Analysis 7 – TCP technique granularity.
1 factor (technique granularity) and 4 treatments (statement, branch, block and (method and function)).

H0 – The means of TCP techniques execution results obtained using branch, statement, block and method/function granularity are equal.
H1 – The means of TCP techniques execution results obtained using branch, statement, block and method/function granularity are significantly different.

Data is available here.

Normality test:
As the sample has 216 values, Kolmogorov-Smirnov test is used.
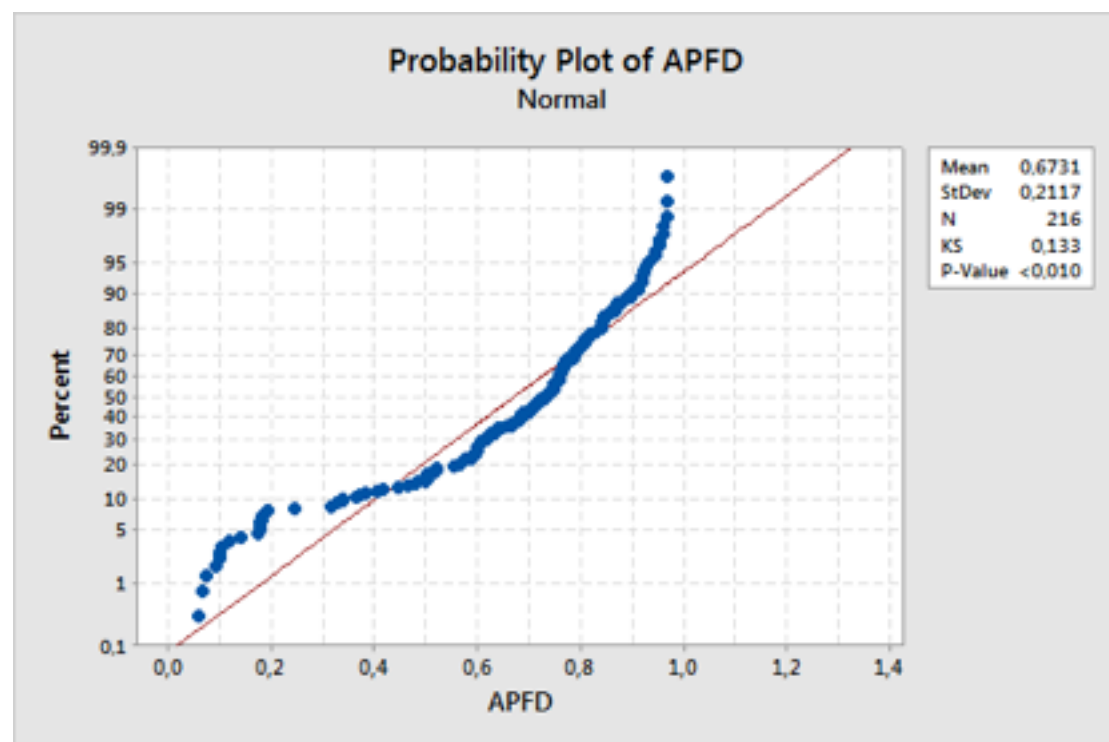
Given that the p-value is < 0.010, which is less than the established level of significance 0.05, the sample has a non normal distribution.

As the distribution is not normal, a non-parametric hypothesis test is used. In this case, we use Kruskal-Wallis test.

Kruskal-Wallis Test: APFD versus GRANULARITY

```
Kruskal-Wallis Test on APFD

GRANULARITY       N  Median  Ave Rank      Z
block            37  0,7550     128,1   2,10
branch           40  0,7480     111,9   0,38
method/function  58  0,7665     126,6   2,58
statement        81  0,6370      84,9  -4,30
Overall         216              108,5
```

```
H = 20,19   DF = 3   P = 0,000
H = 20,19   DF = 3   P = 0,000   (adjusted for ties)
```

A p-value of 0,00, which is less than the established significance level of 0.05, indicates that the null hypothesis can be rejected, thus, accepting the alternative hypothesis that TCP technique granularity has a significant effect on APFD results.

In order to evaluate the difference across treatments (granularities) we perform paired-treatment hypothesis tests.
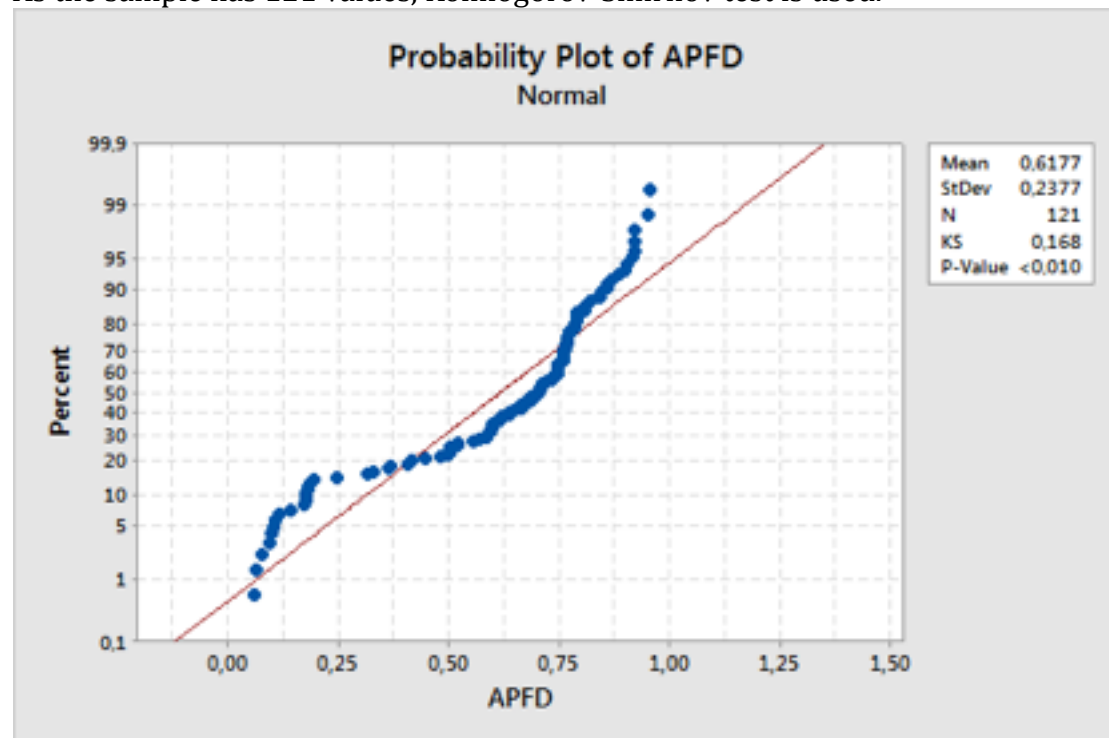
Analysis 7.1 – statement vs. Branch
H0 – Statement and branch means are equal.
H1 – Statement and branch means are different.

Data is available here.

Normality
As the sample has 121 values, Kolmogorov-Smirnov test is used.

Given that the p-value is < 0.010, which is less than the established level of significance 0.05, the sample has a non normal distribution.

As the distribution is not normal, a non-parametric hypothesis test is used. In this case, we use Kruskal-Wallis test.

Kruskal-Wallis Test: APFD versus GRANULARITY

```
Kruskal-Wallis Test on APFD

GRANULARITY    N   Median   Ave Rank      Z
branch        40   0,7480      72,3    2,50
statement     81   0,6370      55,4   -2,50
Overall      121              61,0
```

```
H = 6,26  DF = 1  P = 0,012
H = 6,26  DF = 1  P = 0,012  (adjusted for ties)
```
A p-value of 0,012, which is less than the established significance level of 0.05, indicates that the null hypothesis can be rejected, thus, accepting the alternative hypothesis that statement and branch means are different.
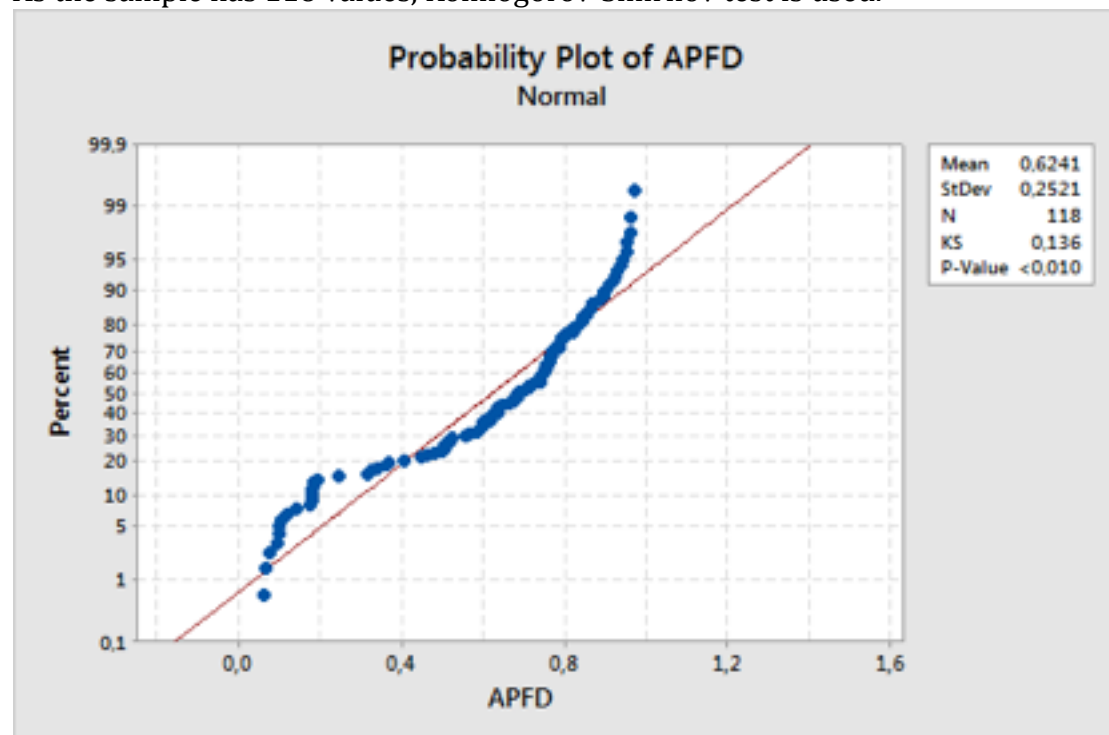
Analysis 7.2 – statement vs. Block
H0 – Statement and block means are equal.
H1 – Statement and block means are different.

Data is available here.

Normality
As the sample has 118 values, Kolmogorov-Smirnov test is used.

Given that the p-value is < 0.010, which is less than the established level of significance 0.05, the sample has a non normal distribution.

As the distribution is not normal, a non-parametric hypothesis test is used. In this case, we use Kruskal-Wallis test.

Kruskal-Wallis Test: APFD versus GRANULARITY

```
Kruskal-Wallis Test on APFD

GRANULARITY    N   Median  Ave Rank     Z
block         37   0,7550     75,2   3,36
statement     81   0,6370     52,3  -3,36
Overall      118              59,5

H = 11,32  DF = 1  P = 0,001
H = 11,32  DF = 1  P = 0,001  (adjusted for ties)
```

A p-value of 0,001, which is less than the established significance level of 0.05, indicates that the null hypothesis can be rejected, thus, accepting the alternative hypothesis that statement and block means are different.

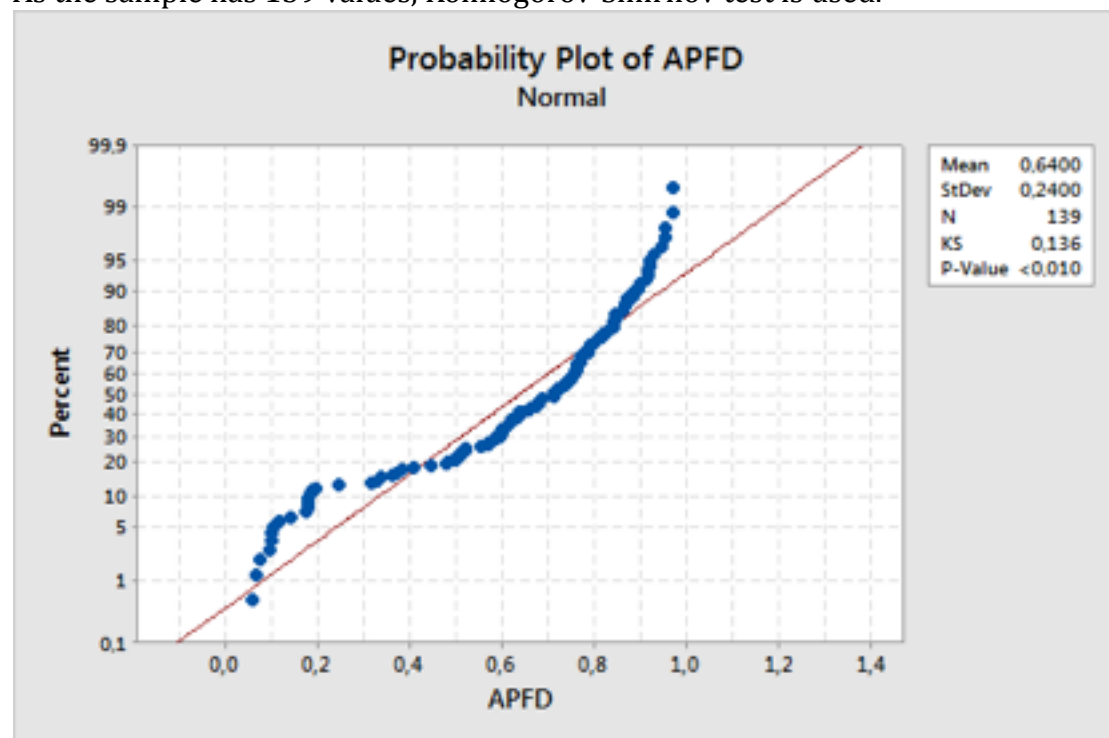Analysis 7.3 – statement vs. Function/method
H0 – Statement and function/method means are equal.
H1 – Statement and function/method means are different.

Data is available here.

Normality
As the sample has 139 values, Kolmogorov-Smirnov test is used.

Given that the p-value is < 0.010, which is less than the established level of significance 0.05, the sample has a non normal distribution.

As the distribution is not normal, a non-parametric hypothesis test is used. In this case, we use Kruskal-Wallis test.

Kruskal-Wallis Test: APFD versus GRANULARITY

```
Kruskal-Wallis Test on APFD

GRANULARITY        N   Median   Ave Rank      Z
method/function   58   0,7665      85,1    3,75
statement         81   0,6370      59,2   -3,75
Overall          139                70,0

H = 14,08   DF = 1   P = 0,000
H = 14,08   DF = 1   P = 0,000   (adjusted for ties)
```

A p-value of 0,000, which is less than the established significance level of 0.05, indicates that the null hypothesis can be rejected, thus, accepting the alternative hypothesis that statement and method/function means are different.
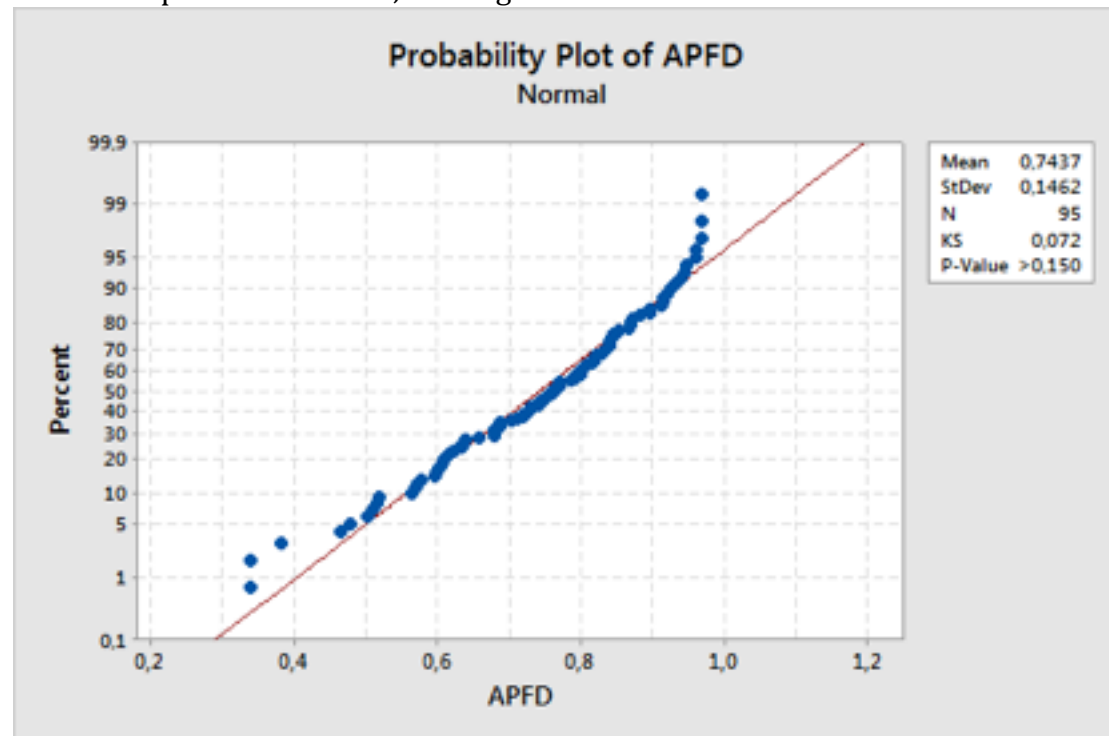
Analysis 7.4 – block vs. function/method
H0 – Block and function/method means are equal.
H1 – Block and function/method means are different.

Data is available here.

Normality
As the sample has 95 values, Kolmogorov-Smirnov test is used.

Given that the p-value is > 0.150, which is bigger than the established level of significance 0.05, the sample has a normal distribution.

As the distribution is normal, a parametric hypothesis test is used. In this case, we use one-way ANOVA test.
One-way ANOVA: APFD versus GRANULARITY

```
Method

Null hypothesis        All means are equal
Alternative hypothesis  At least one mean is different
Significance level     α = 0,05

Equal variances were assumed for the analysis.

Factor Information
Factor        Levels  Values
GRANULARITY       2  block; method/function

Analysis of Variance

Source        DF   Adj SS    Adj MS  F-Value  P-Value
GRANULARITY    1  0,00095  0,000955     0,04    0,834
Error         93  2,00871  0,021599
```

```
Total        94  2,00967


Model Summary

       S   R-sq  R-sq(adj)  R-sq(pred)
0,146966  0,05%      0,00%       0,00%


Means

GRANULARITY       N    Mean   StDev        95% CI
block            37  0,7476  0,1534  (0,6996; 0,7956)
method/function  58  0,7411  0,1428  (0,7028; 0,7794)

Pooled StDev = 0,146966
```

A p-value of 0,834, which is bigger than the established significance level of 0.05, indicates that the null hypothesis can not be rejected, thus, accepting it. Thus, we can say that there is no significant difference between block and method/function means.
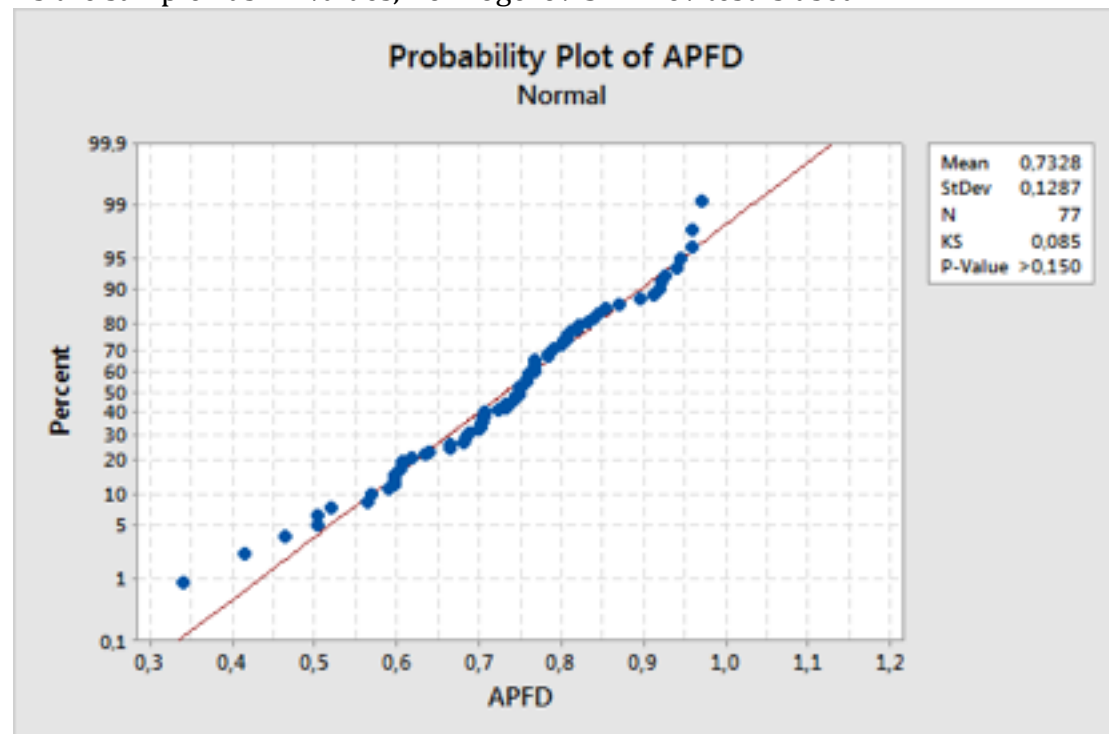
Analysis 7.5 – branch vs. Block
H0 – Branch and block means are equal.
H1 – Branch and block means are different.

Data is available here.

Normality
As the sample has 77 values, Kolmogorov-Smirnov test is used.

Given that the p-value is > 0.150, which is bigger than the established level of significance 0.05, the sample has a normal distribution.

As the distribution is normal, a parametric hypothesis test is used. In this case, we use one-way ANOVA test.

One-way ANOVA: APFD versus GRANULARITY

```
Method

Null hypothesis        All means are equal
Alternative hypothesis  At least one mean is different
Significance level     α = 0,05

Equal variances were assumed for the analysis.


Factor Information

Factor        Levels  Values
GRANULARITY        2  block; branch


Analysis of Variance

Source        DF  Adj SS   Adj MS  F-Value  P-Value
GRANULARITY    1  0,01575  0,01575    0,95    0,333
Error         75  1,24323  0,01658
Total         76  1,25898


Model Summary

       S   R-sq  R-sq(adj)  R-sq(pred)
0,128750  1,25%      0,00%       0,00%


Means

GRANULARITY    N    Mean   StDev        95% CI
block         37  0,7476  0,1534  (0,7055; 0,7898)
branch        40  0,7190  0,1008  (0,6784; 0,7596)

Pooled StDev = 0,128750
```

A p-value of 0,333, which is bigger than the established significance level of 0.05, indicates that the null hypothesis can not be rejected, thus, accepting it. Thus, we can say that there is no significant difference between block and branch means.

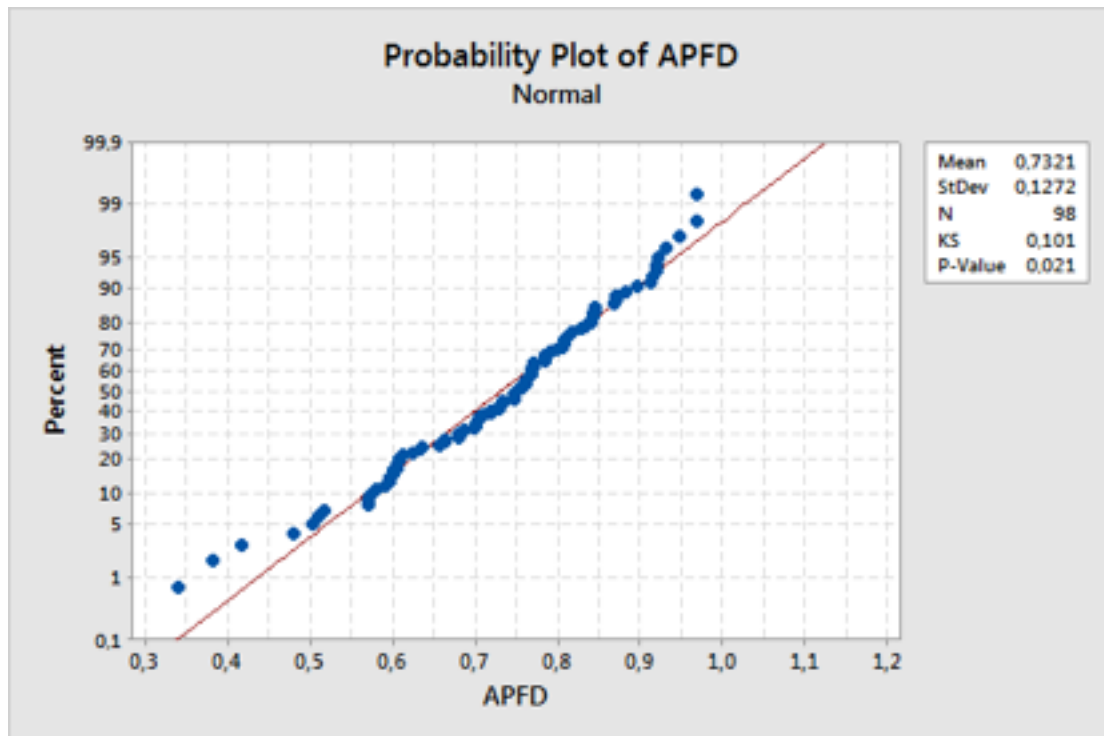Analysis 7.6 – branch vs. Function/method

H0 – Branch and function/method means are equal.
H1 – Branch and function/method means are different.

Data is available here.

Normality
As the sample has 98 values, Kolmogorov-Smirnov test is used.

Given that the p-value is 0.021, which is less than the established level of significance 0.05, the sample has a non normal distribution.

As the distribution is not normal, a non-parametric hypothesis test is used. In this case, we use Kruskal-Wallis test.

Kruskal-Wallis Test: APFD versus GRANULARITY

```
Kruskal-Wallis Test on APFD

GRANULARITY       N  Median  Ave Rank      Z
branch           40  0,7480      44,5  -1,44
method/function  58  0,7665      52,9   1,44
Overall          98                49,5

H = 2,08  DF = 1  P = 0,149
H = 2,08  DF = 1  P = 0,149  (adjusted for ties)
```

A p-value of 0,333, which is bigger than the established significance level of 0.05, indicates that the null hypothesis can not be rejected, thus, accepting it. Thus, we can say that there is no significant difference between branch and method/function means.

Summary of results for paired comparison:

Comparison	P-value	Significant
statement vs branch	0,012	Yes
statement vs block	0,001	Yes
statement vs method/function	0,000	Yes
block vs method/function	0,834	No

branch vs block	0,333	No
branch vs method/function	0,149	No

Granularity	APFD mean	Grouping
block	0,7550	A
branch	0,7480	A
method/function	0,7665	A
statement	0,6370	B