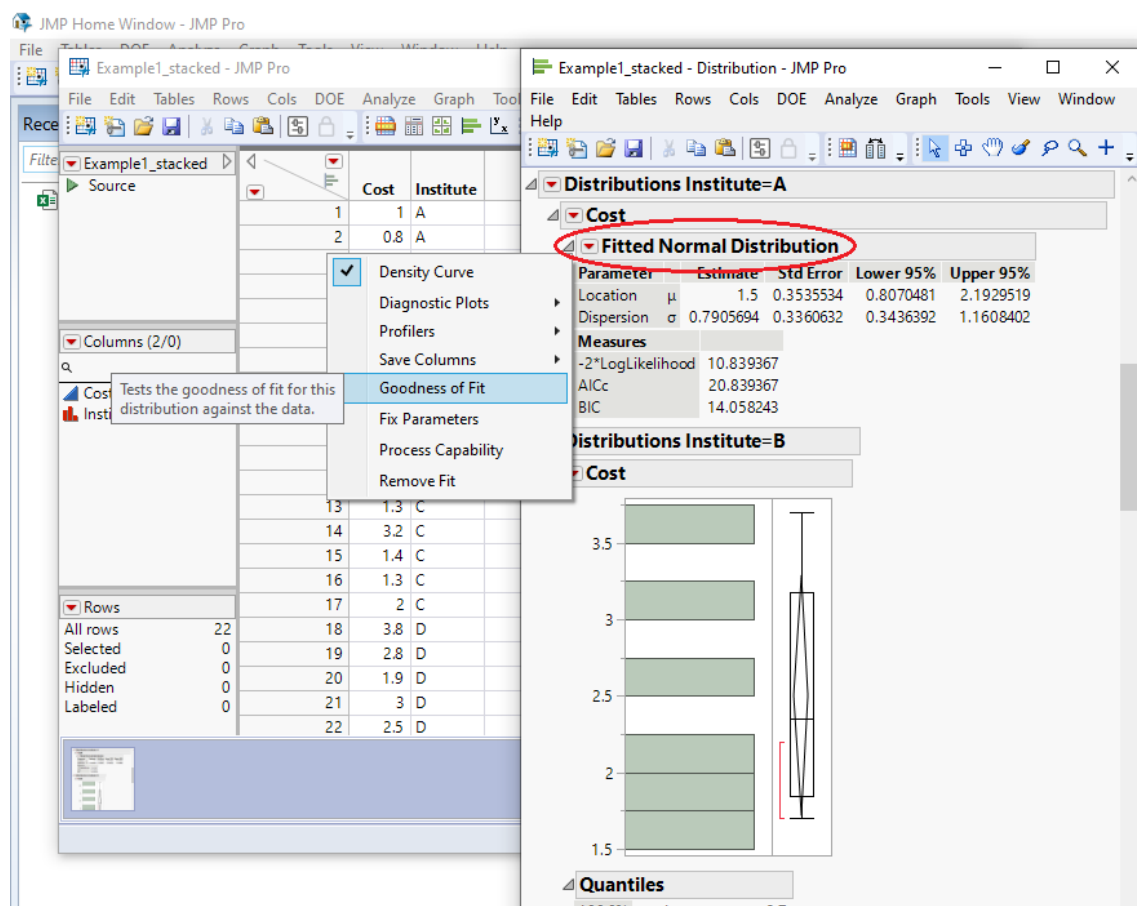


Figure 3: Request normality tests from the “red arrow” menu of “Fitted Normal Distribution”

ANOVA and associated tests

To perform the ANOVA and associated tests, follow the steps below.

1. Select the Fit Y by X option from the **Analyze** menu.
2. Select the Cost variable and press the “Y, Response” button, then select the Institute variable and press the “X, Factor” button (Figure 4) and click OK.

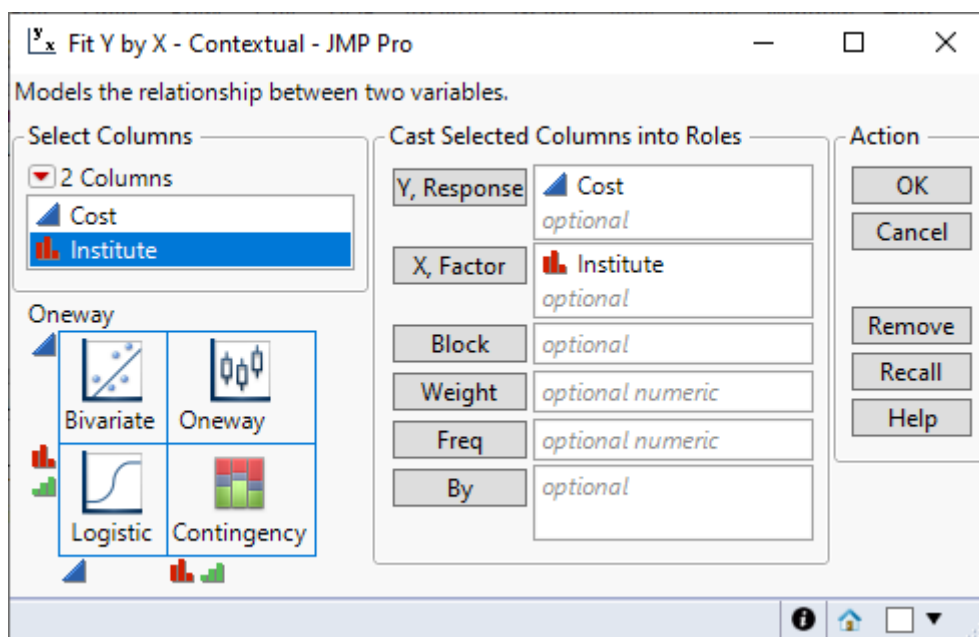


Figure 4: “Fit Y by X” window

3. In the “red arrow” menu of the “Oneway Analysis of Cost by Institute” (Figure 5), select:
 - **Unequal Variances** → displays the results of homoscedasticity tests, such as the **Levene test**, as well as the **Welch’s test** to compare the means of Normal populations allowing for heteroscedasticity.
 - **Means/ANOVA** → displays the results of the **One-way ANOVA**.
 - **Compare Means > All pairs, Tukey HSD** → displays the results of the **Tukey’s HSD test** (and **Tukey-Kramer’s test**).
 - **Nonparametric > Wilcoxon Test** → displays the results of the **Kruskal-Wallis test**.
 - **Nonparametric > Nonparametric Multiple Comparisons > Steel-Dwass All Pairs** → displays the results of the **Steel-Dwass test** on each pair (nonparametric version of the “All Pairs, Tukey HSD” option)².

² For further details, please see the JMP Help documentation on [Nonparametric Multiple Comparisons](#) (accessed: 24 November 2021).

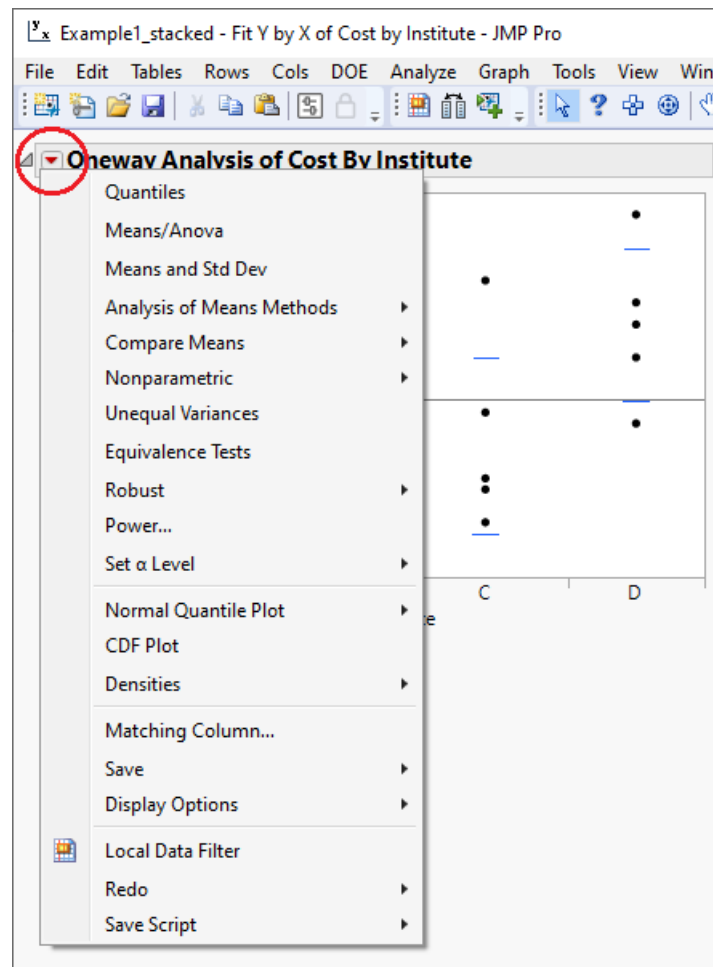


Figure 5: Request ANOVA and associated tests in the “red arrow” menu of “Oneway Analysis of Cost by Institute”