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Relationship between Student Performance at HKAGE and Their HKDSE Results

Introduction

Based on the participation records of an active member (i.e., the one joins at least one HKAGE student programme that requires high engagement; e.g. courses and workshops, or competition since his admission) in HKAGE, we could derive a performance score by simply adding up the number of participations, which would be weighted with respect to different levels of achievement (e.g., completed or completed with honor, etc.). The weights assigned largely follow the frequencies being issued within a certain period of time. It would be interested to investigate whether there is any relationship between student performance scores and their corresponding HKDSE results.

Objectives

The study aims to investigate the relationship between our student performance at HKAGE and their corresponding HKDSE results. Although the courses and workshops, and competitions provided by HKAGE do not focus on the specific content or skills for taking the public examination, it is suspected that the generic skills (e.g., problem solving and critical thinking) learnt and exposure experienced from engaging in HKAGE programmes and activities could somehow help students perform better in the public examination. To support such a speculation, it is important to consider the ability of a student when admitted to the Academy and his school performance in public exam. The selection test score of a student could be used as a proxy measure of his ability level when admitted to the Academy. With regard to the information on school performance in public exam, it was decided to use the moderated school-specific School Based Assessment (SBA) marks of Liberal Studies (LS) in HKDSE as a proxy measure. Based on these moderated SBA marks, various schools could be classified into three different tiers of more or less equal size.

Data Collection

First, HKAGE provided HKIDs of HKAGE alumni who graduated in 2012, 2013, and 2014 to HKEAA, together with their performance and selection scores for retrieving their exam results and their moderated school-specific SBA scores of LS. It should be emphasized that all identification information had been erased when HKAGE received the corresponding exam data. Their public exam results were reflected using the average of grade points (i.e., Level 1 = 1, Level 2 = 2, Level 3 = 3, Level 4 = 4, Level 5 = 5, Level 5* = 6, and Level 5** = 7) of the four compulsory subjects, namely: Chinese Language, English Language, Compulsory Mathematics and Liberal Studies. Finally, 1775 student records were involved in the study.

As mentioned above, the schools concerned were classified into three tiers of more or less equal size based on their moderated school-specific SBA scores, namely: tier 1 (high level of school performance in public exam); tier 2 (middle level) ; and tier 3 (low level). Similarly, the students at HKAGE were classified into three groups based on their performance scores, namely: high performance group (top 10%); middle performance group (the next 10%) and low performance group (the rest 80%).

Data Analysis and Modeling

Along these classifications mentioned above, cross tabulation of HKDSE results by school tier vs. HKAGE performance group is shown below.

Table 1: Cross tabulation of HDSE results by school tier vs. HKAGE performance group

School Tier\ Perf Grp	(L)ow	(M)id	(H)igh	Diff (H – L)
Tier 3	4.00	4.16	4.61	**0.61**
Tier 2	4.60	4.83	4.83	**0.23**
Tier 1	5.08	5.01	5.31	**0.23**

From the Table 1 above, it can be observed that students in the high performance group of HKAGE got better HKDSE results. Moreover, such a phenomenon is most prominent for those students from schools of tier 3.

To support the speculation that the progammes and activities provided by HKAGE would help student get better results in HKDSE results, it is important to consider student ability levels when admitted to the Academy. This is achieved using statistical modeling under Bayesian framework.

Statistical Modeling under Bayesian Framework and its Implementation

The following statistical model (Generalized Linear Model), considering student ability when admitted to HKAGE (based on selection test results) and school tier effect (based on moderated school-specific SBA results of LS), and treating HKAGE performance as the independent variable and HKDSE results as the dependent variable, could be fitted.

HKDSE result of a student =

Beta0 + Beta1 x Student Selection Test Score +

Performance Group Effect +School Tier Effect + Interaction Terms + Noises

The model was implemented under Bayesian framework using WINBUGS (**B**ayesian Inference **U**sing **G**ibbs **S**ampling) as follows:

y[i] ~ dnorm(mu[i], yPrec)
mu[i] <- mu0 + beta*selper[i]+alpha[perGrp[i]] + delta[schGrp[i]] + alphadelta[perGrp[i], schGrp[i]]
where i running from 1 to 1775

To implement Bayesian inference, uninformative prior distributions for the unknown parameters have to be specified. For the model, they were formulated in WINBUGS as follows with some brief comments provided.

```
# Prior distribution of the noise term -  yPrec
yPrec<-1/yVar    yVar<-pow(ySigma, 2)
ySigma~dunif(lowYSigma, highYSigma)
lowYSigma <- ySD/100   highYSigma<-ySD*10

# Prior distribution of the baseline – mu0
mu0 ~ dnorm(yMean, mu0Prec)
mu0Prec<-1/mu0Var   mu0Var<-pow(mu0SD, 2)
mu0SD<-ySD*5

# Prior distribution of beta (coefficient of the independent variable, selection test score (selper)):
# mean =0.0, var= 1000 (which should be large enough to cover all possibilities)
beta ~ dnorm(0.0,0.001)

# Prior distribution of the performance group effect of HKAGE: mean=0.0, var =1000
for (a in 1: LA){  alpha[a] ~ dnorm(0.0, 0.001)}
# Prior distribution of the school tier effect: mean=0.0, var=1000
for (b in 1: LD){ delta[b] ~ dnorm(0.0, 0.001) }

# Prior distribution of the interaction effects between school tier and performance group:
# mean=0.0, var=1000
for (a in 1: LA){
```

```
for (b in 1:LD) { alphadelta[a, b] ~ dnorm(0.0, 0.001)}
}
```

Based on the input data (namely: HKDSE results of student (y[i]), selection test results (selper[i]), performance group indicators of students (perGrp[i]) and the school tiers (schGrp[i])), the posterior distributions of the unknown parameters could be obtained via the well known method, MCMC (Markov Chain Monte Carlo). From the posterior distributions, all the interested results could be estimated. Before showing the estimation results, we would like to check the consistency of the model with the observed data.

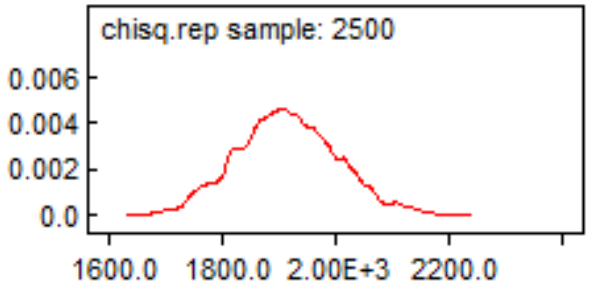
Model Checking

A handy approach under Bayesian framework is to generate the posterior predictive distribution of a summary statistics and check it against the observed value derived from the data set. One of the commonly used statistics is the chi-square statistics as the goodness-of-fit measure of the model. It was implemented in WINBUGS as follows:

```
for(i in 1:n){ y.rep[i]~dnorm(mu[i], yPrec)}   #generate predicted y values from the posterior
# Compile the chi-square statistics using predicted  y values
for(i in 1:n){ chisq.rep.vec[i]<-pow(y.rep[i]-yMean,2)/pow(ySD,2)}
chisq.rep<-sum(chisq.rep.vec[ ] )
# Compile the chi-square statistics using observed  y values
for(i in 1:n){ chisq.obs.vec[i]<-pow(y[i]-yMean,2)/ pow(ySD,2)}
chisq.obs<-sum(chisq.obs.vec[ ] )
```

The results of modeling checking are shown below.

Figure 1: Distribution of chi-square statistics using predicted y values



The chi-square statistics compiled using observed y values was 1774.0. The proportion of times that the chi-square statistics generated from y predicted values was greater than the one generated from the observed y values was 0.59 (i.e. posterior predictive p-value), which was still close to 0.5. Thus, the model was consistent with the observed data using the checking of chi-square statistics.

Parameter Estimation Results

We are interested in the impact of the performance at HKAGE to the HKDSE result of a student within various school tiers, which is defined as the difference of the average of exam scores between high performance group and low performance group within various school tiers after controlling the student ability when admitted to the Academy. The results are shown below:

(i) For tier 3 schools, the impact of HKAGE performance to the HKDSE results of a student was estimated to be 0.50 and Pr (HKAGE performance impact in tier 3 schools < 0 | Data) =0.0028. It implies that the HKAGE impact in tier 3 schools was statistically significantly different from zero.

(ii) For tier 2 schools, the impact of HKAGE performance to the HKDSE results of a student was estimated to be 0.18 and Pr (HKAGE performance impact in tier 2 schools < 0 | Data) =0.0612. It implies that the HKAGE impact in tier 2 schools was statistically significantly different from zero.

(iii) For tier 1 schools, the impact of HKAGE performance to the HKDSE results of a student was estimated to be 0.19 and Pr (HKAGE performance impact in tier 1 schools < 0 | Data) =0.032. It implies that the HKAGE impact in tier 1 schools was statistically significantly different from zero.

Besides, the contrasts of the impact of HKAGE performance in tier 3 schools with that in other school tiers are investigated and the estimated results are shown below.

(i) Pr (the impact of HKAGE performance in tier 3 schools > the one in tier 2 schools | Data) was estimated to be 0.92. Thus, the contrast was statistically significant.

(ii) Pr (the impact of HKAGE performance in tier 3 schools > the one in tier 1 schools | Data) = 0.94. Thus, the contrast was statistically significant.

It can be observed that the estimated impact of HKAGE using statistical modeling is less than the ones shown in Table 1 above. It is because the consideration of the selection test result of a student has explained away part of the impact shown in Table 1. The explanatory power of the selection

test result of a student could be reflected in the estimated value of Beta1 in the model, which is shown below.

node	mean	sd	MC error	5.0%	95.0%
Beta1	0.1522	0.02699	6.439E-4	0.1096	0.1968

It should be noted that the estimated value of Beta1 was positive and was statistically significant. It implies that the selection test result of a student has a positive impact to his HKDSE result.

Summary

From the study, the following findings are obtained.

- After controlling the school tier effect and the ability level of a student when admitted to the Academy, the impact of HKAGE performance to the HKDSE result of a student was positive and was statistically significant.
- Moreover, the positive impact of HKAGE performance was found to be most prominent to those students from tier 3 schools.
- Besides, it is found that there was a positive impact of the selection test result of a student to his HKDSE result.
- Finally, the moderated school-specific SBA scores of LS of those schools, where our HKAGE student members came from, spread quite widely and covered quite well the spectrum of the whole population of schools with various performance levels.