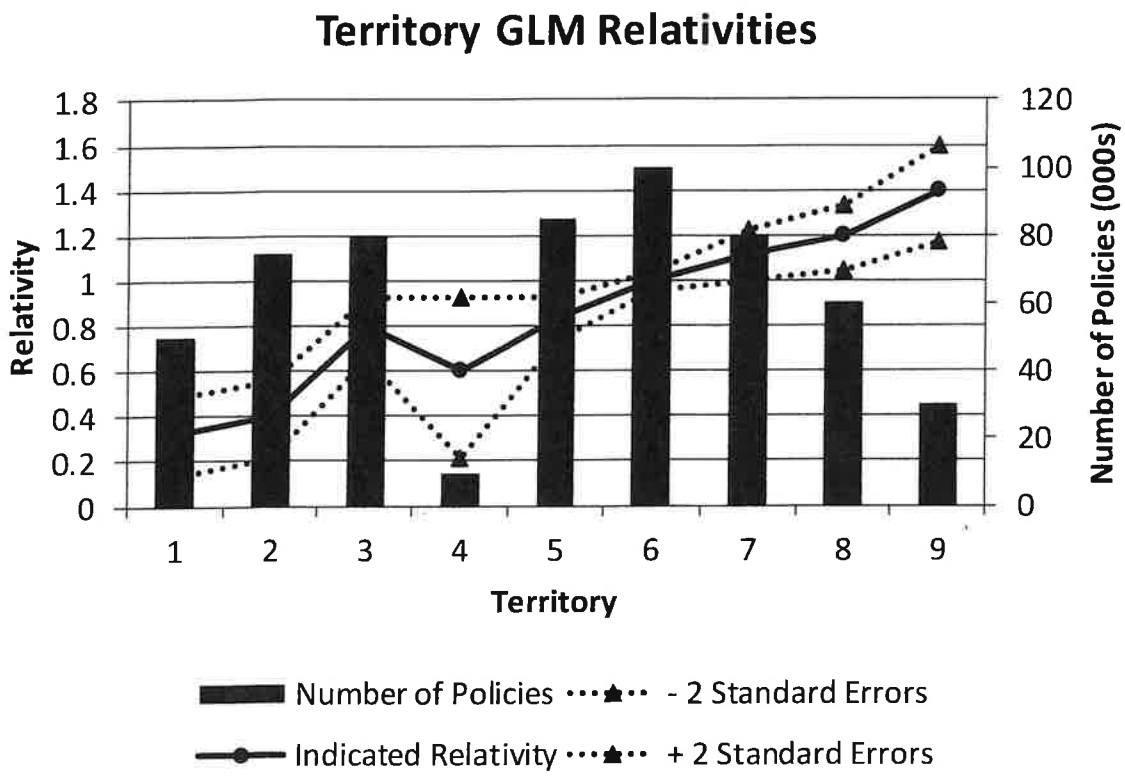
11. (1.5 points)

The output of a generalized linear model (GLM) analysis on relativities for pure premium by territory is shown below:




- Chi-Square Percentage (entire variable) = 0.1%.

a. (0.5 point)

Explain whether the GLM output supports including territory as a rating variable.

b. (0.75 point)

Briefly describe three benefits of using multivariate methods over univariate methods for classification ratemaking.

c. (0.25 point)

Briefly describe how spatial smoothing can be used to improve territory relativity estimates.

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| **QUESTION 11** | |
|---|---|
| **TOTAL POINT VALUE: 1.5** | **LEARNING OBJECTIVE(S): A8** |
| **SAMPLE ANSWERS** | |
| **Part a:** 0.5 point | |

*Sample 1:*
Yes, the GLM supports including territory as a rating variable because the chi-square percentage indicates a strong correlation for territory and expected losses. Also, the different relativities by territory accompanied by narrow confidence intervals in most territories suggests that policies should be rated differently by territory.

*Sample 2*
I believe the GLM output supports territory as a rating variable. The chi-square % is below the necessary threshold, which supports adding it. We see the tight error bands at each level and a clear upward trend in relativity and a great deal of lift between levels. My suggestion would be to consider grouping terr 4 with terr 3 given the lack of data and wider standard error bands.

*Sample 3*
YES, the GLM supports including territory as a rating variable. Standard errors are narrow, we can see an upward trend in the indicated relativity, chi-square % is also small meaning this variable is statistically significant.

**Part b:** 0.75 point

Any three of the following:

- Multivariate models allow for interaction between rating variables (univariate models do not)
- Consider all variables simultaneously & attempts to account for exposure correlation
- They produce model diagnostics which tell us about the appropriateness of fit of the model
- They attempt to focus on the "signal" rather than the "noise"

**Part c:** 0.25 point

*Sample 1:*
Two methods of spatial smoothing include distance-based and adjacency-based. Often, defined territories are so granular that very little data exists. Spatial smoothing allows one to have more data, and thus more credibility, when analyzing these granular territories. Both methods stated above incorporate neighboring territory data (based on distance away or adjacency) which will most likely lead to more narrow confidence intervals and more refined relativities. I would recommend spatial smoothing to get a finer relativity for territory 4 in the GLM output.

*Sample 2:*
Spatial smoothing can credibility-weight the territory's experience with the experience of surrounding territories. The further away from the territory, the less weight is given.

*Sample 3:*
Spatial smoothing can credibility-weight the territory's experience with the experience of surrounding territories. The further away from the territory, the less weight is given.

**EXAMINER'S REPORT**

Candidates were expected to interpret GLM output, understand the fundamentals of univariate and multivariate relativity analyses, and describe how spatial smoothing is used for developing territory indications.

**Part a**

Candidates were expected to be able to interpret the output of a GLM. They needed to correctly identify that territory should be included as a rating variable and provide at least one reason to justify why territory is an appropriate rating variable in the context of a multivariate analysis.

Common errors included:

- Concluding that territory should NOT be included as a rating variable
- Providing incorrect justification to why territory should be included as a rating variable

**Part b**

Candidates were expected to provide three benefits of multivariate models over univariate.

Common errors included:

- Not providing 3 distinct reasons. For example, if the candidate referenced correcting for exposure correlation and distributional bias as two separate reasons, credit was only given for one of those responses.
- Only providing 2 responses

**Part c**

Candidates were expected to discuss how spatial smoothing uses information from nearby territories to improve the territory relativity estimates.

Common errors included:

- No response. Candidates left part c blank more frequently than the other parts.
- Discussing boundary redefinition or clustering rather than spatial smoothing