Online Appendix for Daniel W. Gingerich, "Governance Indicators and the Level of Analysis Problem: Empirical Findings from South America"

The Bayesian Hierarchical ANOVA Model

Specification. The specification of a Bayesian hierarchical ANOVA model for nonnormally distributed responses consists of three steps: the specification of the relationship between the response and the linear predictor, the specification of the linear predictor in terms of the relevant sources of variation being studied, and the specification of prior distributions for all model parameters.

The survey questions analyzed in the paper prompted responses that were either binary or ordinal in form. For the survey questions that prompted a binary response, employee responses were modeled using the logit function,

$$
\begin{aligned}
y_i &\sim \text{Bernoulli}(p_i) \\
p_i &= \text{logit}^{-1}(v_i)
\end{aligned}
$$

where v_i is the value of the linear predictor for subject i. Alternatively, for the survey questions that prompted participants to give a response that belonged to one of M ordered categories, employee responses were modeled using the ordered logit model,

$$
\begin{aligned}
y_i &\sim \text{Multinomial}(p_{1i}, ..., p_{Mi}) \\
p_{mi} &= \begin{cases} 1 - \text{logit}^{-1}(v_i - \tau_m) & \text{if } m = 1 \\ \text{logit}^{-1}(v_i - \tau_{m-1}) - \text{logit}^{-1}(v_i - \tau_m) & \text{if } m \in \{2, ..., M-1\} \\ \text{logit}^{-1}(v_i - \tau_{M-1}) & \text{if } m = M \end{cases}
\end{aligned}
$$

where the cutpoint variables satisfy the ordering constraint $\tau_1 = 0 < \tau_2 < ... < \tau_{M-1}$.

In order to assess the relative importance of cross-agency versus cross-national differences for the observed variation in employee responses, the linear predictor was specified as an additive decomposition consisting of agency-level effects and country-level effects. Let $a_i(j)$ denote the indicator variable equal to 1 if individual i belongs to agency j, 0 otherwise. Similarly, let $c_i(k)$ denote the indicator variable equal to 1 if individual i belongs to country k, 0 otherwise. The linear predictor was written as

$$v_i = \mu + \sum_j^J \gamma_j a_i(j) + \sum_k^K \delta_k c_i(k)$$

where μ is an intercept term, γ_j captures the effect of belonging to agency j on the response and δ_k captures the effect of belonging to country $k \in \{1, ..., K\}$ on the response.

The Bayesian hierarchical ANOVA model treats the quantities μ, $\boldsymbol{\gamma} = (\gamma_1, ..., \gamma_J)'$, and $\boldsymbol{\delta} = (\delta_1, ..., \delta_K)'$ as coefficients whose prior distributions are specified by the user. I chose noninformative priors for all coefficients represented in the linear predictor, modeling these as

$$\begin{aligned} \mu &\sim N(0, 10^4), & \gamma_j &\sim N(0, \sigma_\gamma^2) \text{ for all } j \in \{1, ..., J\} \\ \delta_k &\sim N(0, \sigma_\delta^2) \text{ for all } k \in \{1, ..., K\}, & \sigma_\gamma &\sim U(0, 100) \\ \sigma_\delta &\sim U(0, 100), \end{aligned}$$

For the survey questions having ordinal responses, noninformative priors were also chosen for the cutpoints, with the $\tau_2, ..., \tau_{M-1}$ modeled as mean zero normal random variables having standard deviation of 100 and subject to the ordering constraint presented above.

The paper's measure of the importance of each source of variation for the response is the finite population standard deviation of the constrained coefficients corresponding to that source. Let s_γ denote the value of this statistic for agency characteristics and s_δ denote the value of this statistic for country characteristics. The quantities of interest are

$$
\begin{aligned}
s_\gamma &= \sqrt{\frac{1}{J}\sum_j^J(\gamma_j - \overline{\gamma})^2}, \text{ where } \overline{\gamma} = \frac{1}{J}\sum_j^J \gamma_j \\
s_\delta &= \sqrt{\frac{1}{K}\sum_k^K(\delta_k - \overline{\delta})^2}, \text{ where } \overline{\delta} = \frac{1}{K}\sum_k^K \delta_k
\end{aligned}
$$

I estimated the ANOVA models using the Bayesian statistical package `WinBugs`. In order to speed up convergence, I utilized the redundant parameterization technique described in Gelman and Hill.[1] Three Markov chains were run for each model, with the number of simulation draws taken from each chain chosen so that $\widehat{R} \leq 1.1$ for all agency-level and country-level effect parameters. In each estimation, at least 1000 of the total simulation draws from the posterior distribution were retained for making inferences about the quantities of interest.

Hypothesis Testing. The proposition evaluated for a each survey question on politicization, the stability of bureaucratic career paths, or corruption control is that $s_\gamma \geq s_\delta$, i.e., the influence of agency-level factors on the variability of responses is greater than the influence of country level factors. Evaluating this proposition corresponds to testing the null hypothesis that $s_\gamma < s_\delta$. Let the subscript l denote a particular draw from the simulated posterior distribution. I calculate the probability of the null as

$$\Pr(s_\gamma < s_\delta) = \sum_{l=1}^{n^{\text{sim}}} \mathcal{I}(s_{\gamma,l} < s_{\delta,l})/n^{\text{sim}}$$

where $\mathcal{I}(x)$ is the indicator function equal to 1 if x is true and 0 otherwise and n^{sim} is the number of simulation draws retained from the joint posterior distribution.

The Two Parameter Ordinal Item Response Model

According to the ordinal item response model used in the text, two parameters describe the relationship between the observed responses to a given question q and the latent variable. The first is $\lambda_{q,1}$, the so-called negative item difficulty parameter, which serves as a question-specific intercept term. The second is $\lambda_{q,2}$, the so-called discrimination parameter, which measures the how differences in the value of the latent trait affect the observed responses for q. By examining the sign of $\lambda_{q,2}$ for each question, one can check if the relationship between the latent trait and the observed responses corresponds to expectations.

Appendix Table 1: Posterior density summary of the Bayesian ordinal factor analysis

manifest variables	λ_1	λ_2
Political connections are important in determining who obtains a post in my institution (1=strongly agree, 2=agree, 3=disagree, 4=strongly disagree)	0.89 (0.04)	0.94 (0.04)
Promotions in my institution depend more on good performance in the workplace than on political affiliation or influence (1=strongly agree, 2=agree, 3=disagree, 4=strongly disagree)	1.34 (0.04)	−0.92 (0.04)
Rank of importance of political connections for promotions in agency minus rank of importance of job performance for promotions in agency	2.29 (0.08)	1.41 (0.06)
Indicate with a 1 below the factor that has the greatest influence on dismissals in your institution, 2 the factor that has the second greatest influence, and so on until you have ranked the four factors (outcome is rank assigned to political factors)	1.00 (0.05)	1.15 (0.05)
Party leaders can easily punish employees who do not obey the orders of the governing parties (1=strongly agree, 2=agree, 3=disagree, 4=strongly disagree)	0.60 (0.03)	0.41 (0.03)
How would you characterize the likelihood that you lose your job in the near future? (1=highly probable, 2=probable,3 =improbable, 4=highly improbable)	1.33 (0.04)	0.16 (0.02)
If someone were to misappropriate the resources of your institution, how probable do you think it would be that an internal audit, an external audit,or some other type of investigation would occur as a result? (1=highly probable,2=probable,3=improbable,4=highly improbable)	0.10 (0.03)	−0.72 (0.04)
If an audit or another type of investigation did occur,what do you think would happen to the person who misappropriated the resources? (1=the person would probably be judged in a court of law and sanctioned,2=the person would probably be judged in a court of law but not sanctioned,3=the person would probably neither be judged in a court of law nor sanctioned)	−0.56 (0.04)	−0.76 (0.04)
Would you say that the majority of employees in your institution would file a complaint (denuncia) if they were aware that someone had misappropriated the resources of the institution?(1=yes, 2=no)	−0.09 (0.03)	0.61 (0.04)
N	2343	

Note: The top entry in each row is the posterior mean for a given parameter and the bottom entry (in parentheses) is the posterior standard deviation. The first column of the table (labeled λ_1) presents the negative item difficulty parameters for each survey measure. The second column of the table (labeled λ_2) presents the discrimination parameters (factor loadings) for each survey measure. The chain was run for 50,000 iterations with 5,000 burn-in iterations. Every 50th iteration past the burn-in was saved in order to draw inferences about the parameters in interest.

Appendix table 1 presents posterior density summaries for the negative item difficulty parameters and discrimination parameters for each question contained in the analysis. For all questions, the sign of the mean value of the discrimination parameter was consistent with the hypothesis that a latent, underlying perception of 'Weberianness' was responsible for driving the observed responses.

Moreover, in all cases the discrimination parameters whose means were positive (negative) had essentially no mass to the left (right) of zero, meaning that we can be highly confident in the relationships described by the parameters. Consequently, it seems safe to conclude that the WPSs generated from the model are indeed capturing perceptions of bureaucratic capacity.