NEW APPROACHES TO PERSON FIT ANALYSIS IN COGNITIVE DIAGNOSIS MODELING

A dissertation presented by

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ABSTRACT

New Approaches to Person Fit Analysis in Cognitive Diagnosis Modeling

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The mastery or nonmastery of required attributes in answering a test may not necessarily be reflected in test scores due to examinees' aberrant response behavior such as creative responding, lack of motivation, or cheating. The degree of fit between a psychometric model and an examinee's response pattern can be measured using a person fit (PF) statistic. A response pattern is flagged as aberrant if it is unlikely to be observed given a particular psychometric model. Identification of aberrant response patterns is of paramount importance because they can affect classification decisions, item parameter estimates, and goodness-of-fit statistics. To minimize the chances of making invalid and misleading inferences, it is imperative to detect these kind of response patterns.

Much of the previous research on PF concentrated on unidimensional item response theory (IRT) models. In cognitive diagnosis models (CDMs), the validity of the diagnostic feedback students obtain heavily relies on the appropriateness of the estimated attribute profiles. With the emergence of assessments designed to diagnose fine grained skills, further research on methods for detecting aberrant response patterns are needed. As a contribution in the CDM literature, this dissertation ultimately proposes three approaches to PF analysis.

Chapter 2 of this dissertation examines different adjustment methods for the standardized log likelihood of a response pattern l_Z, namely, using the correction based on Cornish-Fisher expansion, a scaled Chi-square distribution for a higher-order approximation (Molenaar & Hoijtink, 1990), and an approximation based on Edgeworth expansion (Bedrick, 1997). Results show that the Cornish-Fisher expansion and chi-square approximation perform better than the Edgeworth expansion as long as the items are of at least mixed quality. In addition, the viability of two resampling-based approaches, namely, parametric bootstrap (Efron, 1979) and posterior predictive checking method (e.g., Gelman, Carlin, Stern, & Rubin, 2003) are assessed in this study. It is found that the two resampling-based methods have comparable results and they perform well even when items are low discriminating.

Chapter 3 extends the implementation of the forward search algorithm (Atkins, Riani, & Cerioli, 2004) to CDMs to identify person misfit and, at the same time, to mitigate the possible adverse impact of the aberrant response patterns by providing robust estimates of the CDM parameters. Two versions of the FS algorithm are proposed in this chapter – one for reduced CDMs and one for more general CDMs. It is found that the maximum conditional likelihood contribution of each examinee works well as a criterion in progressing with the search. In addition, to monitor drastic changes and identify possible aberrant response patterns, the forward plots of the goodness-of-fit statistics are the most informative.

In Chapter 4, the mixture fit index π^* (Rudas, Clogg, & Lindsay, 1994) is applied to CDMs. It assumes that observations can be classified into two groups, namely: those that conform to a parametric model and those that do not – residual group. π^* gives the proportion of observations belonging to the residual group. This chapter utilizes π^* not only to measure lack of fit but also to identify aberrant response patterns using posterior probabilities. Expectation-Maximization algorithm similar to Revuelta (2008) is embedded in the bisection

algorithm is employed to estimate π^*. The results reveal that this approach looked promising for short tests only.

Finally, Chapter 5 integrates all the key findings in this dissertation and provides the possible areas for future research in PF analysis in the CDM context.

Key Words: *aberrant response patterns, cognitive diagnosis models, person fit, resampling methods, forward search algorithm, mixture fit index*

SCHOOL OF STATISTICS
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September 16, 2017

The Dean
School of Statistics
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Diliman, Quezon City

Sir:

We have the honor to inform you that the undersigned served in the oral examination of **Mr. Kevin Carl P. Santos,** a Ph.D. (Statistics) candidate, who defended his doctoral dissertation titled "*New Approaches to Person Fit Analysis in Cognitive Diagnosis Modeling*" on September 16, 2017 and voted as follows:

	For Approval	For Disapproval
Dr. Erniel B. Barrios Adviser		
Dr. Jimmy de la Torre Co-Adviser		
Dr. Matthias von Davier Reader		
Dr. Joseph Ryan G. Lansangan Member/Chairman		
Dr. Reynaldo Romualdo M. Rey Member		

Committee's Decision: (Check One) [✓] Passed [ ] Failed

Additional Remarks:

Very truly yours,

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Re: Approval of Dissertation

Sir:

I would like to inform you that, as the external member in the oral examination of **Mr. Kevin Carl P. Santos,** a Ph.D. (Statistics) candidate, I voted for the **APPROVAL** of his doctoral dissertation titled "*New Approaches to Person Fit Analysis in Cognitive Diagnosis Modeling*".

Thank you.

Respectfully,