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Bivariate Linear Regression Analysis of Impact of Faults on OO Software

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ABSTRACT

In this research paper two variable linear regression analysis of impact of faults of the three projects InterCafe1, TermoProjekt1 and Zuzel1 are discussed. This means it is used to examine the usefulness of the metrics when used collectively. It informs the user about the levels of predictive performance that can be achieved. It also tells which metrics may play significant and more dominant role in predicting fault-proneness.

I.INTRODUCTION

Bivariate LR can be used to build a prediction model for the fault-proneness of classes. The Multivariate LR uses the combination of metrics to identify the effect on the dependent variable.

The following statistics are noted down for each of the metric

- **R^2 Statistic**- It is the proportion of the variance in the dependent variable that is explained by the variance of the independent variables. The large the effect of the model's explanatory variables, the better the accuracy of the given model.
- **R^2(adjusted)**–It is the modified version of R^2. It has been adjusted for the number of predictors in the model. If the value of adjusted R^2 increases, this means the new variable improves the model more than would be expected by chance. If the value decreases this means the new variable improves the model by less than expected by chance. This value is always smaller than the R^2.
- **Standard Error –** It is ameasure of the statistical accuracy of an estimate. The smaller values of the standard error indicate that the observations are closer to the fitted line and are better.

These statistics are analysed and reported using the SPSS package.In this research paper multivariate (two, three, four, five and six) variable linear regression analysis of impact of faults of the three projects InterCafe1, TermoProjekt1 and Zuzel1 are discussed.

II. REVIEW OF LITERATURE

N. Rajkumar et al. established the relationship, at class level, among object oriented metrics and fault proneness. The fault was taken as a function of DIT, CBO, WMC, NOC, RFC, and LCOM. All these metrics were of the CK metric suite. The authors showed that for prediction of fault proneness, conceptual relations between classes could be a excellent metric. The authors showed some of the coupling and inheritance measures through

multivariate analysis. They showed that it is possible to derive accurate models to predict the classes that contain most of the faults. They showed that when predicting fault prone classes, the best model shows 80% of correct classifications and finds over 90% of faulty classes.

Tang, M.H., Kao, M.H., & Chen, M.H. worked on an empirical study on object-oriented metrics. The study was based on three real-time systems. These systems contain several natural faults. The faults were classified into three categories namely object-oriented faults, object management faults and traditional faults. The study used CK metrics to validate these faults. The study used logistic regression analysis. The study revalidates CK metrics using three real-time systems. The authors found that WMC metric was a good indicator for faulty classes. The RFC metric was a good indicator for OO faults.

Briand, L., Daly, J., Porter, V., & Wust, J. worked on the comprehensive empirical validation of design measures for object-oriented systems. The study used descriptive statistics, principal component analysis, and univariate regression analysis against the fault data. The study concluded that the univariate analysis results have shown that many coupling and inheritance measures are strongly related to the probability of fault detection in a class. On the other hand, cohesion did not have a significant impact on fault-proneness.

III. OBJECTIVE

To study Bivariate analysis of object oriented metrics model for fault prediction to improve the performance of software product.

IV.BIVARIATELINEAR REGRESSION ANALYSIS

The objective of the bivariate linear regression analysis is to study how accurately the differentcombinations of considered metrics could predict the number-of-faults. We have selected various combinations of bivariate metrics as independent variables and variable "Bug" as dependent variable at a time to predict the faults.Table 1 gives the bivariate subsets regression analysis (i.e. values of R^2, R^2 (Adjusted) and Standard Error) for various combinations of metrics, when two metrics are considered as independent variables, in case of the project InterCafe1.

Table 1:Result of Bivariate Logistic Regression for InterCafe1

Combination of Metrics	R^2-Value	R^2-(adj) Value	Std. Error
WMC & RFC	0.494	0.452	0.527
WMC &CBO	0.526	0.487	0.510
WMC & LCOM	0.522	0.483	0.512
WMC & DIT	0.483	0.440	0.533
WMC & NOC	0.458	0.413	0.546
RFC & CBO	0.528	0.489	0.509
RFC & LCOM	0.509	0.468	0.519
RFC & DIT	**0.605**	**0.572**	**0.466**
RFC & NOC	0.442	0.395	0.554

CBO & LCOM	0.510	0.469	0.519
CBO & DIT	0.505	0.464	0.521
CBO & NOC	0.501	0.459	0.524
LCOM & DIT	0.137	0.065	0.689
LCOM & NOC	0.126	0.054	0.693
DIT & NOC	0.017	0.000	0.735

Figure 1: Comparison chart of R^2-(adj) Values for the project InterCafe1

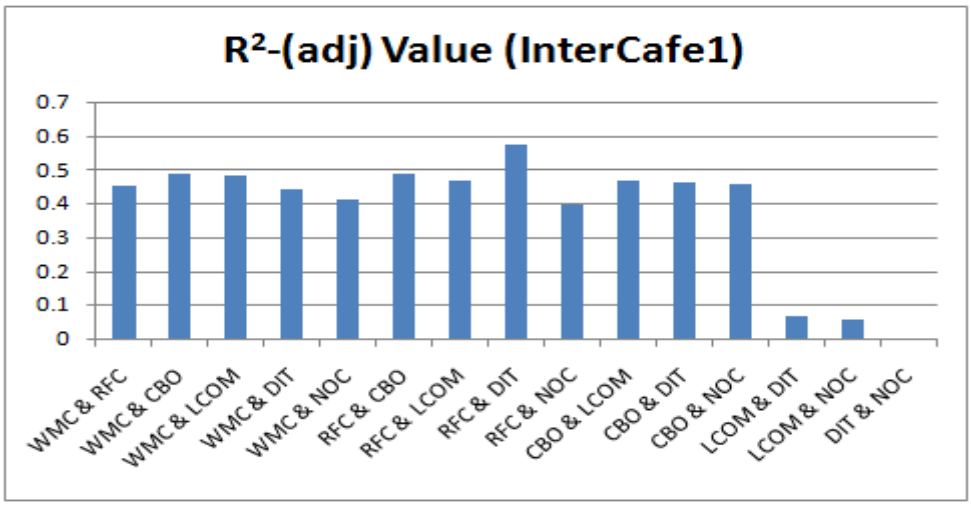


Figure 2: Comparison chart of R^2 Values for the project InterCafe1

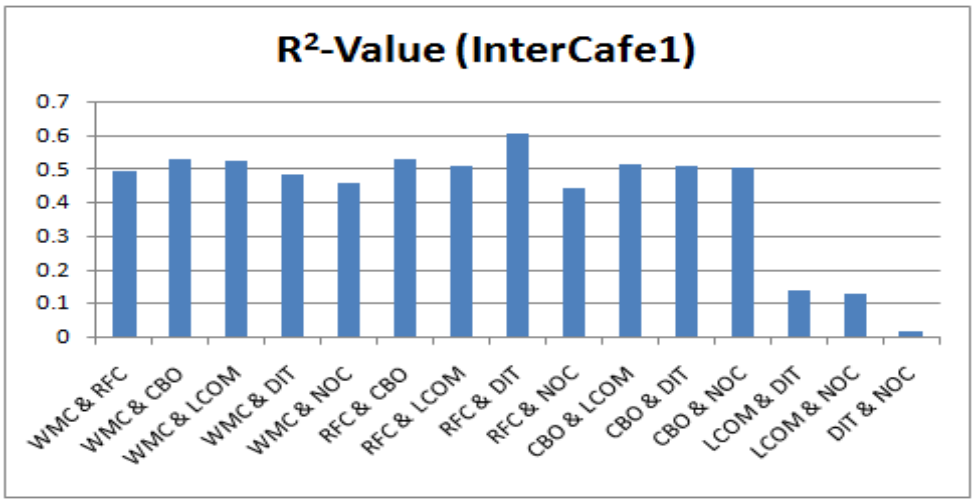
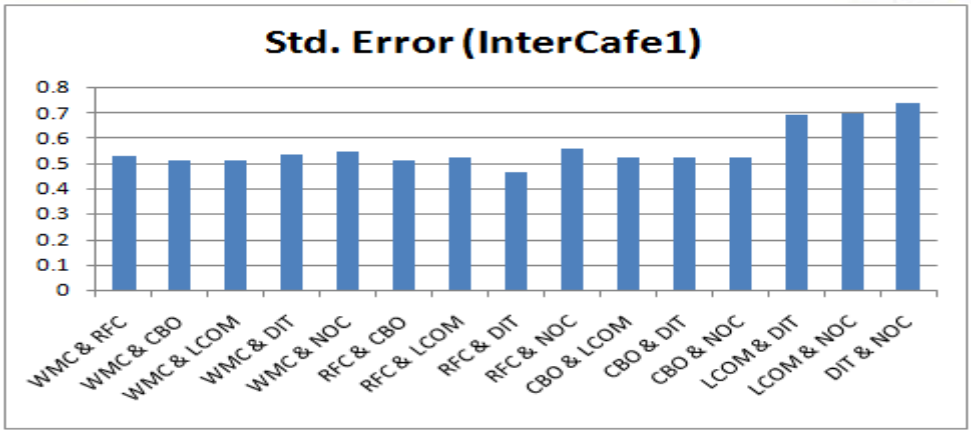


Figure 3: Comparison chart of Standard Error Values for the project InterCafe1



From the Table 1 and Figure1, it has been observed that the R^2 (adj)-value is maximum (i.e. 0.572) for the combination of metrics RFC& DIT among all the combination of metrics. Also, the R^2-vlaue for this model as shown in Table 1 and Figure2 is 0.605 which is again the highest. The Std. Error value (i.e 0.466) as shown in Table 1 and Figure3 is the lowest for the combination of metrics RFC& DIT among all the combination of metrics. As higher the values of R^2(adj), R^2 and lowest the value of Std. Error means that RFC & DIT is best combination of metrics among all the combination of metrics for the Project InterCafe1.

The Table 2 gives the bivariate subsets regression analysis (i.e. values of R^2, R^2 (Adjusted) and Standard Error) for various combinations of metrics, when two metrics are considered as independent variables, in case of the project TermoProjekt1.

Table 2: Result of Bivariate Logistic Regression for TermoProjekt1

Combination of Metrics	R^2-Value	R^2-(adj) Value	Std. Error
WMC & RFC	0.298	0.262	0.602
WMC & CBO	0.258	0.220	0.619
WMC & LCOM	0.269	0.232	0.614
WMC & DIT	0.276	0.239	0.611
WMC & NOC	0.265	0.227	0.616
RFC & CBO	0.300	0.264	0.601
RFC & LCOM	**0.320**	**0.285**	**0.592**
RFC & DIT	0.298	0.262	0.602
RFC & NOC	0.302	0.266	0.600
CBO & LCOM	0.191	0.149	0.646
CBO & DIT	0.243	0.204	0.625
CBO & NOC	0.173	0.131	0.653
LCOM & DIT	0.212	0.171	0.638
LCOM & NOC	0.176	0.124	0.655

DIT & NOC	0.142	0.098	0.665

Figure 4: Comparison chart of R^2-(adj) Values for the project TermoProjekt1

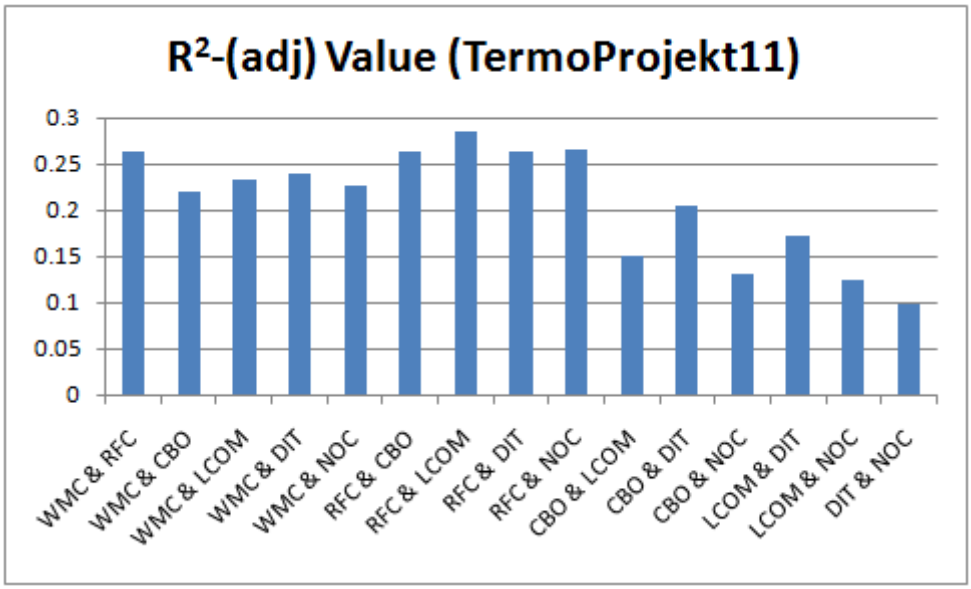


Figure 5: Comparison chart of R^2 Values for the project TermoProjekt1

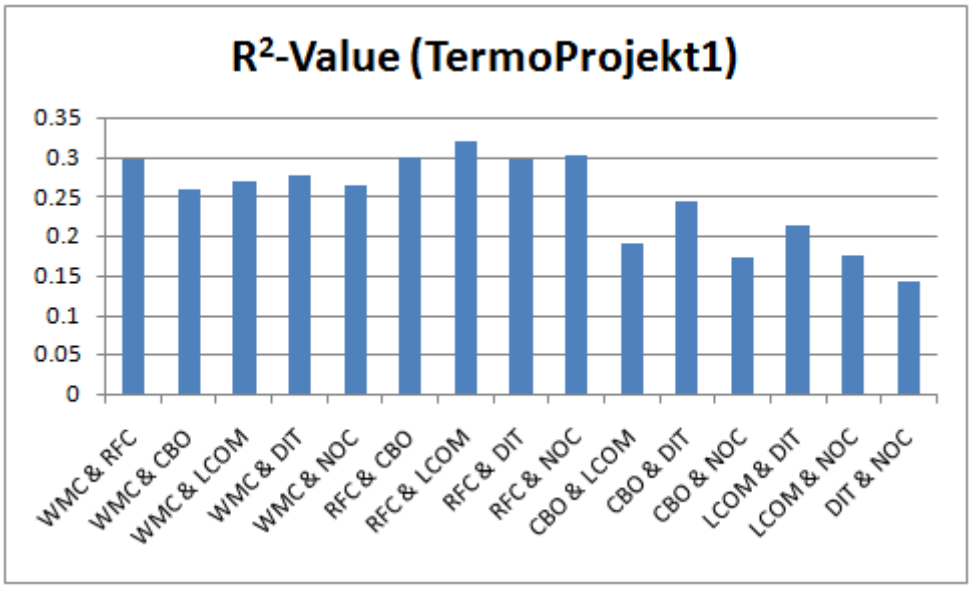
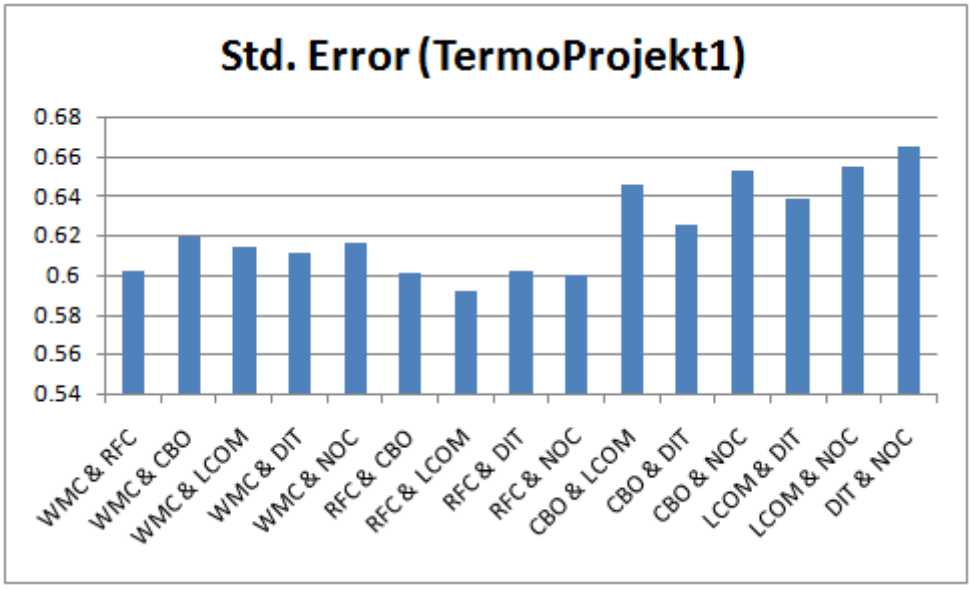


Figure 6: Comparison chart of Standard Error Values for the project TermoProjekt1



From the Table 2 and Figure4, it has been observed that the R^2 (adj)-value is maximum (i.e. 0.285) for the combination of metrics RFC &LCOM among all the combination of metrics. Also, the R^2-vlaue for this model as shown in Table 2 and Figure5 is 0.320 which is again the highest. The Std. Error value (i.e. 0.592) as shown in Table 2 and Figure6 is the lowest for the combination of metrics RFC &LCOM among all the combination of metrics. As higher the values of R^2(adj), R^2 and lowest the value of Std. Error means that RFC &LCOM is best combination of metrics among all the combination of metrics for the Project TermoProjekt1.

The Table 3 gives the bivariate subsets regression analysis (i.e. values of R^2, R^2 (Adjusted) and Standard Error) for various combinations of metrics, when two metrics are considered as independent variables, in case of the project Zuzel1.

Table 3:Result of Bivariate Logistic Regression for Zuzel1

Combination of Metrics	R^2-Value	R^2-(adj) Value	Std. Error
WMC & RFC	**0.589**	**0.557**	**0.681**
WMC & CBO	0.299	0.245	0.889
WMC & LCOM	0.296	0.242	0.891
WMC & DIT	0.426	0.382	0.804
WMC & NOC	-*	-*	-*
RFC & CBO	0.542	0.507	0.719
RFC & LCOM	0.558	0.524	0.706
RFC & DIT	0.541	0.506	0.719
RFC & NOC	-*	-*	-*
CBO & LCOM	0.261	0.204	0.913
CBO & DIT	0.438	0.395	0.796

CBO & NOC	-*	-*	-*
LCOM & DIT	0.407	0.361	0.818
LCOM & NOC	-*	-*	-*
DIT & NOC	-*	-*	-*

*The value of NOC is zero in all columns.

Figure7: Comparison chart of R^2-(adj) Values for the project Zuzel1

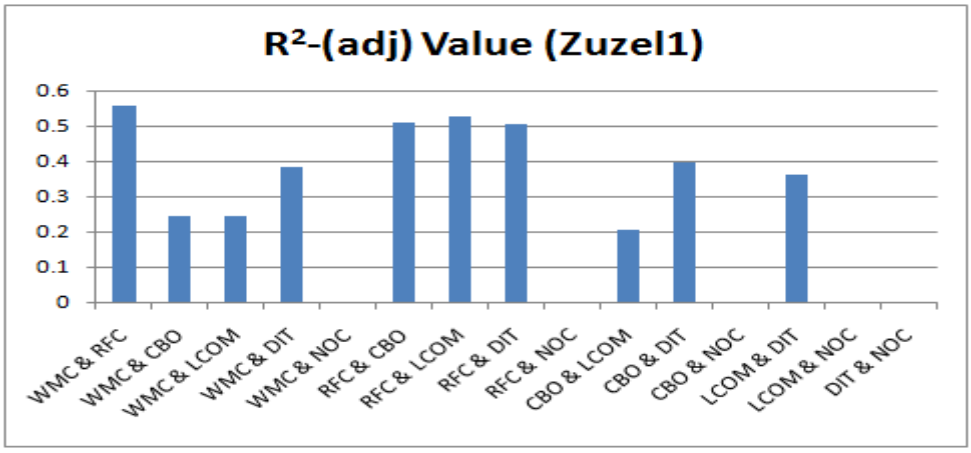


Figure 8: Comparison chart of R^2 Values for the project Zuzel1

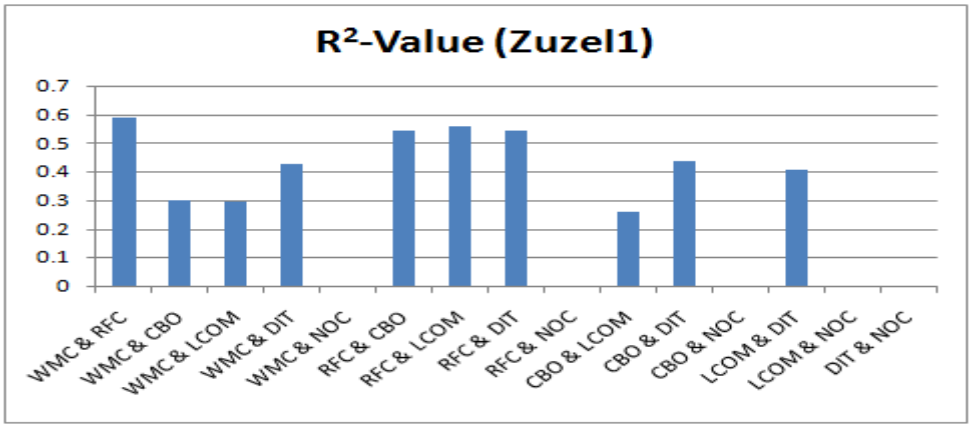
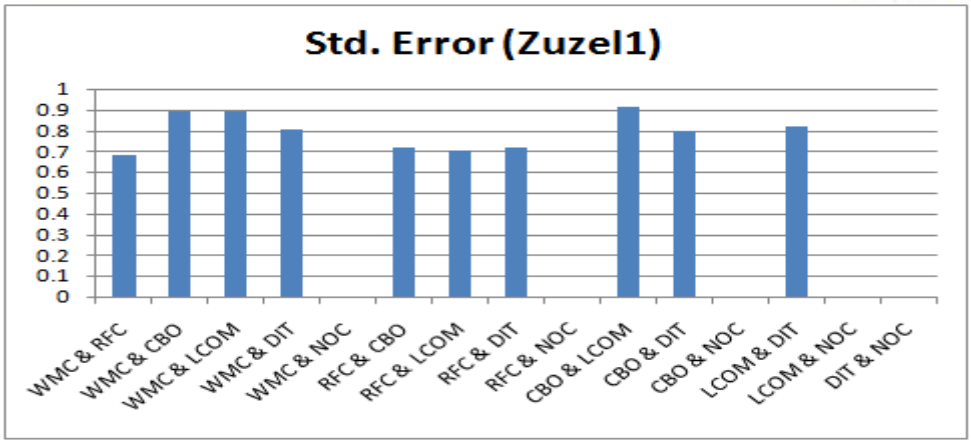


Figure 9: Comparison chart of Standard Error Values for the project Zuzel1



From the Table 3 and Figure7, it has been observed that the R^2 (adj)-value is maximum (i.e. 0.557) for the combination of metrics WMC & RFC among all the combination of metrics. Also, the R^2-vlaue for this model as shown in Table 3 and Figure8 is 0.589 which is again the highest. The Std. Error value (i.e. 0.681) as shown in Table 3 and Figure9 is the lowest for the combination of metrics WMC & RFC among all the combination of metrics. As higher the values of R^2(adj), R^2 and lowest the value of Std. Error means that WMC & RFC is best combination of metrics among all the combination of metrics for the Project Zuzel1.

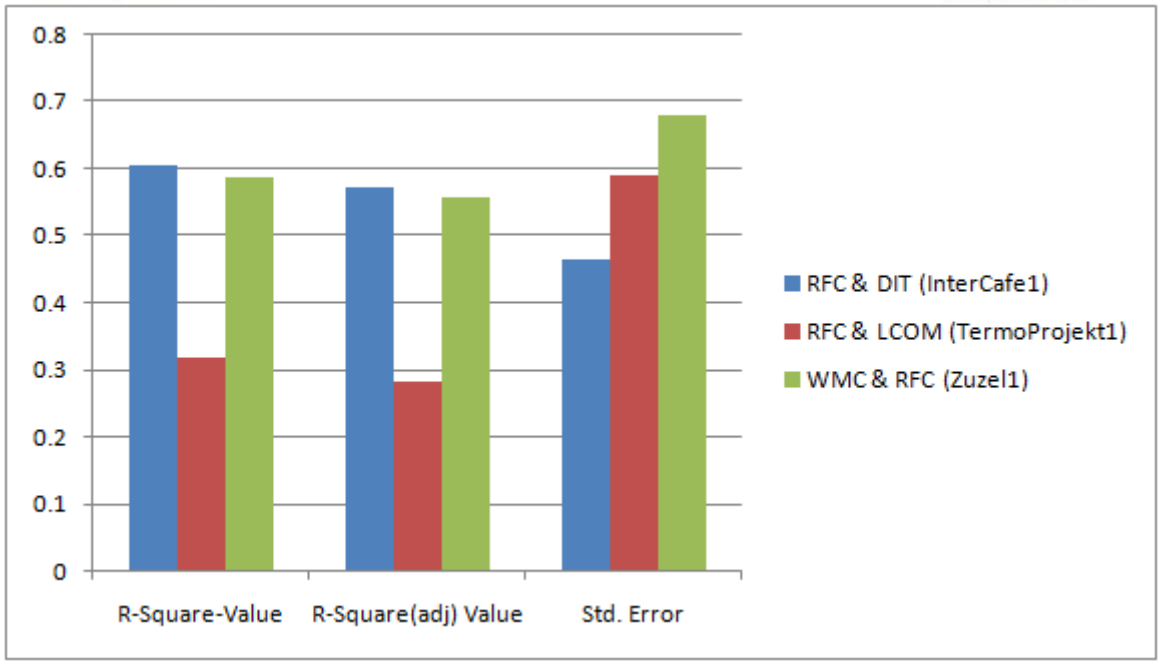
V. LINEAR REGRESSION ANALYSIS PROJECT WISE

The Table 4 is obtained by taking the best values of the projects InterCafe1, TermoProjekt1 and Zuzel1 from the Tables 1, 2 and 3. The Corresponding column chart is shown in Figure10.

Table 4: Comparison Table for best combination of Two Metrics project-wise

Combination of Metrics (Project)	R^2-Value	R^2-(adj) Value	Std. Error
RFC & DIT (InterCafe1)	**0.605**	**0.572**	**0.466**
RFC & LCOM (TermoProjekt1)	**0.32**	**0.285**	**0.592**
WMC & RFC (Zuzel1)	**0.589**	**0.557**	**0.681**

Figure 10: Comparison of best combination of Two Metrics project-wise



From Table 4 and Figure 10, it is clearly shown that R^2-(adj) and R^2 values for the combination of metrics in InterCafe1 is highest means having best values. The Std. Error value for the combination of metrics in InterCafe1 is lowest. By definition of R^2-(adj), if adding a variable raises the R^2 (adjust) for a regression, that's a better indication that is has improved the model as given. By definition of R^2, the high value of R^2has the indication that the model's independent variables have higher effect the model is more accurate the model. By definition of Std. Error, The lower standard error is, the lower the impact of the faults in a class and the higher standard error is, the higher the impact of faults in a class. So InterCafe1 has low impact of faults in the classes.

VI.CONCLUSION

To see the result of Two Variables, it is noted that by the definition of R^2-(adj), R^2 and Std. Error, as discussed of the Bivariate regression analysis in connection with fault-proneness prediction in terms of low/medium/high impact of faults,the following points have been noted down. The InterCafe1 project has low impact of faults in the classes. The TermoProjekt1 project has medium impact of faults in the classes. The Zuzel1 project has high impact of faults in the classes.

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