Unit 3 paper

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Introduction

School security can be an extremely important part of keeping schools safe especially during a time when threats to schools and school shootings are on the rise. However, some school security measures can create an environment where students can feel trapped in prison like environment which can be toxic to an environment intended for learning. This relationship was explored by Finn & Servoss (2014) where one of the more important aspects of the research included creating a security measure from a series of survey questions asked of United States principles at multiple high schools. Each question in the survey asked whether or not the school implemented the specific security measure listed. The measures were then coded as 1 if the measure was enacted at the school, 0 if the measure was not implemented, or N/A if the question was left unanswered. Then the answers to each of the 20 questions asked was input into the dataset by school. Then, to create the security measure seven of the questions were used to create security indices using a method known as Rasch modeling. Rasch Modeling allows questions to have different weights depending upon how often the questions are answered, which then will assign a security index to specific schools based on how the questions were answered.

The main goals of this paper are as follows: First, to recreate the Rasch model indices created by Finn & Servoss's original study to observe how their security index behaves. Second, due to the creation of these security index using the Rasch model Finn & Servoss encountered an error-in-variables problem where a variables true value cannot be measured, however a related variable is measure with some some error away from the true value. This research will look to see if the indices showcase data patterns which will allow for the correction

of this problem using proper statistical methods. Third, an alternative model will be fit to create a new style of security index using different questions from the original model, and fitting the Rasch model using a different fitting algorithm involving Bayesian statistical analysis. Finally, both security indices will be compared in terms of how school indices are rank the schools.

Methods

The dataset to be used is a reduced version of the full dataset gathered by Finn & Servoss, which includes answers from each of the schools to the 20 questions in the questionnaire. This data has a total 656 schools, however not all schools answered all 20 questions, leading to missing data. For our purposes the researchers will focus on the missing data from the 14 question being used in the analysis: the 7 from the original study and the 7 from the current follow up analysis. The 7 security questions used in the original study are: whether students are required to pass through metal detectors each day, Where random metal detector checks are performed, whether random dog sniffs were used, whether other random sweeps were used, whether drug test were required, were security cameras were in use, and if security or paid law enforcement were used during school hours. From these 7 questions 19 schools had some form of missing questions. However, scores for schools are still calculated for schools with missing data through the Rasch model assumptions of data missing at random. This is an assumption used for all Rasch models used in this analysis. After, gathering the original data on the 656 schools data manipulation is used to transform the dataset into a format usable by the Rasch model where the predictors were the schools answering the question sets and which question is being answered. The binary response variable is whether the security measure is enacted or not. The logistic regression coefficients produced by the rasch model for the schools are then used as the security index.

For the second analysis a parametric bootstrap is used to assess whether the indices produced by the rasch model seem to follow a normal distribution with common variance, which if true will allow the coefficients to be error-in-variables problem to be corrected for using statistical methods. This bootstrap dataset is then fitted to the Rasch model to produce 100 coefficients for each school to assess their distributions. To assess the distributions box plots were created after scaling the coefficients for 10 randomly selected schools, and standard deviations were compared along with means. If the indices showcase normal distributions with common variance, then the root mean squared error will be calculated with all school coefficients to then be used to correct for the error-in-variables problem.

For the third section of analysis an alternative Rasch model was fitted using a set of 7 different questions from the original study. The researchers reasoning for doing this is two-fold: first the question only seem to get at two aspects of security mainly metal detection and drug checks. This seems to be too narrow of a focus on these security features which greatly inconvenience only a subset off all students while others feel no stress from these measures, if not feel safer overall. Second, since these security measures focus on these two areas it seems likely that if a school uses one technique they would use others. This essentially means that Finn & Servoss are looking at the same measures which does not get at the plethora of other inconveniences students may face and lead to variables which are highly related. Therefore with these two issues in mind the 7 questions for the alternative model were selected by first, attempting to get security measures which have a similar response pattern to the original questions (i.e. if few people use the security measure including a similar response rated question in the second set). Next, the security questions looked to measure different sections of security measures which will affect all students and do not seem to show as much relation to the other questions included in the indices calculation. Both of these question selection criteria are

showcased in the reproducibility appendix, but will not be discussed in length in this paper. The seven questions used were: controlled access to building during school hours, required clear or no book bags on school grounds, required students to wear ID badges, provided an emergency alarm or call button in most classrooms, having a program that involves parents at school helping to maintain school discipline, having law enforcement at school activities, and having law enforcement when school or school events were not occuring. From these questions, 20 schools had some form of missing data. The Rasch model was then fit using the bias reduction in Binomial-response general linear model. This model uses Bayesian methods to reduce bias in the calculation of its coefficients and reduces the overall variance in the model. Coefficients from this model are then calculated for the schools in the same manner as the original Rasch model.

Finally, The models indices are compared using a Kendall-Tau correlation coefficient which looks to assess similarity in the ordering of the two models coefficients. A full explanation of this coefficient can be seen within the reproducibility appendix. Included in this analysis is also a visualization of the ranks of each model's coefficients and the difference between the ranks.

Results

For the first part of the analysis the creation of the indices are calculated from the original model proposed by Finn & Servoss. These indices can be seen in Table 1 which range from -18 to 18 and seem to be more located near the bottom end of the spectrum. Next, the parametric bootstrap of the indices produces multiple indices scores for the schools. Figure 1 shows the standardized boxplots of 10 of the schools indices. From these boxplots we can see issues with the assumptions of indices being normally distributed. We can see this also supported when looking at the standardized means of the variables in Table 3 where although

many of the means are around 0 others are too low or too high such as school 4352. Table 4 also calls into question the assumptions of a common variance as we can see that the standard deviations are widely varied from almost 10 to 5. Therefore the determination was made that it was not possible to correct for the error-in-variables problem through typical statistical means.

Var1	Freq
-18	77
-17	3
-1	156
0	184
1	136
2	72
3	23
4	4
18	1

Table 1 - indices from the original Rasch model

Var1	Freq
-3	16
-2	4
-1	64
0	194
1	191
2	129
3	43
4	11
5	4

Table 2 - Indices from the alternative Rasch model

Next, the alternative Rasch model was fit using the other questions. The output from this Rasch model of the school indices is shown in Table 2. These indices go from -3 to 5 which is a tighter index range and seems to show a more even distribution in the security level with the majority of indices located between -1 and 2. For the final part of the analysis the ordering of the two Rasch model indices was compared. The Kendall Tau correlation coefficient showcased a slightly positive relationship between the ordering of the security indices (τ = .257). This positive relationship is also shown when taking a visualization of the rank of the security indices in each model and then taking the difference between the the indices rankings (Figure 2). We can see from this figure that there is a clear section in the middle of the plot showcasing the positive relationship, but the spread as shown by the lighter sections is why the relationship is not entirely positive and relatively low.

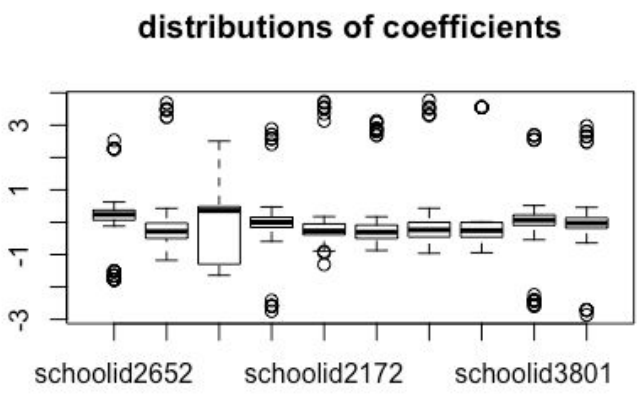

Figure 1 - Boxplot of Bootstrapped indices

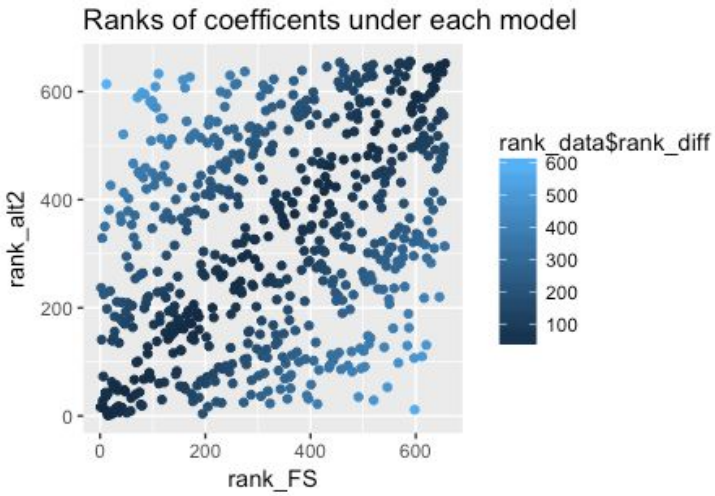

Figure 2 - Ranking visualization

	x
schoolid2652	-0.224
schoolid1752	0.487
schoolid3922	-0.371
schoolid3362	0.189
schoolid2172	0.485
schoolid3621	0.810
schoolid2061	0.452
schoolid4352	-2.169
schoolid3801	0.137
schoolid3321	0.204

Table 3 - Standardized means of indices

	x
schoolid2652	9.389
schoolid1752	5.059
schoolid3922	9.986
schoolid3362	7.373
schoolid2172	5.272
schoolid3621	5.982
schoolid2061	5.047
schoolid4352	5.000
schoolid3801	7.677
schoolid3321	7.090

Table 4 - Bootstrap Standard Deviations

Discussion

From these analyses the researchers have gained more insights into the measurements used by Finn & Servoss. First, after recreating the original indices from the study, we found that the indices error-in-variables problem is not able to be corrected by typical statistical means due to the distributions showcased by these indices, found using bootstrapped versions. Next, after

fitting the an alternative model it was found that the summary of the indices showed a smaller range of indices which may be more interpretable. However, it may not be measuring the same type of security as the original model as showcased by the small positive correlation between the two indices measures according to the Kendall Tau coefficient.

This leads to next steps in the research. The first step in the future research that choose to use the alternative model should start the same way as this research, mainly looking to correct for the error-in-variables problem showcased by the Finn & Servoss model. If the alternative model showcases a more predictable and correctable error distribution, it may be advantageous model to produce school security indices. However, if it does not researchers should look towards other questions in the questionnaire to create an alternative measure of security.

Another question to be asked by future research is how to measure school security. If future research is looking to measure a school security measure related specifically to drug crackdowns and metal detection it may be more advantageous to use the original model as opposed to the alternative model. However, if the research is looking at school security as a broader range of topics, the alternative model may measure security more closely to this construct. Overall, at this point it would seem to be the discretion of the researcher and research in question to determine the best measure of use, and more research on the topic may determine a better more consistent measure.

References

Finn, J. D., & Servoss, T. J. (2014). Misbehavior, suspensions, and security measures in high school: Racial/ethnic and gender differences. *Journal of Applied Research on Children: Informing Policy for Children at Risk*, *5*(2), 11.