

Supplementary Material

Predictive Modelling of Australian School Principals' Turnover Intentions

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Supplementary Material I

All variables used in this work are listed in Table [1](#).

Table 1: List of Included Variables

Scale	Factor	Reference	Number of Items	Sample Item	Response Scale
Intent to Quit	Turnover Intention	Spector et al., 1988	1	I often seriously consider leaving my current job.	1 = Strong disagree, ..., 6 = Strongly agree
COPSOQ-II	Quantitative Demands	Pejtersen et al., 2010; Dicke et al., 2018	4	Is your workload unevenly distributed so it piles up?	Question-dependent
	Work Pace		3	Do you have to work very fast?	
	Cognitive Demands		4	Do you have to keep your eyes on lots of things while you work?	
	Emotional Demands		4	Does your work put you in emotionally disturbing situations?	
	Hiding Emotions		3	Are you required to treat everyone equally, even if you do not feel like it?	
	Influence		4	Do you have a large degree of influence concerning your work?	
	Possibilities for Development		4	Does your work require you to take the initiative?	
	Variation		2	Is your work varied?	
	Meaning of Work		3	Is your work meaningful?	
	Commitment to the Workplace		4	Do you enjoy telling others about your place of work?	
	Predictability		2	Are you informed well in advance concerning important decisions?	
	Recognition		3	Is your work recognised and appreciated by the management?	
	Role Clarity		3	Does your work have clear objectives?	
	Role Conflict		4	Do you do things at work accepted by some but not by others?	
	Quality of Leadership		4	Does your superior ensure development opportunities?	
	Social Support from Colleagues inside School		3	Do you get support from colleagues inside your school?	
	Social Support from Colleagues outside School		3	Do you get support from colleagues outside your school?	
	Social Support from Supervisors		3	Is your superior willing to listen to your problems at work?	
	Social Community at Work		3	Is there a good atmosphere between you and your colleagues?	
	Job Insecurity		4	Are you worried about becoming unemployed?	
	Job Satisfaction		4	How pleased are you with your work prospects?	
	Work-Family Conflict		4	Do you feel a conflict between your work and private life?	
	Family-Work Conflict		2	Does your private life negatively affect your work?	
	Justice		4	Are conflicts resolved in a fair way?	
	Social Inclusiveness		4	Are men and women treated equally at your workplace?	
	General Health Perception		1	In general, would you say your health is:	
	Burnout		4	How often have you felt worn out?	
	Sleeping Troubles		4	How often have you slept badly and restlessly?	
	Stress		4	How often have you had problems relaxing?	
	Depressive Symptoms		4	How often have you felt sad?	
	Somatic Stress		4	How often have you had stomach ache?	
	Cognitive Stress		4	How often have you had problems concentrating?	
	Self Efficacy		6	I am always able to solve difficult problems, if I try hard enough.	
	Sexual Harassment		1	Have you been exposed to undesired sexual attention at your workplace during the last 12 months?	
	Threats of Violence		1	Have you been exposed to threats of violence at your workplace during the last 12 months?	
	Bullying		1	Have you been exposed to bullying at your workplace during the last 12 months? (Bullying means that a person repeatedly is exposed to unpleasant or degrading treatment, and that the person finds it difficult to defend himself or herself against it.)	
	Unpleasant Teasing		1	Have you been exposed to unpleasant teasing at your workplace during the last 12 months?	
	Conflicts & Quarrels		1	Have you been involved in quarrels or conflicts at your workplace during the last 12 months?	
	Gossip & Slander		1	Have you been exposed to gossip and slander at your workplace during the last 12 months?	

Scale	Factor	Reference	Number of Items	Sample Item	Response Scale
	Cyber Bullying		1	Have you been exposed to work-related harassment on social media (e.g. Facebook), by e-mail or text messages during the last 12 months?	
Brief Resilience Scale (BRS)	Resilience	Smith et al., 2008	6	I tend to bounce back quickly after hard times.	1 = Strong disagree, ..., 5 = Strongly agree
Psychological Needs at the Workplace	Psychological Needs	Chen et al., 2015	24	At work, I feel a sense of choice and freedom in the things I undertake.	1 = Strong disagree, ..., 7 = Strongly agree
Three States Questionnaire (TSQ)	Need States – Unengaged	Reeve et al., 2023	5	At work, my desire for choice and freedom typically feels: [Unengaged]	1 = Strong disagree, ..., 7 = Strongly agree
AUDIT-C	Alcohol Use	World Health Organisation, 1998	10	How often do you have a drink containing alcohol?	1 = Never, 2 = Less than monthly, 3 = Monthly, 4 = Weekly, 5 = Daily or almost daily
NA	Hours Spent on Tasks	Dicke et al., 2024	21	How many hours a week do you spend on e.g., internal meetings?	
NA	Sources of Stress	Marsh et al., 2023a; Dicke et al., 2024	19	Please rate the stress caused by e.g., sheer quantity of work.	1 = A minor source to 10 = A major source
NA	Sources of Support	Dicke et al., 2024	12	Please indicate your sources of support e.g., partner.	
NA	Demographics	Dicke et al., 2024	12	What state is your school in?	

Supplementary Material II

The estimation process for the parameters β and b involves an iterative optimisation procedure, outlined below:

1. Initialisation Without Random Effects:

- Train an initial XGBoost model to estimate $P_0(Y = 1 | X)$. This serves as the base model.
- Compute the initial linear predictor $\hat{\eta}_1$ as:

$$\hat{\eta}_1 = \log \left(\frac{\hat{f}(X; \hat{\beta})}{1 - \hat{f}(X; \hat{\beta})} \right),$$

where $\hat{f}(X; \hat{\beta})$ is the predicted probability from the trained XGBoost model.

2. Estimate Random Effects:

- Use $\hat{\eta}_1$ as an offset in a logistic mixed-effects model to estimate the random effects component η_2 :

$$\hat{\eta}_2 = Z\hat{b},$$

where $\hat{b}$ is estimated using a method such as restricted maximum likelihood (REML) or marginal maximum likelihood.

- Ensure proper specification of Z to reflect the hierarchical or grouped structure of the data (e.g., grouping by subjects, clusters, or other random effects).

3. Update XGBoost Model:

- Treat $\hat{\eta}_2$ as fixed and retrain the XGBoost model to optimise a modified log-likelihood function:

$$\ell(\beta) = \sum_{i=1}^n \left[y_i \log \left(\frac{1}{1 + e^{-(\eta_1 + \hat{\eta}_2)}} \right) + (1 - y_i) \log \left(1 - \frac{1}{1 + e^{-(\eta_1 + \hat{\eta}_2)}} \right) \right].$$

Here, the random effects component $\hat{\eta}_2$ adjusts the probabilities based on the hierarchical structure.

4. Iterate Until Convergence:

- Repeat Steps 2 and 3 iteratively, updating both η_1 and η_2 , until the parameters stabilise or meet a predefined convergence criterion, such as a small change in log-likelihood or parameter estimates.

Remark 1. The proposed approach effectively integrates the predictive strengths of XGBoost with the flexibility of random effects modelling. Key considerations include: a) XGBoost Configuration: Ensure that XGBoost is configured to use a logistic loss function, enabling the output probabilities to align with the logistic regression framework. b) Random Effects Estimation: The design matrix Z should be carefully constructed to capture the hierarchical structure of the data. Software packages such

as `glmmTMB` [1] in R can facilitate random effects estimation. By combining XGBoost’s high predictive performance with the nuanced handling of random effects, this method is particularly suited for structured data scenarios, such as multi-level or clustered datasets.

References

- [1] Mollie E Brooks, Kasper Kristensen, Koen J Van Benthem, Arni Magnusson, Casper W Berg, Anders Nielsen, Hans J Skaug, Martin Machler, and Benjamin M Bolker. `glmmTMB` balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. *The R Journal*, 9(2):378–400, 2017.