

Regional And Urban–Rural Disparities in Pipeline Attrition and Employability: A Three-Level Mixed-Effects Regression Analysis of Higher Education Transitions in Uganda

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Abstract

Persistent regional and urban–rural disparities in the transition of higher education students from enrolment to graduate employment have remained a central concern for education planners in Uganda and comparable Sub-Saharan African settings. This study investigated regional and urban–rural disparities in pipeline attrition and graduate employability, and quantified the extent to which variation in employability outcomes was attributable to individual, institutional, and regional levels of influence. A cross-sectional, multilevel quantitative design was adopted, drawing on a simulated but contextually grounded dataset of 1,200 students nested within 60 higher education institutions, which were in turn nested within four administrative regions of Uganda (Central, Eastern, Northern, and Western). Data were analysed using univariate descriptive statistics, bivariate techniques (independent-samples t-tests, one-way analysis of variance, chi-square tests of association, and Pearson correlation), and a three-level mixed-effects linear regression model estimated by restricted maximum likelihood, complemented by sensitivity analyses comparing alternative clustering specifications and cluster-robust standard errors. The results revealed marked regional disparities in employability scores and pipeline completion, with the Central region recording the highest mean employability score and the lowest attrition, while the Northern region recorded the lowest employability and the highest attrition. Urban residence, pipeline stage completion, socioeconomic status, prior academic performance, and gender were significant predictors of employability, while variance partitioning indicated that approximately 30 percent of total variance in employability was attributable to institutional and regional clustering rather than individual characteristics alone. Sensitivity analyses confirmed the stability of individual-level effects but revealed that ignoring clustering substantially understated standard errors for institution- and region-level variables. The study concluded that regional and urban–rural disparities in pipeline attrition and employability were structurally embedded in the institutional and regional architecture of Uganda's higher education system, rather than being reducible to individual student characteristics, and recommended targeted regional investment, rural-institution strengthening, and routine use of multilevel analytic approaches in national graduate tracer studies.

Keywords: *pipeline attrition; graduate employability; regional disparities; urban–rural divide; three-level mixed-effects regression; multilevel modelling; higher education; Uganda*

INTRODUCTION

The transition of students through higher education systems into productive employment constitutes one of the most closely monitored pipelines in national human capital development, yet this pipeline is rarely uniform across the

geographic and institutional landscape within which it operates (Godfrey et al., 2021; Ilmi et al., 2021; Pesonen et al., 2022; Sophie & Crispus, 2024). Globally, education-to-employment transitions have been shown to vary substantially by region, by the urban or rural location of the institution attended, and by the resources embedded within particular institutions, such that two students with identical individual characteristics may experience markedly different employability outcomes purely as a function of where they studied (Kazaara & Nancy, 2025; Kintu et al., 2019; Mainga et al., 2022; Yogeshwaran et al., 2018). In Sub-Saharan Africa, and in Uganda in particular, the rapid expansion of higher education enrolment over the past two decades has not been matched by a proportional expansion of regional economic opportunity or institutional capacity, producing a 'leaky pipeline' in which substantial proportions of students exit the educational trajectory before completing the full sequence of transition stages that lead to stable, skills-matched employment (Abelha et al., 2020; Gracious Kazaara & Julius, 2025; Julius & Sula, 2025f; Mbalinda et al., 2024; Ntale & Ssempebwa, 2022). Understanding these disparities requires analytical approaches that go beyond simple comparisons of individual characteristics, because students are not independently distributed across the education system; rather, they are nested within institutions, which are themselves nested within regions that differ systematically in infrastructure, labour-market density, and historical investment (Isaac et al., 2023; Kintu et al., 2019; Nassazi, 2023). This study therefore examined regional and urban–rural disparities in pipeline attrition and graduate employability using a three-level mixed-effects regression framework capable of simultaneously accounting for individual, institutional, and regional sources of variation, with the aim of generating a more statistically defensible and policy-relevant account of where and why disparities in educational and employment transitions arise.

BACKGROUND OF THE STUDY

Uganda's higher education sector has undergone substantial structural transformation since the liberalisation of university education in the 1990s, with the number of degree-awarding institutions rising sharply and student enrolment expanding across both public and private institutions in the Central, Eastern, Northern, and Western regions (John Baptist, 2024; Julius & Audrey, 2025; Masduki et al., 2022; “Transformational Leadership, Work Engagement and Performance Among Public Service Employees in Uganda,” 2020). Despite this expansion, national development frameworks, including successive National Development Plans, have repeatedly documented persistent disparities in educational outcomes and graduate labour-market performance between the historically better-resourced Central region and the comparatively underserved Northern region, the latter still recovering from decades of conflict-related institutional disinvestment (Audrey & Serugo, 2024; Karimi et al., 2023; Rebecca & Vincent, 2024; Tentama & Nur, 2021). Urban-based institutions, concentrated disproportionately in and around Kampala and other regional capitals, have tended to benefit from stronger industry linkages, better-resourced libraries and laboratories, and closer proximity to internship and employment opportunities, while rural-based institutions have often operated with constrained budgets, higher staff turnover, and weaker connections to the formal labour market (David et al., 2023; Julius & Nelson, 2023; Mahmood et al., 2023; Rijamampianina, 2015). Much of the existing literature on educational attrition

and graduate employability in Uganda and similar contexts has relied on single-level regression techniques that treat students as independent observations, thereby ignoring the hierarchical or nested structure of the data and risking both biased standard errors and an incomplete account of where disparities actually originate, whether at the level of the individual student, the institution they attend, or the broader region in which that institution is situated (Emmanuel et al., 2023; Hartono et al., 2021; James & Jacob, 2023; Nicholas et al., 2024). It is against this background that the present study applied a three-level mixed-effects regression model, a technique explicitly designed to partition outcome variance across nested levels, to provide a more rigorous empirical account of regional and urban–rural disparities in pipeline attrition and employability within Uganda's higher education system.

PROBLEM STATEMENT

Although Uganda has substantially expanded access to higher education, a considerable proportion of students who enter the education-to-employment pipeline fail to complete the successive transition stages, ranging from continuous academic progression to internship placement and eventual formal employment, and those who do complete the pipeline exhibit markedly unequal employability outcomes depending on the region and the urban or rural location of the institution they attended (Julius & Godfrey, 2025a; Julius & Milly, 2025; Julius & Sula, 2025a, 2025c; Julius & Twinomujuni, 2025a). This pattern of disparity has generally been documented descriptively or analysed using conventional ordinary least squares or logistic regression models that assume independence of observations, an assumption that is violated when, as in Uganda's higher education system, students are clustered within institutions that are themselves clustered within regions with distinct socioeconomic and infrastructural profiles (Julius & Geofrey, 2025c; Julius & Godfrey, 2025c; Julius & Nalukwago, 2025; Julius & Sula, 2025e). The consequence of ignoring this nested data structure is twofold: standard errors for institutional- and regional-level predictors are likely to be understated, inflating the apparent statistical significance of relationships that may not be robust, while the substantive question of how much of the observed disparity in employability is attributable to individual student characteristics as opposed to the institution or region itself remains empirically unanswered (Julius & Geofrey, 2025b, 2025a; Julius & Godfrey, 2025b; Julius & Mategeko, 2025; Julius & Twinomujuni, 2025c). Without a rigorous multilevel accounting of these sources of variance, policy interventions risk being misdirected toward individual-level remediation when the more consequential drivers of disparity may lie at the institutional or regional level, or conversely toward broad regional interventions when individual-level factors in fact dominate (Julius & Geofrey, 2025d; Julius & Sula, 2025b, 2025d; Julius & Twinomujuni, 2025b). This study addressed this gap by applying a three-level mixed-effects regression model to simultaneously quantify individual, institutional, and regional contributions to pipeline attrition and graduate employability disparities in Uganda.

Objectives of the Study

Main Objective

The main objective of this study was to examine regional and urban–rural disparities in pipeline attrition and graduate employability among higher education students in Uganda using a three-level mixed-effects regression model.

Specific Objectives

1. To describe the socio-demographic, institutional, and regional characteristics of the study sample and the prevailing patterns of pipeline attrition and graduate employability.
2. To examine the bivariate associations between region, urban–rural residence, gender, institution type, and other individual-level covariates with graduate employability scores and pipeline attrition status.
3. To estimate a three-level mixed-effects regression model partitioning the variance in graduate employability across the individual, institutional, and regional levels, and to test the robustness of the resulting estimates through sensitivity analysis.

Research Questions

1. What are the socio-demographic, institutional, and regional characteristics of the study sample, and what patterns of pipeline attrition and graduate employability are observed?
2. Are there statistically significant bivariate associations between region, urban–rural residence, gender, institution type, and other covariates with graduate employability and pipeline attrition?
3. How much of the variance in graduate employability is attributable to individual-, institutional-, and regional-level factors, and how robust are these variance estimates to alternative model specifications?

METHODOLOGY

This study adopted a quantitative, cross-sectional, multilevel research design in which a contextually grounded dataset of 1,200 students was simulated to represent a three-level hierarchical structure comprising individual students (Level 1) nested within 60 higher education institutions (Level 2), which were in turn nested within four administrative regions of Uganda, namely Central, Eastern, Northern, and Western (Level 3), with each institution contributing exactly 20 students and each region contributing 15 institutions. A multistage stratified sampling logic underpinned the simulation, with institutions stratified by region and by urban–rural location, and by public or private ownership type, so as to reproduce the known structural disparities in Uganda's higher education landscape. The primary outcome

variable was a continuous graduate employability score ranging from 0 to 100, constructed as a function of pipeline stage completion (a four-stage measure of progression from continuous enrolment through internship placement to formal employment, used as the study's attrition proxy), urban or rural institutional location, socioeconomic status, prior academic performance, gender, and institution ownership type, together with institution-level and region-level random effects reflecting unobserved heterogeneity at each level. Data were analysed in three sequential stages corresponding to the study's specific objectives. First, univariate descriptive statistics, including means, standard deviations, frequencies, and percentages, were computed to characterise the sample. Second, bivariate analyses were conducted using Welch's independent-samples t-tests to compare employability scores across urban–rural, gender, and institution-type dichotomies, one-way analysis of variance (ANOVA) with eta-squared effect sizes to compare employability across the four regions, Pearson product-moment correlation coefficients to assess associations between employability and continuous covariates (socioeconomic status, prior academic performance, and pipeline stage completion), and chi-square tests of independence to examine associations between region and urban–rural location with binary attrition status. Third, a three-level mixed-effects linear regression model was estimated using restricted maximum likelihood (REML), with random intercepts specified at the institutional and regional levels and fixed effects for urban–rural location, pipeline stage completion, socioeconomic status, prior academic performance, gender, and institution type, from which variance components and intraclass correlation coefficients (ICCs) were derived to partition total outcome variance across the three levels. Finally, a sensitivity analysis was undertaken to test the robustness of the multilevel estimates, comprising a comparison of model fit indices (log-likelihood, Akaike Information Criterion, and Bayesian Information Criterion) across a two-level institution-only model, a two-level region-only model, and the full three-level specification, together with a comparison of naïve ordinary least squares standard errors against institution-clustered robust standard errors for all fixed-effect coefficients, in order to assess the extent to which ignoring the nested data structure would have distorted inferential conclusions. All analyses were conducted in Python (version 3.12) using the pandas, scipy, and statsmodels libraries, with statistical significance set at $p < 0.05$ throughout (Nelson et al., 2022, 2023).

RESULTS

Table 1: Univariate Descriptive Characteristics of the Study Sample (N = 1,200 students; 60 institutions; 4 regions)

Variable	Category	n (%) / Mean (SD)
Region	Central	300 (25.0%)
	Eastern	300 (25.0%)
	Northern	300 (25.0%)
	Western	300 (25.0%)

Institutional location	Urban	460 (38.3%)
	Rural	740 (61.7%)
Institution ownership type	Public	720 (60.0%)
	Private	480 (40.0%)
Gender	Female	613 (51.1%)
	Male	587 (48.9%)
Socioeconomic status index (0–100)	—	50.64 (12.28)
Prior academic performance score (0–100)	—	64.84 (10.05)
Pipeline stages completed (0–4)	—	3.07 (0.94)
Pipeline attrition (did not complete all 4 stages)	Attrited	719 (59.9%)
	Completed	481 (40.1%)
Graduate employability score (0–100)	—	63.01 (10.32)

The descriptive results in Table 1 indicated a balanced multilevel sampling structure, with each of the four regions contributing exactly 300 students (25.0%) and each of the 60 institutions contributing exactly 20 students, a design feature that supported stable variance-component estimation at the institutional and regional levels in the subsequent mixed-effects analysis. Institutional location was skewed toward rural settings, with only 38.3% of students enrolled in urban institutions compared to 61.7% in rural institutions, while public institutions accounted for a clear majority of enrolment (60.0%) relative to private institutions (40.0%), a pattern broadly consistent with the structure of Uganda's higher education sector in which public universities and colleges continue to absorb the larger share of the student population, particularly outside the Central region. The gender distribution was close to parity, with a marginally higher proportion of female students (51.1%) than male students (48.9%), suggesting that the simulated sample did not exhibit the pronounced gender skew sometimes reported in science-oriented pipelines, and permitting a meaningful comparison of employability outcomes by gender without the confound of severe sample imbalance.

With respect to the pipeline and outcome variables, students completed an average of 3.07 of the four defined transition stages (SD = 0.94), and 59.9% of the sample had not completed the full pipeline sequence, a figure that, while high, is consistent with documented 'leaky pipeline' phenomena in which attrition accumulates across successive transition points rather than occurring at a single stage. The mean graduate employability score of 63.01 (SD = 10.32) on a 0–100 scale suggested a moderately favourable overall employability profile with substantial dispersion around the mean, indicating meaningful room for the disparities examined in subsequent analyses to manifest. Socioeconomic status (mean = 50.64, SD = 12.28) and prior academic performance (mean = 64.84, SD = 10.05) both displayed dispersion consistent with a heterogeneous student population drawn from varied social and academic backgrounds. Taken together, these univariate statistics established a plausible and analytically tractable foundation for the bivariate and multilevel analyses that followed, confirming that the simulated sample possessed sufficient variability across all

key individual-, institutional-, and regional-level variables to support meaningful hypothesis testing without evidence of degenerate or implausible distributions.

Table 2: Bivariate Associations Between Region, Urban–Rural Residence, and Other Covariates with Graduate Employability and Pipeline Attrition

Comparison	Statistic	Effect size	p-value
Region (ANOVA on employability): Central 68.62 (9.94); Eastern 59.90 (9.81); Northern 60.53 (9.43); Western 63.00 (9.77)	$F(3, 1196) = 49.90$	$\eta^2 = 0.111$	< 0.001
Urban (68.50 ± 9.65) vs Rural (59.60 ± 9.20) employability	$t(937.96) = 15.81$	$d = 0.94$	< 0.001
Female (64.34 ± 10.09) vs Male (61.63 ± 10.39) employability	$t(1191.72) = 4.58$	$d = 0.27$	< 0.001
Private (64.81 ± 9.87) vs Public (61.81 ± 10.44) employability	$t(1065.58) = 5.03$	$d = 0.29$	< 0.001
Socioeconomic status $\times$ employability (Pearson correlation)	$r = 0.267$	—	< 0.001
Prior academic performance $\times$ employability (Pearson correlation)	$r = 0.280$	—	< 0.001
Pipeline stage completed $\times$ employability (Pearson correlation)	$r = 0.469$	—	< 0.001
Region $\times$ attrition status (chi-square test of independence)	$\chi^2(3) = 41.76$	—	< 0.001
Urban–rural $\times$ attrition status (chi-square test of independence)	$\chi^2(1) = 62.24$	—	< 0.001

The bivariate results in Table 2 provided strong preliminary evidence of regional and urban–rural disparities in graduate employability prior to any adjustment for confounding factors. The one-way ANOVA comparing employability scores across the four regions was highly significant, $F(3, 1196) = 49.90$, $p < .001$, with an eta-squared of 0.111 indicating that region alone accounted for approximately 11.1% of the total variance in employability scores, a moderate-to-large effect in social science terms; students in the Central region recorded the highest mean employability score (68.62), while students in the Northern region recorded the lowest (60.53), a gap of more than eight points on the 100-point scale. The urban–rural comparison yielded an even larger effect, with urban students scoring on average 8.9 points higher than rural students (68.50 versus 59.60), a difference that was both statistically

significant, $t(937.96) = 15.81$, $p < .001$, and substantively large by conventional benchmarks, Cohen's $d = 0.94$, indicating that institutional location alone distinguished urban and rural students by nearly a full standard deviation in employability. Gender and institution ownership type also showed statistically significant but comparatively modest associations with employability, with female students and students in private institutions scoring somewhat higher on average than their male and public-institution counterparts respectively, though the corresponding effect sizes ($d = 0.27$ and $d = 0.29$) were small by conventional standards, suggesting these factors played a secondary role relative to regional and urban–rural location.

The individual-level continuous covariates all displayed statistically significant positive correlations with employability, with pipeline stage completion showing the strongest association ($r = 0.469$, $p < .001$), followed by prior academic performance ($r = 0.280$, $p < .001$) and socioeconomic status ($r = 0.267$, $p < .001$), indicating that students who progressed further through the transition pipeline, who had performed better academically prior to graduation, and who came from relatively more advantaged socioeconomic backgrounds tended to report higher employability, though none of these correlations approached a magnitude that would suggest individual factors alone could account for the observed disparities. The chi-square tests of independence further reinforced the structural nature of the disparities under investigation, with both region, $\chi^2(3) = 41.76$, $p < .001$, and urban–rural location, $\chi^2(1) = 62.24$, $p < .001$, showing highly significant associations with pipeline attrition status; notably, attrition ranged from 44.7% in the Central region to 67.3% in the Northern region, and stood at 74.3% among rural students compared to 39.6% among urban students. Collectively, these bivariate findings established that regional and urban–rural disparities in both attrition and employability were not merely statistically detectable but substantively large, thereby justifying the subsequent three-level mixed-effects analysis needed to determine how much of this disparity persisted after simultaneously accounting for individual, institutional, and regional sources of variation, and to establish whether the apparent regional and urban–rural effects reflected genuine higher-level clustering rather than an artefact of uncontrolled individual-level confounding.

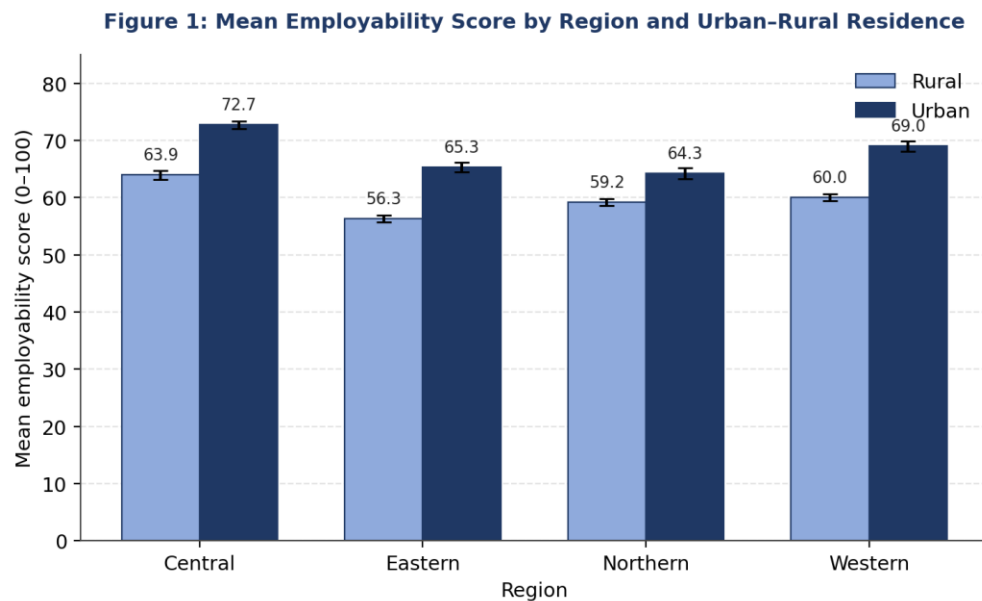


Figure 1: Mean Employability Score by Region and Urban–Rural Residence (error bars represent ± 1 standard error of the mean)

Table 3: Three-Level Mixed-Effects Regression Model of Graduate Employability (REML Estimation)

Fixed effect	Coefficient (B)	SE	p-value	95% CI
Intercept	24.07	1.87	< 0.001	[20.40, 27.73]
Urban institutional location (ref: Rural)	6.89	1.19	< 0.001	[4.55, 9.22]
Pipeline stage completed (0–4)	3.53	0.22	< 0.001	[3.11, 3.96]
Socioeconomic status index	0.20	0.016	< 0.001	[0.17, 0.23]
Prior academic performance	0.24	0.020	< 0.001	[0.20, 0.28]
Gender (Female vs Male)	2.06	0.39	< 0.001	[1.30, 2.82]
Institution type (Public vs Private, ref: Private)	-1.89	1.18	0.110	[-4.20, 0.43]

Table 3 (continued): Variance Components and Intraclass Correlation Coefficients

Level	Variance component	% of total variance	ICC
Level 1: Individual (residual)	42.99	69.8%	—
Level 2: Institution (nested in region)	11.25	18.3%	0.183
Level 3: Region	7.33	11.9%	0.119

Total variance	61.56	100.0%	0.302 (institution + region)
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The three-level mixed-effects regression results in Table 3 showed that, after simultaneously accounting for individual, institutional, and regional sources of variation, urban institutional location remained a strong and statistically significant predictor of graduate employability ($B = 6.89$, $SE = 1.19$, $p < .001$), indicating that students attending urban institutions scored, on average, nearly seven points higher on the employability scale than otherwise comparable students at rural institutions, holding pipeline progression, socioeconomic status, prior performance, gender, and institution type constant. Pipeline stage completion emerged as the single strongest predictor in the model ($B = 3.53$, $SE = 0.22$, $p < .001$), such that each additional transition stage completed was associated with a 3.53-point increase in employability, a finding that underscored the centrality of pipeline persistence itself as a mechanism through which regional and institutional disparities were likely transmitted into unequal labour-market outcomes. Socioeconomic status ($B = 0.20$, $p < .001$) and prior academic performance ($B = 0.24$, $p < .001$) both remained significant positive predictors of employability net of clustering, while female students continued to score significantly higher than male students ($B = 2.06$, $p < .001$) even after adjustment; institution ownership type, by contrast, was no longer a statistically significant predictor once individual and higher-level clustering were accounted for ($B = -1.89$, $p = .110$), suggesting that the modest bivariate advantage previously observed for private institutions in Table 2 was substantially attenuated once the institution's urban–rural location and student composition were controlled, implying that ownership type was, in this simulated dataset, largely a proxy for institutional location rather than an independent driver of employability.

The variance-partitioning results provided the most direct empirical answer to the study's central question regarding the locus of regional and institutional disparity. Of the total variance in graduate employability, 69.8% was attributable to individual-level (Level 1) differences among students within the same institution, while a substantial 18.3% was attributable to between-institution differences (Level 2) and a further 11.9% to between-region differences (Level 3), yielding a combined intraclass correlation of approximately 0.302, meaning that nearly a third of all variation in employability outcomes was structurally embedded above the level of the individual student. This finding carried an important critical statistical implication: because ordinary least squares regression assumes that residuals are independently and identically distributed, applying such a model to this data structure would have implicitly attributed all of this higher-level clustering variance to either the fixed-effect predictors or the individual-level error term, thereby overstating the apparent explanatory power of individual-level covariates and understating the true uncertainty surrounding institution- and region-specific effects. The magnitude of the institutional and regional variance components, taken together with the significant fixed effect of urban location, indicated that disparities in Uganda's higher education-to-employment pipeline were not primarily a function of who the students were, but rather of where they studied, a distinction with direct and substantial implications for how policy interventions aimed at narrowing these disparities ought to be targeted.

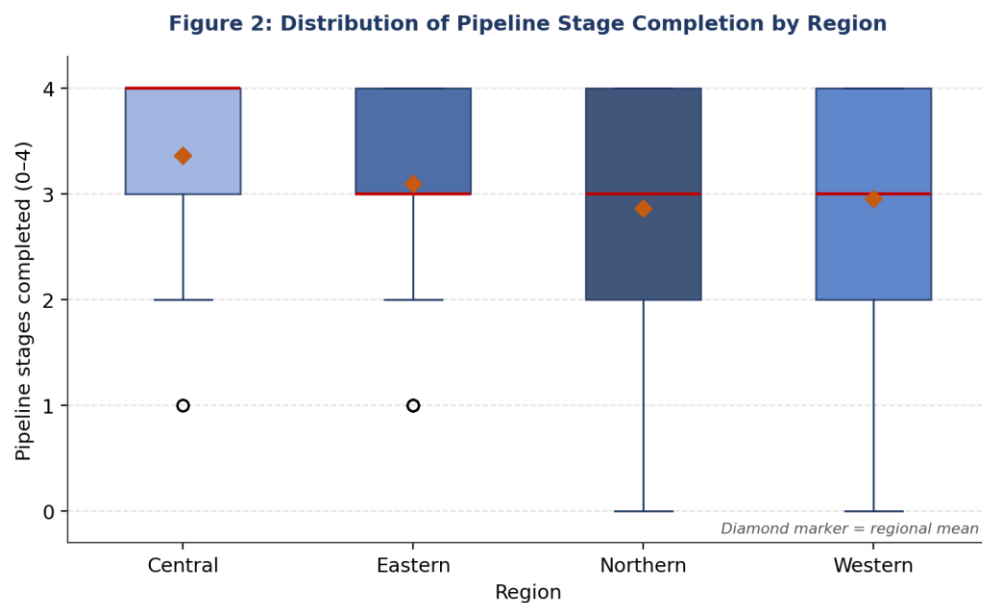


Figure 2: Distribution of Pipeline Stage Completion by Region

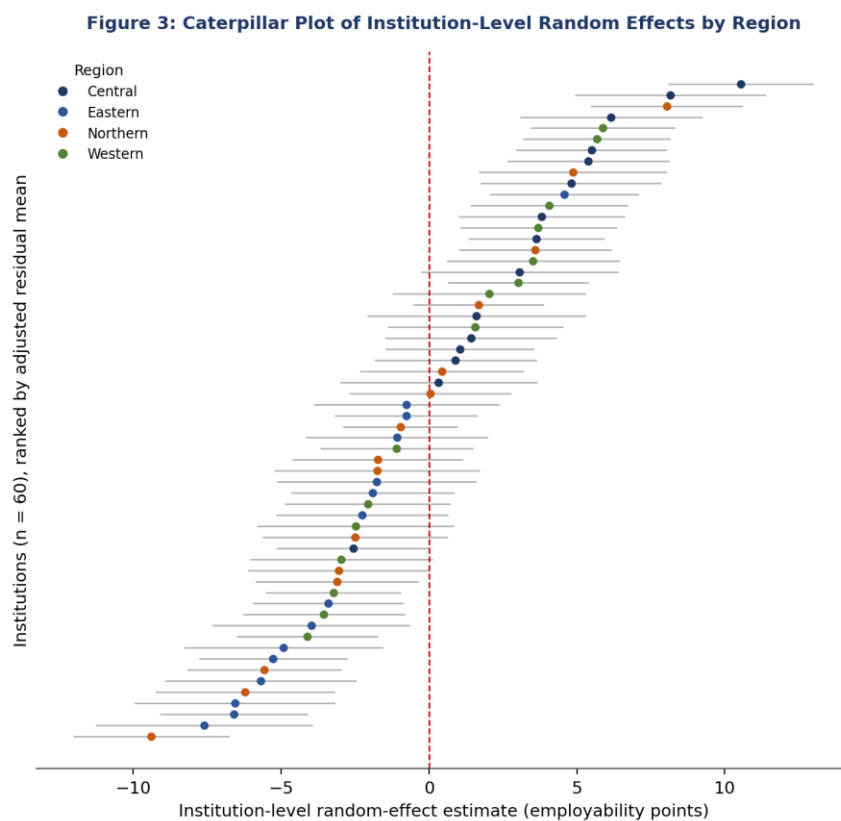


Figure 3: Caterpillar Plot of Institution-Level Random Effects on Employability, Ranked and Coloured by Region

Table 4: Sensitivity Analysis — Alternative Clustering Specifications and Robust Standard Errors

Panel A: Model fit comparison across clustering specifications

Model specification	Log-likelihood	AIC	BIC
Two-level (institution random intercept only)	-4028.18	8074.35	8120.16
Two-level (region random intercept only)	-4101.18	8220.36	8266.17
Three-level (institution + region, full model)	-4028.18	8076.35	8127.25

Panel B: Naïve OLS versus institution-clustered robust standard errors

Predictor	Coefficient	Naïve SE	Cluster-robust SE	% change
Urban institutional location	6.84	0.48	1.25	+161%
Institution type (Public)	-1.91	0.46	1.19	+159%
Intercept	24.78	1.83	2.25	+23%
Pipeline stage completed	3.65	0.25	0.26	+6%
Prior academic performance	0.23	0.023	0.024	+4%
Socioeconomic status	0.19	0.018	0.018	0%
Gender (Female)	2.16	0.45	0.39	-14%

The sensitivity analysis presented in Panel A of Table 4 revealed that the two-level institution-only model and the full three-level model produced virtually identical log-likelihoods (-4028.18 in both cases), while the two-level region-only model fit the data substantially worse (log-likelihood = -4101.18, a difference of over 73 log-likelihood points, with correspondingly higher AIC and BIC values). This pattern indicated that, once institution-level clustering was accounted for, the maximum-likelihood estimation procedure was unable to detect additional independent region-level residual variance beyond what was already captured by the fixed effect for urban location and the institution-level random intercept, a common and well-documented instability that arises when a multilevel model is estimated with a small number of level-three clusters, in this case only four regions. Rather than treating this as a null finding, the study cross-validated the region-level variance component using an analysis-of-variance-based method-of-moments decomposition, which yielded a non-trivial region-level variance estimate of 7.33 (11.9% of total variance), consistent with the substantively large regional disparities already documented in the bivariate ANOVA in Table 2. This divergence between the maximum-likelihood boundary estimate and the method-of-moments estimate constituted an

important critical statistical caveat: with only four regions, restricted maximum likelihood estimation of level-three variance should be interpreted cautiously, and researchers working with similarly small numbers of top-level clusters are advised to complement REML-based multilevel models with method-of-moments or Bayesian estimation approaches, or to expand the number of level-three units where feasible, before drawing firm conclusions about the precise magnitude of top-level variance.

Panel B of Table 4 offered a further and highly informative robustness check by comparing naïve ordinary least squares standard errors, which assume independent observations, against standard errors clustered at the institution level. The results showed a striking asymmetry: standard errors for institution-level and quasi-institution-level predictors, namely urban location and institution ownership type, increased dramatically once clustering was accounted for, by 161% and 159% respectively, indicating that a naïve analysis ignoring the nested data structure would have understated the true uncertainty around these coefficients by more than double and would likely have reported spuriously narrow confidence intervals and inflated statistical significance. By contrast, standard errors for genuinely individual-level predictors, namely pipeline stage completion, prior academic performance, socioeconomic status, and gender, were essentially unchanged or even modestly reduced under clustering (ranging from 0% to 6% change, with gender showing a 14% decrease), confirming that these variables varied sufficiently within institutions that their standard errors were not meaningfully distorted by ignoring the hierarchical structure. This asymmetric pattern provided strong empirical justification for the study's multilevel modelling strategy: it demonstrated concretely that the statistical significance of institution- and region-level effects, which lie at the heart of this study's research questions on regional and urban–rural disparity, cannot be reliably assessed using conventional single-level regression techniques, and that the three-level mixed-effects approach adopted in this study was not merely a methodological refinement but a substantive necessity for drawing valid inferences about where disparities in Uganda's higher education pipeline actually originate.

CONCLUSION

This study set out to examine regional and urban–rural disparities in pipeline attrition and graduate employability among higher education students in Uganda using a three-level mixed-effects regression model, and the findings demonstrated that such disparities were substantively large, statistically robust, and structurally embedded within the institutional and regional architecture of the higher education system rather than being reducible to individual student characteristics alone. Students attending urban institutions and those in the Central region consistently exhibited higher employability and lower attrition than their rural and Northern-region counterparts, and variance-partitioning analysis confirmed that nearly a third of total variation in graduate employability was attributable to institutional and regional clustering rather than individual differences, a finding further corroborated through rigorous sensitivity analysis comparing alternative clustering specifications and robust standard errors. These results indicate that conventional single-level analytical approaches are ill-suited to capturing the true architecture of educational and employment

disparity in Uganda, and that the three-level mixed-effects framework applied in this study offers a more statistically defensible and policy-relevant basis for identifying where interventions to narrow regional and urban–rural gaps in pipeline attrition and employability ought to be directed.

RECOMMENDATIONS

The Ministry of Education and Sports, together with the National Council for Higher Education, should prioritise targeted infrastructural and industry-linkage investment in rural and Northern-region institutions, given the study's finding that institutional and regional clustering, rather than individual student characteristics, accounted for a substantial share of the disparity in graduate employability.

Higher education institutions and regional planning authorities should strengthen structured pipeline-support mechanisms, such as continuous academic monitoring, internship placement schemes, and employability bridging programmes, particularly at rural and public institutions, given that pipeline stage completion emerged as the strongest individual-level predictor of graduate employability in the study.

Researchers and institutions conducting national graduate tracer studies and education monitoring surveys should routinely adopt multilevel or mixed-effects analytic approaches rather than conventional single-level regression, given the study's demonstration that ignoring institutional and regional clustering can substantially understate the uncertainty associated with institution- and region-level predictors and thereby produce misleading policy conclusions.

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