H-STATISTIC WITH WINSORIZED MODIFIED ONE-STEP *M*-ESTIMATOR AS CENTRAL TENDENCY MEASURE

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of Arts And Sciences

Universiti Utara Malaysia

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Abstrak

Ujian *t*-dua sampel bebas dan *ANOVA* adalah kaedah klasik yang masing-masing digunakan secara meluas untuk menguji kesamaan dua kumpulan dan lebih daripada dua kumpulan. Walau bagaimanapun, kaedah berparameter ini mudah dipengaruhi oleh ketidak kenormalan, lebih ketara lagi apabila wujud varians yang heterogen dan saiz sampel yang tidak seimbang. Sebagaimana yang diketahui umum, pelanggaran dalam andaian ujian ini akan menyebabkan peningkatan dalam Ralat jenis I dan kemorosotan dalam kuasa ujian. Kaedah tidak berparameter seperti Mann-Whitney dan Kruskal-Wallis adalah merupakan alternatif kepada kaedah berparameter, namun, kehilangan maklumat berlaku disebabkan oleh data berpangkat. Bagi meringankan masalah ini, kaedah teguh boleh digunakan sebagai alternatif lain. Salah satu daripada kaedah tersebut adalah *H*-statistik. Apabila digunakan dengan penganggar *M*-satu langkah terubahsuai (*MOM*), statistik ujian ini (*MOM-H*) dapat menghasilkan kawalan Ralat jenis I yang baik walaupun dalam keadaan saiz sampel yang kecil, tetapi tidak konsisten pada beberapa keadaan yang dikaji. Tambahan pula, kuasa ujian adalah rendah yang berkemungkinan disebabkan oleh proses pangkasan data. Dalam kajian ini, *MOM* diwinsor (*WMOM*) bagi mengekalkan saiz sampel asal data. *H*-statistik apabila digabungkan dengan *WMOM* sebagai sukatan kecenderungan memusat (*WMOM-H*) telah menunjukkan kawalan Ralat jenis I yang lebih baik berbanding dengan *MOM-H* terutamanya di bawah rekabentuk seimbang walaupun dalam apa saja bentuk taburan. Ia juga menunjukkan prestasi yang baik di bawah taburan yang amat pencong dan berhujung berat bagi rekabentuk yang tidak seimbang. Di samping itu, *WMOM-H* juga mampu menjana kuasa yang lebih baik berbanding dengan *MOM-H* dan *ANOVA* di bawah kebanyakan keadaan yang dikaji. *WMOM-H* juga didapati dapat mengawal Ralat jenis I dengan lebih baik tanpa nilai liberal (>0.075) berbanding dengan kaedah berparameter (*t*-dua sampel bebas dan *ANOVA*) dan tidak berparameter (Mann-Whitney dan Kruskal-Wallis). Secara umum, kajian ini menunjukkan bahawa proses winsor (*WMOM*) boleh meningkatkan prestasi *H*-statistik dari segi kawalan Ralat jenis I dan meningkatkan kuasa ujian.

Kata kunci: Winsor, Ralat jenis I, Kuasa Ujian, Kaedah Teguh, *H-s*tatistik

Abstract

Two-sample independent *t*-test and *ANOVA* are classical procedures which are widely used to test the equality of two groups and more than two groups respectively. However, these parametric procedures are easily affected by non-normality, becoming more obvious when heterogeneity of variances and unbalanced group sizes exist. It is well known that the violation in the assumption of the tests will lead to inflation in Type I error rate and decreasing in the power of test. Nonparametric procedures like Mann-Whitney and Kruskal-Wallis may be the alternative to the parametric procedures, however, loss of information occur due to the ranking data. In mitigating these problems, robust procedures can be used as the other alternative. One of the procedures is *H*-statistic. When used with modified one-step *M*-estimator (*MOM*), the test statistic (*MOM-H*) produces good control of Type I error rate even under small sample size but inconsistent under certain conditions investigated. Furthermore, power of test is low which might be due to the trimming process. In this study, *MOM* was winsorized (*WMOM*) to retain the original sample size. The *H*-statistic when combines with *WMOM* as the central tendency measure (*WMOM-H*) shows better control of Type I error rate as compared to *MOM-H* especially under balanced design regardless of the shape of distributions. It also performs well under highly skewed and heavy tailed distribution for unbalanced design. On top of that, *WMOM-H* also generates better power value, as compared to *MOM-H* and *ANOVA* under most of the conditions investigated. *WMOM-H* also has better control of Type I error rates with no liberal value (>0.075) compared to the parametric (*t*-test and *ANOVA*) and nonparametric (Mann-Whitney and Kruskal-Wallis) procedures. In general, this study demonstrates that winsorization process (*WMOM*) is able to improve the performance of *H*-statistic in terms of controlling Type I error rate and increasing power of test.

Keywords: Winsorization, Type I error rate, Statistical Test Power, Robust Statistics, *H*-statistic

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APPENDIX A

List of Abbreviations

ANOVA	Analysis of Variance
H-statistic	Robust test to measure the equality of central tendency Measure
MOM	Modified One-step M-estimator
WMOM	Winsorized Modified One-Step M-estimator
SAS	Statistical Analysis Software
SAS/IML	Statistical Analysis Software/ Interactive Matrix Language

CHAPTER ONE

INTRODUCTION

1.1 Background

In recent years, procedures for testing the equality of central tendency (location) measures or locating group effects has been studied and improved. The main purpose of this continuous improvement is to get a procedure that can perform well in controlling Type I error rate, simultaneously increasing power to detect the effects. It is well known that distribution of data and the variance among treatment groups are one of main concern for parametric procedures such as *t*-test and analysis of variance (*ANOVA*). In order to use these procedures, assumptions such that the data must be normally distributed and the variances must be homogeneous have to be fulfilled. Any deviation from these two assumptions will cause Type I error rate to be inflated and depressed in power rate (Keselman, Algina, Lix, Wilcox, & Deering, 2008; Syed Yahaya, 2005; Syed Yahaya, Othman, & Keselman, 2006). As a consequence, the null hypothesis will be falsely rejected and the effect of the procedures will go undetected. In real world, data that we get can hardly fulfill the assumptions needed by the parametric procedures.

Conventionally, nonparametric procedures such as Mann-Whitney and Kruskal-Wallis are the common alternatives when data fail to fulfill the assumptions of parametric procedures. However, the nonparametric procedures are more appropriate for weak measurement scale data and larger sample size is needed to reject a false hypothesis due to low power as compared to parametric procedures (Md Yusof, Abdullah, & Syed Yahaya, 2012a). Moreover, lesser information could be captured

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APPENDIX A

SAS/IML Programming for *WMOM-H*

```
***USING THE MOM ESTMATOR ON THE H STATISTIC***;
OPTIONS PS=40;
OPTIONS NOCENTER;
PROC IML;
RESET NONAME;

**PREPARING DATA FOR CALCULATING WMOM-ESTIMATOR**;
(Please Refer To Author If Need Full Programming)
START DATAMOD(Y, CRIT, YMAT)  GLOBAL (NX, NTOT, WOBS, BOBS);
NTOT = NROW(Y);
WOBS = NCOL(Y);
BOBS = NCOL(NX);
YT = J(NTOT, WOBS, 0);
GMAD = J(WOBS, BOBS, 0);
GMED = J(WOBS, BOBS, 0);
F = 1;
M = 0;
DO I = 1 TO BOBS;
.
.
.
.
.
.
FINISH;

**VARIABLE WINSORIZING BASED ON CRITERIA VECTOR**;
(PLEASE REFER TO AUTHOR IF NEED FULL PROGRAMMING)
START WINSMOD(YMAT, CRIT, WINSOR, MUBARM, H) GLOBAL(NX, NTOT, WOBS,
BOBS);
WINSOR = J(WOBS, BOBS, 0);
F = 1;
M = 0;
.
.
.
.
.
.
FINISH;

**FINDING THE P-VALUE OF THE H STATISTIC REQUIRES BOOTSTRAP**;
**GENERATING BOOTSTRAP SAMPLE**;
(PLEASE REFER TO AUTHOR IF NEED FULL PROGRAMMING)
START BOOTDAT(Y, WINSOR, YB) GLOBAL(NX, NTOT, WOBS, BOBS, SEED);
F = 1;
M = 0;
.
.
.
.
```

```
.
.
FINISH;

**CALCULATING BOOTSTRAP H STATISTIC**;
(PLEASE REFER TO AUTHOR IF NEED FULL PROGRAMMING)
START BOOTSTAT(YB, HB) GLOBAL(NX, NTOT, WOBS, BOBS, SEED);
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.
.
.
.
.
FINISH;

*********TRIAL RUN ON BOOTSTRAPPING WITH GENERATED DATA**********;
SSEED=439839383;
CPOPVAR = {1 1 1 1};
CNX = {20 20 20 20};
CPOPMN = {0 0 0 0};
CN = CNX[,+];
COND = NROW(CPOPVAR);
NSIM = 5000;
F = 1;

**NUMBER OF BOOTSTRAP SAMPLES**;
NUMSIM = 599;
**SEED FOR BOOTSTRAPPING**;
SEED = 40389;

COUNTER = 0;
ALPHA = 0.05;

****GENERATE DATA FOR CONDITIONS****;
(PLEASE REFER TO AUTHOR IF NEED FULL PROGRAMMING)
DO K = 1 TO NSIM;
  DO I = 1 TO COND;
.
.
.
.
.
.
    RUN WMOM1;
    IF (RESULTS[2] <= ALPHA) THEN COUNTER = COUNTER + 1;
  END; *DO I;
END; *DO K;

DO I = 1 TO COND;
   V = CPOPVAR[I,];
   S = CNX[I,];
   M = CPOPMN[I,];
   COUNT = COUNTER/NSIM;
   PRINT 'STUDY CONDITIONS ARE:';
   PRINT 'ALPHA IS:' ALPHA[FORMAT = 5.2];
   PRINT 'GROUP POPULATION VARIANCES:' V[FORMAT = 4.0];
   PRINT 'GROUP SAMPLE SIZES:' S[FORMAT = 4.0];
   PRINT 'GROUP MEANS:' M[FORMAT = 4.0];
   PRINT 'TEST FOR:4pemmn' COUNT[FORMAT = 6.5];
END; *DO I;
```