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An alternative test for the equality of variances for several populations in randomised complete block design

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ABSTRACT

In the last 50 years, eight major modifications and extensions of Levene's test and Bartlett's test had been developed for Randomized Complete Block Design (RCBD). The improvement from these works can be divided mostly into three categories as follows: (i) adjust fixed block effects and degrees of freedom in F test, (ii) improve the power of variance homogeneity tests, and (iii) develop a robust test that can be applied to non-normal distributions. Surprisingly, very little attention has been paid to the homogeneity of within treatment variance when the number of treatment groups is large and the number of blocks is relatively small. Even under normality assumption, all tests either suffer from severe inflation of Type I error rate or lose statistical power to detect heterogeneity of variances.

In this paper, we consider the problem of homogeneity of variance in Randomized Complete Block Design (RCBD) and develop a new F_{max}-test for the equality of variances in RCBD. The Type I error of this new test is well controlled and the power is higher than eight other tests when the number of treatment groups is larger than the number of blocks. Under normality assumption, none of the eight other tests are consistent top-performer. Our new F_{max}-test either outperforms or is comparable to the top-performer of the other eight tests. The new F_{max}-test can be recommended for future use by practitioners in cases such as sensory monadic testing with more than 10 products and blood glucose variability testing.

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1. Introduction

Analysis of Variance (ANOVA) is an important technique to test the homogeneity of means for several populations. One of the basic assumptions for ANOVA is that the variances of several populations are equal. In the real world, this kind of assumption may or may not be true. One needs to check the validity of this assumption before applying the technique of ANOVA. Several tests have been proposed for the homogeneity of variances by Conover et al. [4] in Completely Randomized Design (CRD) and so far, the most frequently cited and used are methods proposed by Bartlett [1], Box [3], Hartley [9], Levene [14]. Bhandary and Dai [2] recently proposed an alternative test in this situation. Harris [8] developed a variance homogeneity test for correlated variables, Piepho [16–19] proposed several methods to test homoscedasticity.

In this paper, we consider the problem of the homogeneity of variance test in Randomized Complete Block Design (RCBD). Schaalje and Despain [20] reviewed the variance homogeneity test for RCBD with fixed as well as random block effects and performed simulation studies of RCBD with random block effects. The improvement from these variance homogeneity tests can be divided into three categories (i) to adjust fixed block effects and degrees of freedom in F test, (ii) to improve the power of variance homogeneity tests, and (iii) to develop a robust test that can be applied to non-normal distributions. Surprisingly, very little attention has been paid to testing the variance homogeneity among treatment groups when the number of treatment groups is large and the number of blocks is relatively small. Our simulation results indicate that even under normality assumption, all previously developed tests either suffer from severe inflation of Type I error rate or lose statistical power to detect heterogeneity of variances when the number of treatment groups is larger than the number of blocks.

We developed a new $F_{\max}$-test for the equality of variances in RCBD. Our method and simulation assessment has strengths in three important areas:

- The $F_{\max}$ test shows good control of Type I error and strong power compared to other 8 tests, especially when the number of treatment groups is large. Our method provides an effective tool to handle RCBD with large treatment groups.
- The new $F_{\max}$-test method is very easy to perform and the critical points are listed in Table 1.
- Schaalje and Despain [20] reviewed variance homogeneity test in RCBD with fixed as well as random block effect and performed simulation studies with random block effects. In this work, variance homogeneity test in RCBD with fixed block effects is comprehensively reviewed and assessed by simulation studies.

In Section 2, we review eight variance homogeneity tests in RCBD with fixed block effects. In Section 3, we describe our test and in Section 4, we compare the Type I error and power of our test with the other tests through simulation study. Case studies are presented in Section 5.

2. Review of variance homogeneity tests in RCB design

We describe below eight tests for the equality of variances for several populations (treatment groups) in RCBD.

Suppose, we have t treatments and b blocks and the ith treatment is applied to all b blocks, $i = 1, 2, \ldots, t$ and the data structure is shown as follows:

	Tr. 1	*Tr.* 2	$\cdots$	*Tr.* t
	y_{11}	y_{21}	$\cdots$	y_{t1}
Block 1	y_{12}	y_{22}	$\cdots$	y_{t2}
	$\cdots$	$\cdots$	$\cdots$	$\cdots$
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
	$\cdots$	$\cdots$	$\cdots$	$\cdots$
Block b	y_{1b}	y_{2b}	$\cdots$	y_{tb}