ALEXANDER-GOVERN TEST USING WINSORIZED MEANS

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Abstrak

Ujian klasik bagi menguji kesamaan kumpulan bebas yang berasaskan min aritmetik boleh menghasilkan keputusan yang tidak sah terutama apabila berurusan dengan data yang tidak normal dan varians heterogen (heteroskedastisiti). Bagi mengurangkan masalah ini, para penyelidik mengusahakan kaedah yang lebih sesuai dengan kondisi yang telah dinyatakan termasuk prosedur yang dikenali sebagai ujian Alexander-Govern. Prosedur ini adalah tidak sensitif terhadap kehadiran heteroskedastisiti di bawah taburan normal. Walau bagaimanapun, ujian yang menggunakan min aritmetik sebagai ukuran kecenderungan memusat adalah sensitif kepada data yang tidak normal. Ini adalah disebabkan oleh hakikat bahawa min aritmetik mudah dipengaruhi oleh bentuk taburan. Dalam kajian ini, min aritmetik digantikan dengan penganggar teguh, iaitu min *Winsor* atau min *Winsor* suai. Ujian Alexander-Govern yang dicadangkan dengan min *Winsor* dan dengan min *Winsor* suai masing-masing ditandakan sebagai *AGW* dan *AGAW*. Bagi tujuan perbandingan, peratusan pe*Winsoran* yang berbeza iaitu 5%, 10%, 15% dan 20% dipertimbangkan. Satu kajian simulasi telah dijalankan untuk mengkaji mengenai prestasi ujian berdasarkan kadar Ralat Jenis I dan kuasa. Empat pembolehubah; bentuk taburan, saiz sampel, tahap keheterogenan varians dan sifat pasangan dimanipulasi untuk mewujudkan keadaan yang boleh menyerlahkan kekuatan dan kelemahan setiap ujian. Prestasi ujian yang dicadangkan ini dibandingkan dengan kaedah parametrik lain yang setaraf iaitu, ujian-*t* dan *ANOVA*. Ujian yang dicadangkan menunjukkan peningkatan dari segi kawalan Ralat Jenis I dan kuasa yang semakin tinggi di bawah pengaruh heteroskedastisiti dan ketidaknormalan. Ujian *AGAW* menunjukkan prestasi terbaik dengan 10% pe*Winsoran* manakala ujian *AGW* menunjukkan prestasi terbaik dengan 5% pe*Winsoran*. Di bawah kebanyakan keadaan (74%), ujian *AGAW* mengatasi ujian *AGW*. Oleh yang demikian, min *Winsor* dan min *Winsor* suai berupaya meningkatkan prestasi asal ujian Alexander-Govern dengan berkesan. Prosedur yang dicadangkan ini memberi manfaat kepada pengamal statistik dalam menguji kesamaan kumpulan bebas walaupun di bawah pengaruh ketidaknormalan dan varians heterogen.

Kata Kunci: Min *Winsor*, Min *Winsor* suai, Ketaknormalan, Varians tak homogen

Abstract

Classical tests for testing the equality of independent groups which are based on arithmetic mean can produce invalid results especially when dealing with non-normal data and heterogeneous variances (heteroscedasticity). In alleviating the problem, researchers are working on methods that are more adapt to the aforementioned conditions which include a procedure known as Alexander-Govern test. This procedure is insensitive in the presence of heteroscedasticity under normal distribution. However, the test which employs the arithmetic mean as the central tendency measure is sensitive to non-normal data. This is due to the fact that the arithmetic mean is easily influenced by the shape of distribution. In this study, the arithmetic mean is replaced by robust estimators, namely the Winsorized mean or adaptive Winsorized mean. The proposed Alexander-Govern test with Winsorized mean and with adaptive Winsorized mean are denoted as *AGW* and *AGAW*, respectively. For the purpose of comparison, different Winsorization percentages of 5%, 10%, 15% and 20% are considered. A simulation study was conducted to investigate on the performance of the tests which is based on rate of Type I error and power. Four variables; shape of distribution, sample size, level of variance heterogeneity and nature of pairings are manipulated to create the conditions which could highlight the strengths and weaknesses of each test. The performance of the proposed tests is compared with their parametric counterparts, the *t*-test and *ANOVA.* The proposed tests show improvement in terms of controlling Type I Error and increasing power under the influence of heteroscedasticity and non-normality. The *AGAW* test performed best with 10% Winsorization while *AGW* test performed best with 5% Winsorization. Under most conditions (74%), *AGAW* tests outperform *AGW* tests. Therefore, the Winsorized mean and the adaptive Winsorized mean can significantly improve the performance of the original Alexander-Govern test. These proposed procedures are beneficial to statistical practitioners in testing the equality of independent groups even under the influence of non-normality and variance heterogeneity.

Keywords: Winsorized mean, Adaptive Winsorized mean, Non-normality, Heteroscedasticity

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List of Abbreviations

ANOVA	Analysis of variance
***A*-test**	Alexander-Govern test
AGW	Alexander-Govern test with Winsorized mean
AGW_5	Alexander-Govern test with 5% Winsorized mean
AGW_10	Alexander-Govern test with 10% Winsorized mean
AGW_15	Alexander-Govern test with 15% Winsorized mean
AGW_20	Alexander-Govern test with 20% Winsorized mean
AGAW	Alexander-Govern test with adaptive Winsorized mean
AGAW_5	Alexander-Govern test with 5% adaptive Winsorized mean
AGAW_10	Alexander-Govern test with 10% adaptive Winsorized mean
AGAW_15	Alexander-Govern test with 15% adaptive Winsorized mean
AGAW_20	Alexander-Govern test with 20% adaptive Winsorized mean

CHAPTER ONE

INTRODUCTION

Classical parametric tests, such as *t*-test and analysis of variance (*ANOVA*) *F* test are widely used by researchers in many disciplines. These tests are useful in comparing the equality of two or more treatment groups. A review conducted by Farcomeni and Ventura (2010) found that most of the studies in health sciences such as medicine and genetics, used classical test in comparing treatment groups. In addition, Erceg-Hurn and Mirosevich (2008) also mentioned the extensive usage of classical test in psychology studies.

The classical parametric tests are based on assumptions of normality and homoscedasticity. However, in dealing with real data, these assumptions are rarely met. For example, Micceri (1989) found that the majority of real data from the psychological and education literatures are skewed and heavy-tailed. Studies by Wilcox (1990) also found that most real data are often non-normal with the tendency to be either non-smooth, multi-modal, highly skewed or heavy-tailed. Besides that, comprehensive journal review conducted by Keselman et al. (1998) demonstrated that it is very hard to find homogeneous variances when dealing with education data as well as with data of child, clinical and experimental psychology. Another study by Erceg-Hurn and Marosevich (2008) claimed that it is usual for the homogeneous variances assumption to be violated when dealing with real data. The classical tests have been shown to have lack of robustness under the violation of the assumptions of normality and

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