

LATENT PROFILES OF PERCEIVED SYSTEMIC E-GOVERNMENT BARRIERS IN SUDANESE HIGHER EDUCATION: A PERSON-CENTRED ANALYSIS OF EMPLOYEE SURVEY DATA

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Abstract: Studies of e-government barriers in developing settings often report average scores or variable-centred dimensions, implicitly treating employees as a single response population. This paper applies latent profile analysis to employee survey data from Sudanese higher education to examine whether perceived systemic e-government barriers cluster into hidden response groups. The dataset includes 275 valid responses and 35 five-point barrier items. A three-profile solution was retained because it provided the most defensible balance between statistical fit, class size, entropy, and substantive interpretability. The retained profiles are best understood as low-, moderate-, and high-systemic barrier groups rather than as sharply specialized domain types. The high-systemic profile reported elevated scores across governance, leadership, capability, digital inclusion, financing, and utilities. Qualification, job role, and years of experience were associated with profile membership. Robustness checks using alternative covariance structures and split-half estimation recovered the same substantive ordering. The study contributes to person-centred barrier modelling by showing that employee heterogeneity in this setting lies primarily in the intensity of system-wide constraints, with practical implications for more differentiated reform design.

Keywords: e-government barriers; latent profile analysis; person-centred analysis; higher education; survey; Sudan

1. Introduction

Digital transformation in the public sector is no longer understood as a narrow technology upgrade. It is increasingly viewed as a longer-term process of organizational change involving structures, routines, capabilities, service design, and administrative coordination [1][2][3]. In digital government settings, technical systems may be visible, but implementation success often depends on less visible conditions such as leadership continuity, standards, interdepartmental alignment, and institutional capacity [4][5][6].

Higher education institutions provide a particularly revealing setting for studying these issues because they combine public administration, service provision, internal bureaucracy, and knowledge-intensive work. Recent reviews consistently show that higher education digital transformation is shaped by governance, infrastructure, digital literacy, leadership, organizational culture, and resistance to change[7][8][9][10][11]. Yet much of this literature



addresses pedagogy, blended learning, or broad institutional modernization rather than e-government implementation inside administrative systems.

A related limitation appears in the wider e-government literature. Many studies focus on citizen adoption, privacy, trust, and service use [12][13][14]. That work is important, but it addresses a different analytical question: why citizens use or avoid digital public services. It does not fully explain how employees within public institutions perceive the barriers that make digital government difficult to implement and sustain. In lower-capacity settings, internal constraints may become visible before citizen adoption becomes the dominant problem.

A second limitation in the literature is methodological. Barrier studies often report means, rankings, or global dimensions, which are informative but still assume that respondents can be described through an overall average pattern. Person-centred methods challenge that assumption by asking whether hidden subgroups exist inside the same sample [15][16][17]. In public administration, such methods are useful even when profiles differ more in intensity than in sharply different shape, because uneven exposure to the same institutional problem can still produce meaningful employee segments. Recent work on public-sector digital transformation also suggests that governance ambiguity, status quo bias, and uneven administrative capability can create different implementation experiences across organizational actors [18][19][20][21]. Figure 1 summarizes the analytical logic of the study. The 35 barrier items were first condensed into interpretable domains, after which model-based latent profile solutions were compared and linked to background characteristics for policy interpretation.

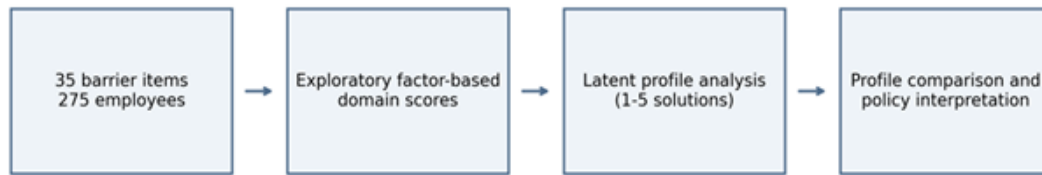


Figure 1. Analytical workflow used to derive latent profiles from the barrier survey.

2. Research gap and study contribution

This study addresses a specific gap in the literature on digital government implementation in constrained public-sector environments. Existing work increasingly recognizes that digital reform is shaped by administrative continuity, public-sector capability, leadership, and institutional alignment rather than infrastructure alone [4][5][6][21]. However, most empirical studies still treat employee responses as homogeneous and rarely test whether distinct internal profiles of perceived barriers exist. Just as importantly, where person-centred approaches are used, it is often left unclear whether the resulting profiles represent qualitatively different response patterns or mainly different levels of systemic constraint.

The paper, therefore, makes two linked contributions. Empirically, it offers evidence from Sudanese higher education, a context that remains underrepresented in international digital government research. Methodologically, it applies a person-centred latent profile approach to show whether employees cluster into hidden groups once barrier indicators are organized into coherent institutional domains. Its main contribution lies in showing that employees do not simply differ in isolated item responses; they cluster into broader intensity-based patterns of perceived system-wide constraint. That contribution matters for reform practice. If a high-systemic barrier intensity profile exists alongside more moderate or lower-intensity profiles, then uniform interventions are unlikely to be efficient. A segmented administrative response may be more appropriate, especially in public organizations operating under resource scarcity, uneven infrastructure, and fragile implementation continuity [22][23][24].

3. Research questions

RQ1. Do the perceived barriers to e-government implementation form latent profiles of systemic barrier intensity among employees in Sudanese higher education?

RQ2. Which latent profile solution offers the most interpretable and practically meaningful representation of employee heterogeneity?

RQ3. How do the retained profiles differ across the main barrier domains?

RQ4. Are profile memberships associated with gender, age, educational qualification, job role, and years of experience?

4. Method

4.1 Design and Data Source

The study uses a cross-sectional quantitative design based on secondary analysis of an anonymous employee survey dataset. The raw file contains 275 valid responses from Sudanese higher education employees and 35 barrier items measured on a five-point Likert scale, where higher values indicate stronger perceived barriers. The study is explanatory-descriptive rather than causal and is intended to identify hidden patterns of employee responses rather than estimate policy effects. Its central question is whether employees cluster into latent profiles once a set of substantively coherent barrier domains is used as person-centred indicators.

As shown in Table 1, the sample is experienced and institutionally mature. Men account for 73.8% of respondents, 82.6% are aged 40 years or older, and 95.3% report at least five years of work experience. Because the dataset does not document a probability-based national sampling frame, the findings should be interpreted as sectoral evidence rather than nationally representative estimates. No independent national benchmark was available for the composition of the higher education workforce, so the sample skew towards older, male, and more experienced respondents cannot be calibrated against sector totals.

Table 1: Sample Characteristics (n = 275).

Variable	Category	n	%
Gender	Male	203	73.8
	Female	72	26.2
Age	<30	10	3.6
	30-<40	38	13.8
	40-<50	102	37.1
	50+	125	45.5
Qualification	Secondary	69	25.1
	University degree	104	37.8
	Postgraduate	102	37.1
Job role	Employee	115	41.8
	Faculty member	86	31.3
	Administrator	25	9.1
	Other	49	17.8
Experience	<5 years	13	4.7
	5-<15 years	83	30.2
	15-<25 years	107	38.9

	25+ years	72	26.2
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4.2 Domain Construction and Indicator Preparation

Before profile extraction, the barrier items were reorganized into six continuous domain indicators constructed from conceptually related item groups within the survey. Using domain-level indicators rather than the full 35-item matrix reduces model complexity and allows the profiles to be interpreted in substantive administrative terms. Internal consistency was rechecked in the current analytical sample and was acceptable for five domains (Cronbach's $\alpha = 0.74\text{--}0.84$). The two-item affordability and utility domain showed a moderate inter-item correlation ($r = 0.43$), which was considered adequate for a substantively narrow indicator pair.

For each employee i and domain j , standardized scores were computed as:

$$z_{ij} = (x_{ij} - \bar{x}_j) / s_j \quad (1)$$

where x_{ij} is the observed domain score, $\bar{x}_j$ is the sample mean for domain j , and s_j is the corresponding standard deviation. Standardization placed all indicators on the same scale before profile estimation.

4.3 Latent Profile Analysis

Latent profile analysis (LPA) was then used to identify hidden subgroups of employees based on the six standardized domain indicators. In operational terms, the analysis was estimated through model-based Gaussian mixture clustering with continuous indicators, which is consistent with the logic of LPA in person-centred research [15][16][17]. Models with one to five profiles were compared.

The posterior probability that respondent i belongs to profile c was estimated as:

$$P(c|z_i) = [\pi_c f(z_i | \mu_c, \Sigma_c)] / \sum_k [\pi_k f(z_i | \mu_k, \Sigma_k)] \quad (2)$$

where π_c denotes the profile proportion and $f(z_i | \mu_c, \Sigma_c)$ the multivariate normal density for profile c . Solutions were evaluated using the Akaike information criterion (AIC), Bayesian information criterion (BIC), entropy, class size, and substantive interpretability. The final solution was selected by balancing statistical fit against parsimony and the practical usefulness of the resulting profiles. As an auxiliary robustness exercise, the three-profile interpretation was re-examined under diagonal, tied, and spherical covariance specifications and in two random half-samples. The aim of these checks was not to privilege a single alternative model, but to assess whether the low-, moderate-, and high-systemic ordering remained substantively stable. As summarized in **Table 2**, statistical fit improved as additional profiles were added, but solutions beyond three profiles produced increasingly small classes and offered less practical interpretability. The three-profile solution therefore provided the most defensible balance between fit, entropy, class size, and substantive clarity.

Table 2. Model Fit Comparison For One- To Five-Profile Solutions.

Profiles	AIC	BIC	Entropy	Smallest Class n	Smallest Class %
1	6298.05	6395.7	N/A	275	100.0
2	5871.7	6070.62	0.827	125	45.1
3	5717.59	6017.78	0.870	46	16.7
4	5623.37	6024.83	0.931	27	9.8
5	5187.95	5690.68	0.923	9	3.3

Note. Entropy is not reported for the one-profile solution because classification uncertainty is not defined when only one latent profile is estimated

Auxiliary robustness checks supported that interpretation. Although alternative covariance specifications changed the exact class proportions, each reproduced the same substantive ordering: a lower-intensity group, a middle group near the sample average, and a high-systemic group elevated across the domains. A random split-half exercise recovered the same ordering in both subsamples, suggesting that the profile narrative is not an artefact of one specific covariance assumption. As shown in Figure 2, information criteria improved as additional profiles were added, but the gains beyond three profiles came with increasingly small classes. The five-profile solution produced a class of only 3.3% of the sample, and the four-profile solution largely split the lower-barrier end of the data without yielding a substantially clearer policy interpretation. For that reason, the three-profile solution was retained.

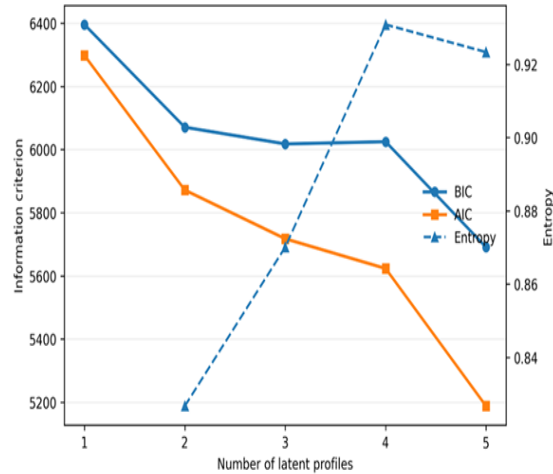


Figure 2. Information criteria and entropy across latent profile solutions.

4.4 Profile Interpretation and Background Comparisons

After profile selection, mean standardized domain scores were computed for each profile and compared across the six domains. Background associations were then examined using chi-square tests for gender, age, educational qualification, job role, and years of experience. One-way comparisons were also used to estimate the magnitude of between-profile separation across the domain indicators. These tests were used to describe concentration patterns rather than to claim population-level causal effects.

5. Results

5.1 Domain Structure Used as Profile Indicators

The six domains used in the profile model were substantively coherent and captured recurring barrier groupings within the survey. Table 3 presents the domain labels and a small set of representative indicators for each domain. Together, these domains span human and organizational capability, societal readiness, financing, governance, infrastructure affordability, and leadership continuity. Rechecking the indicators within the current analytical sample suggested acceptable reliability for five domains, while the narrower two-item affordability and utility domain remained substantively useful despite more modest internal association.

Table 3: Domain Indicators Used In The Latent Profile Analysis.

Domain	Representative indicators	Illustrative loading range
Human capability, trust, and bureaucracy ($\alpha = 0.84$)	Bureaucratic avoidance of public-sector work; weak communication across project actors; reliance on external expertise	0.653-0.735

Societal access and digital inclusion ($\alpha = 0.83$)	Low use of computers and smartphones; low internet use; low ICT awareness among the public	0.695-0.825
Financial and infrastructure readiness ($\alpha = 0.79$)	Limited project budgets; insufficient funding for infrastructure; weak training finance	0.715-0.777
Strategic governance and interoperability ($\alpha = 0.78$)	Lack of unified standards; incompatible technology standards; weak data security	0.643-0.767
Affordability and utility constraints ($r = 0.43$)	Weak electricity coverage; high communication costs	0.669-0.719
Leadership, awareness, and change readiness ($\alpha = 0.74$)	Low managerial awareness; policy discontinuity; weak initiative and resistance to change	0.494-0.662

Reliability was strongest for human capability, trust, and bureaucracy; societal access and digital inclusion; and financial and infrastructure readiness. Strategic governance and leadership/change readiness were also acceptable for exploratory person-centred modelling. The affordability and utility domain should be read more parsimoniously because it is based on only two tightly focused indicators.

5.2 Retained Profile Solution

The three-profile model produced acceptable entropy (0.870) and no trivially small classes. The mean posterior assignment probability was 0.950, indicating strong average classification certainty. The retained profiles comprised 73 respondents in the low-barrier profile (26.5%), 156 in the moderate-barrier profile (56.7%), and 46 in the high-systemic barrier profile (16.7%).

Substantively, the three profiles are best interpreted as a severity gradient in perceived systemic barriers rather than sharply different domain specializations. The low-barrier profile reported below-average barrier scores on all six domains. The moderate-barrier profile clustered near the sample mean and reflected a more balanced but still non-trivial perception of constraints. The high-systemic barrier profile reported elevated scores on every domain, indicating that a meaningful minority of employees experience implementation problems as broad institutional strain rather than as one isolated issue. The profile-specific domain means reported in **Table 4** confirm that the retained solution is best understood as a gradient of systemic barrier intensity.

Table 4: Standardized Domain Means For The Retained Latent Profiles Of Barrier Intensity.

Profile	Human capability, trust, and bureaucracy	Societal access and digital inclusion	Financial and infrastructure readiness	Strategic governance and interoperability	Affordability and utility constraints	Leadership, awareness, and change
Low-barrier	-1.67	-1.52	-1.76	-1.32	-0.66	-0.92
Moderate barrier	0.08	0.11	0.3	-0.07	0.01	-0.0
High-systemic	2.39	2.05	1.77	2.32	1.01	1.48

The profile interpretation was also stable in auxiliary robustness checks. When the three-profile solution was re-estimated under diagonal, tied, and spherical covariance assumptions, the same low-, moderate-, and high-systemic ordering reappeared even though the exact class sizes varied. The same substantive ordering was recovered in two random half-samples, which supports the stability of the interpretation without implying that the class shares themselves should be over-read.

Figure 3 makes the separation of the profiles clear. The high-systemic barrier profile is elevated across all domains, with especially strong scores on strategic governance and interoperability, human capability and trust, and societal access constraints. The low-barrier profile is consistently below zero across the same domains, while the moderate-barrier remains close to the sample average. This pattern indicates that employees differ mainly in overall barrier intensity, but with the high-systemic group showing particularly strong concern over governance and organizational capability.

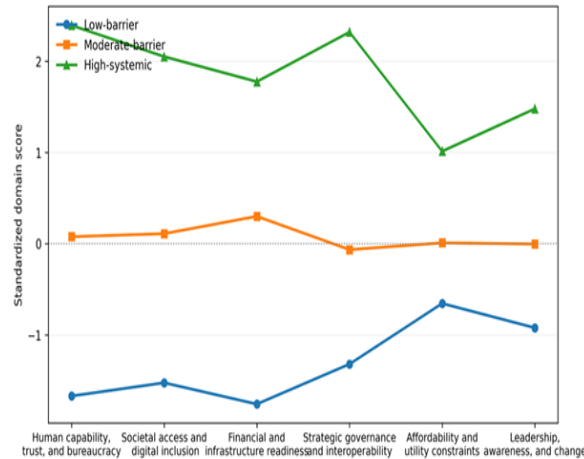


Figure 3: Profile-Specific Intensity Patterns Across The Six Barrier Domains.

5.3 Between-profile Domain Differences

One-way comparisons confirmed that the profiles differed significantly on every domain. The largest separation appeared in financial and infrastructure readiness ($F = 94.65$, $p < 0.001$), followed by societal access and digital inclusion ($F = 86.77$, $p < 0.001$), human capability, trust, and bureaucracy ($F = 84.76$, $p < 0.001$), and strategic governance and interoperability ($F = 71.64$, $p < 0.001$). Even affordability and utility constraints, which were comparatively less discriminatory, still differed significantly across profiles ($F = 21.65$, $p < 0.001$). Approximate η^2 values based on these F-ratios were large for financial and infrastructure readiness ($\eta^2 \approx 0.41$), societal access and digital inclusion ($\eta^2 \approx 0.39$), human capability, trust, and bureaucracy ($\eta^2 \approx 0.38$), and strategic governance and interoperability ($\eta^2 \approx 0.35$), and smaller but still meaningful for affordability and utility constraints ($\eta^2 \approx 0.14$). Taken together, these results indicate that the retained profiles are not statistical artefacts of a single domain, even though they differ more in overall severity than in qualitatively different shape.

5.4 Profile Membership and Background Characteristics

Profile membership was not distributed evenly across all background variables. Chi-square tests showed no statistically significant association with gender ($p = 0.325$) and only a marginal pattern for age ($p = 0.073$). In contrast, educational qualification ($p = 0.009$), job role ($p = 0.016$), and years of experience ($p = 0.002$) were significantly associated with profile membership.

Descriptively, the high-systemic profile showed larger within-sample shares of respondents with secondary education and respondents in the 'other' job-role category. The moderate-barrier contained the largest postgraduate share, whereas the low-barrier profile included relatively larger shares of faculty members and respondents with 15- <25 years of experience. These are concentration patterns within the surveyed sample rather than population estimates, but they help locate where systemic barrier intensity is more visible.

As summarized in **Table 5**, profile membership was more clearly associated with educational qualification, job role, and years of experience than with gender or age. These patterns should be interpreted as within-sample concentration patterns rather than as population estimates.

Table 5: Background Correlates Of Latent Profile Membership.

Background variable	Chi-square	p-value	Interpretive summary
Educational qualification	13.50	0.009	Sample-specific concentration: the high-systemic profile contained a larger share of respondents with secondary education, whereas the moderate-barrier contained the largest postgraduate share.
Job role	15.67	0.016	Sample-specific concentration: the high-systemic profile was more visible in 'Other' roles, while the low-barrier and moderate-barriers contained relatively larger faculty shares.
Years of experience	21.22	0.002	Sample-specific concentration: the low-barrier profile was most concentrated in 15-<25 years, whereas the moderate-barrier was more visible in the 5-<15 years group.
Gender	2.25	0.325	No meaningful profile differentiation in the surveyed sample.
Age	11.54	0.073	Older respondents were somewhat more visible in the high-systemic profile, but the pattern was not statistically robust.

6. Discussion

The main contribution of this paper is therefore more specific than a generic claim that employees are not homogeneous. The retained profiles differ primarily in the intensity with which employees experience system-wide implementation constraints, not in the existence of completely different domain combinations. This distinction matters. In person-centred research, severity-based profiles can still be substantively meaningful when a setting produces uneven exposure to the same underlying institutional problem[15][16][17]. In the present case, the employee population appears segmented along a gradient from lower to high-systemic constraint.

The high-systemic barrier profile is especially revealing. Members of this group reported elevated barriers across governance, leadership, financing, infrastructure, human capability, and societal access. Rather than signaling one isolated bottleneck, this profile suggests what may be described as an institutional pessimism cluster: a segment of employees who experience digital reform as broadly obstructed across multiple administrative conditions. This reading is consistent with work on governance ambiguity, status quo bias, and stalled public-sector digital strategies, where repeated exposure to fragmented reform can produce a generalized sense that implementation conditions are misaligned[18][19][21].

The contribution of the article therefore lies in showing that employees are unevenly distributed across low-, moderate-, and high-intensity response profiles once institutionally meaningful barrier domains are used as person-centred indicators. The key insight is not simply that barriers exist, but that they are experienced with different levels of systemic severity across groups of employees. This gives the findings practical value for administrative prioritization because it suggests that reform may need to vary in depth and intensity across segments rather than relying on a one-size-fits-all implementation approach.

The retained profiles also add nuance to the infrastructure debate. Weak connectivity, electricity, and affordability remain visible, especially in the high-systemic profile. However, these material conditions are intertwined with standards, leadership continuity, and organizational capability. For that reason, the high-systemic group should not be read as a purely infrastructural cluster. It is better understood as a group for whom material and

institutional constraints accumulate together. This is why a uniform reform narrative centred only on hardware or internet access is insufficient.

From a practical perspective, the results support differentiated reform depth rather than entirely different reform content. Employees in the low-barrier profile may need targeted communication and incremental support. Those in the moderate-barrier may respond to clearer standards and capability-building. The high-systemic profile, by contrast, points to the need for a more integrated package addressing leadership continuity, administrative direction, funding, interoperability, and utilities together. This does not identify a causal sequence, but it does indicate where implementation strain is perceived as systemic rather than marginal.

The profiles should therefore be interpreted as empirically useful employee segments for diagnosis and prioritization, not as fixed or exhaustive categories of public-sector staff.

6.1 Study Limitations and Interpretation Boundaries

Several limitations should be acknowledged. First, the study relies on cross-sectional survey data and therefore captures latent differences in perceived barriers at a single point in time rather than changes in profile membership or barrier intensity over time. The findings should accordingly be interpreted as a diagnostic snapshot of employee perceptions under the surveyed institutional conditions. Future studies could use repeated cross-sectional or longitudinal designs to examine whether these profiles remain stable or shift as institutional and policy conditions change. Second, the sample was drawn from employees in Sudanese higher education and was not designed to produce nationally representative estimates for Sudan as a whole. The results are therefore best understood as sector-specific evidence from a strategically important public-sector setting rather than as national population estimates. This sectoral focus remains analytically valuable because higher education institutions combine administrative coordination, service delivery, and digital reform pressures in ways that make them an informative setting for studying public-sector implementation barriers. Third, the dataset does not include downstream outcome variables such as actual service use, perceived service quality, or implementation success. The analysis therefore focuses on latent heterogeneity in perceived constraints rather than on linking profile membership to observed implementation outcomes. Here, the categories should be interpreted as patterns of perceived implementation difficulty, not as indicators of performance outcomes. Future research could extend this design by examining whether the identified profiles are associated with actual system use, service quality perceptions, implementation progress, or organizational readiness indicators. . Fourth, the latent profile analysis was conducted on six domain-level indicators rather than the full set of 35 individual items. This choice was made to reduce dimensionality, improve model stability, and support interpretable profile extraction, but it may also conceal finer-grained variation at the item level. These limitations define the scope of the study more precisely: the article identifies employee profiles as configurations of perceived implementation difficulty, not nationally representative categories or causal predictive categories.

7. Conclusion

This paper examined whether employees in Sudanese higher education perceive e-government implementation barriers in the same way. The answer is qualified rather than absolute. A person-centred latent profile analysis identified three hidden groups best interpreted as low-, moderate-, and high-systemic barrier intensity profiles.

The main implication is not that employees fall into radically different barrier types. Rather, a meaningful minority experiences the same institutional environment as much more severely constrained across multiple domains. This person-centred result shows how a common set of institutional barriers can be distributed unevenly across employees and, therefore, why segmented reform depth may be more useful than one-size-fits-all implementation strategies.

A logical next step would be to test the retained profile structure on a new sample and then examine whether profile membership predicts actual implementation outcomes such as usage, service quality, readiness, or administrative performance. Even in its current form, however, the study provides a credible and policy-relevant

account of hidden variation in systemic barrier intensity during digital government implementation under resource-constrained public-sector conditions.

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