

# Issues in Validating Object-Oriented Metrics for Early Risk Prediction

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## 1 Introduction

A large number of object-oriented class metrics have been proposed over the last decade, for example [1][3][5]. The basic premise behind the development of object-oriented metrics is that they can serve as early predictors of classes that contain faults (found during testing or that result in field failures) or that are costly to maintain. A growing body of work has attempted to empirically validate this premise, for example [2][3].

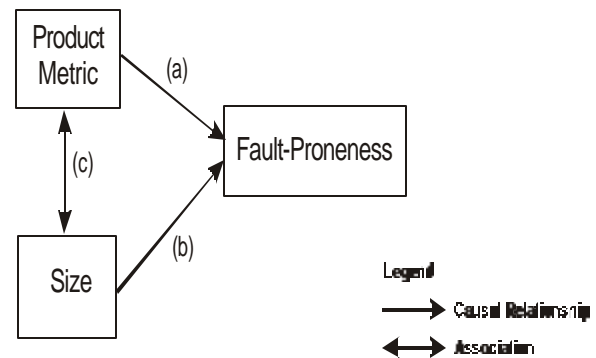
In this paper we show that common empirical validation methods to date can provide misleading conclusions as to the validity of object-oriented metrics. We present the results of an empirical validation study of a set of object-oriented metrics on a C++ telecommunications systems to illustrate this.

## 2 Validation Methods

A typical empirical validation of object-oriented metrics proceeds by investigating the relationship between each metric and the outcome of interest. In our case we will consider only fault-proneness as an outcome.<sup>1</sup> If this relationship is found to be statistically significant, then the conclusion is drawn that the metric is empirically validated. For example, recent studies used the bi-variate correlation between object-oriented metrics and the number of faults to investigate the validity of the metrics

<sup>1</sup> We define fault-proneness as the probability of a class having a fault.

[2]. Also, uni-variate logistic regression models are used as the basis for demonstrating the relationship between object-oriented product metrics and fault-proneness in [3].



**Figure 1:** Path diagram illustrating the confounding effect of size.

However, this approach completely ignores the confounding effect of class size. This can be illustrated with reference to Figure 1. Path (a) is the main hypothesized relationship between the metric and fault-proneness. Here we see that class size (for example, measured in terms of SLOC) is associated with the object-oriented metric (path (c)). Evidence supporting this for many contemporary metrics is found in [3][4]. Also, class size is known to be associated with the incidence of faults in object-oriented systems, path (b), and is supported in [3][4]. The pattern of relationships shown in Figure 1 exemplifies a classical confounding effect [7]. This means that the relationship between the

object-oriented metric and fault-proneness will be inflated due the effect of size. This also means that without controlling for the effect of size, previous validation studies have been optimistic about the validity of the metrics that they have investigated.

### 3 Example Study

We performed a study using data from 174 classes in a C++ telecommunications systems [6]. The method of analysis that we used was logistic regression. The results are summarized in Table 1. The table shows the change in the odds ratio and the p-value. The former is the increase in the odds of a class having a fault as the metric value increases by one standard deviation. The latter is the probability of getting a regression coefficient as large as that observed if the true parameter was zero. Here we can see the results for five of the metrics studied. The metrics WMC, RFC, CBO, and LCOM were defined in [5] and the NMA metric was defined in [8].

The results make clear the confounding effect of size. The first column shows the relationship between each of the metrics and fault-proneness without controlling for size. All of the metrics have a non-negligible effect that is statistically significant. The second column shows the results after controlling for size. As can be seen, the effects disappeared: none are statistically significant anymore. Therefore, their initial effects were due the influence of size.

Metric	With Size Control		No Size Control	
	$\Delta\psi$	p-value	$\Delta\psi$	p-value
WMC	1.74	0.002	0.8	0.3073
CBO	1.38	0.0266	1.024	0.4494
RFC	1.84	0.0013	0.73	0.2520
LCOM	1.33	0.0391	1.107	0.2830
NMA	1.975	0.0007	0.97	0.478

**Table 1:** Summary of validation results.

### 4 Conclusions

In this paper we have shown that size can have an important confounding effect on the validity of object-oriented metrics. Most previous studies did not control for this size effect. Therefore, it is prudent for previous conclusions about the validity of object-oriented metrics to be revisited, and future research should always control for size.

### 5 References

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