School-to-School Variation in ACT and GPA

Technical Report

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Overview

Some Knox County Schools (KCS) staff feel there is evidence suggesting significant variation in grading policies between KCS high schools. Some cite the alignment between student grade point averages (GPAs) and standardized measures of student academic ability (i.e. ACT scores) to support this argument. The department of Research, Evaluation, and Assessment (REA) commissioned this study to quantify school-to-school variation in GPAs, student performance on the ACT exam, and post-secondary enrollment. This study seeks to report the levels of school-to-school variation in GPA and ACT, document the level of GPA-to-ACT alignment, and identify some policy implications of the findings.

The findings of this study suggest that there are significant between-school differences in how GPA and ACT composite scores predict college enrollment. The magnitude of the school-to-school variation is similar when using GPA or ACT to predict post-secondary enrollment.

The data suggest that students from different schools with the same GPA have different probabilities of enrolling in college (after controlling for observable student demographic variables). However, the data also suggests students from different schools with the same ACT composite score have different probabilities of enrolling in college. This suggests that ACT scores by themselves may not be a precise measure of post-secondary readiness. These findings mirror those of Allensworth and Clark (Allensworth, 2020) and ACT's own internal research (Noble, 2002).

Methodology

The methodology for this study was largely based on research by Allensworth and Clark (Allensworth, 2020).

The study involved five cohorts of 12th grade KCS students from the 2014-2015 school year (SY1415) to SY1819. This study only included students with a 12th grade GPA from a traditional KCS high school and a valid ACT composite score. The most recent student-level ACT score was used in modeling (since some students took the ACT as middle school students). GPAs weighted for participation in advanced courses were used to provide differentiation between students with perfect unweighted GPAs (4.0). Student level ACT scores, weighted GPAs, and demographic variables were extracted from the KCS student information database (ASPEN). Data were extracted using Microsoft SQL Server Management (version 18.6). Post-secondary enrollment information was obtained from the National Student Clearinghouse (NSC) annual reports. Readers should note that not all post-secondary institutions report to NSC. Students enrolled in institutions that do not report to the NSC were not considered college enrollees in this study.

Regression analysis involved Hierarchical Linear Modeling (HLM), with demographic variables (Demo) and year-of-graduation (YOG) treated as fixed effects. A student was labeled as a minority student if they identified as Hispanic, African American, Native American, or Hawaiian/Pacific Islander. HLM slopes and intercepts were allowed to vary by the school where a student was enrolled during their senior year (2nd semester). A general linear model was used to regress ACT scores on GPAs using restricted maximum likelihood criteria. A logistic model was used to regress the probability of post-secondary enrollment on GPA and ACT using maximum likelihood criteria. Regression models were created in R version 3.6.1 running on RStudio version 1.3.959 and using the lme4 package (version 1.1-21). 8,803 students were used in the analysis.

Results: ACT versus Weighted KCS GPA

Residual analysis suggests that the relationship between ACT and weighted GPA is non-linear. Therefore, a GPA squared term was included in the model. The final general linear regression model is shown in Equation 1.

Equation 1: ACT versus Weighted KCS GPA Model

$$ACT_{ij} = \beta_{0j} + \sum_{s=1}^{5} \beta_s Demo_{sij} + \beta_6 YOG_{ij} + \beta_{7j} GPA_{ij} + \beta_{8j} GPA_{ij}^2$$

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$
$$\beta_{7j} = \gamma_{70} + \mu_{7j}$$
$$\beta_{8j} = \gamma_{80} + \mu_{8j}$$

The fixed effects for the ACT versus weighted GPA regression are available in Table 1. The random effects are available in Table 2.

Table 1: ACT versus Weighted KCS GPA Fixed Effects

Fixed Effects	Estimate	Std. Error	t value
γ_{00}: Intercept (District-Level)	18.50	0.74	24.98
$\beta_1 Demo_1$: Special Education (1=Yes)	-2.32	0.08	-28.76
$\beta_2 Demo_2$: Economically Disadvantaged (1=Yes)	-0.13	0.07	-2.03
$\beta_3 Demo_3$: Minority (1=Yes)	-1.18	0.06	-18.30
$\beta_4 Demo_4$: English Language Learner (1=Yes)	-2.49	0.17	-15.06
$\beta_5 Demo_5$: Gender (1=Male)	0.97	0.05	21.06
β_6: YOG	-0.14	0.02	-8.36
γ_{70}: GPA (District-Level)	-3.81	0.37	-10.19
γ_{80}: GPA^2 (District-Level)	1.36	0.07	20.21

Table 2: ACT Versus Weighted KCS GPA Random Effects

School	μ_{0j}: Intercept (School-Level)	μ_{7j}: GPA (School-Level)	μ_{7j}: GPA^2 (School-Level)
Austin East High School	-2.53	1.08	-0.29
Bearden High School	0.40	0.00	0.09
Career Magnet	0.93	-0.37	0.05
Carter High School	-1.28	0.15	-0.06
Central High School	-0.86	0.30	0.00
Farragut High School	4.10	-2.37	0.45
Fulton High School	-1.40	0.72	-0.22
Gibbs High School	-1.39	-0.04	0.05
Halls High School	-0.11	-0.06	0.07
Hardin Valley Academy	2.23	-1.14	0.24

Karns High School	-1.41	0.72	-0.11
L & N Stem Academy	5.72	-1.10	0.08
Powell High School	-0.75	-0.08	0.00
South Doyle High School	-2.21	0.92	-0.19
West High School	-1.45	1.27	-0.16

Figure 1 shows the modeled relationship between ACT and GPA for non-special education, non-economically disadvantaged, non-minority, non-English language learner, female students with a 2017 year of graduation.
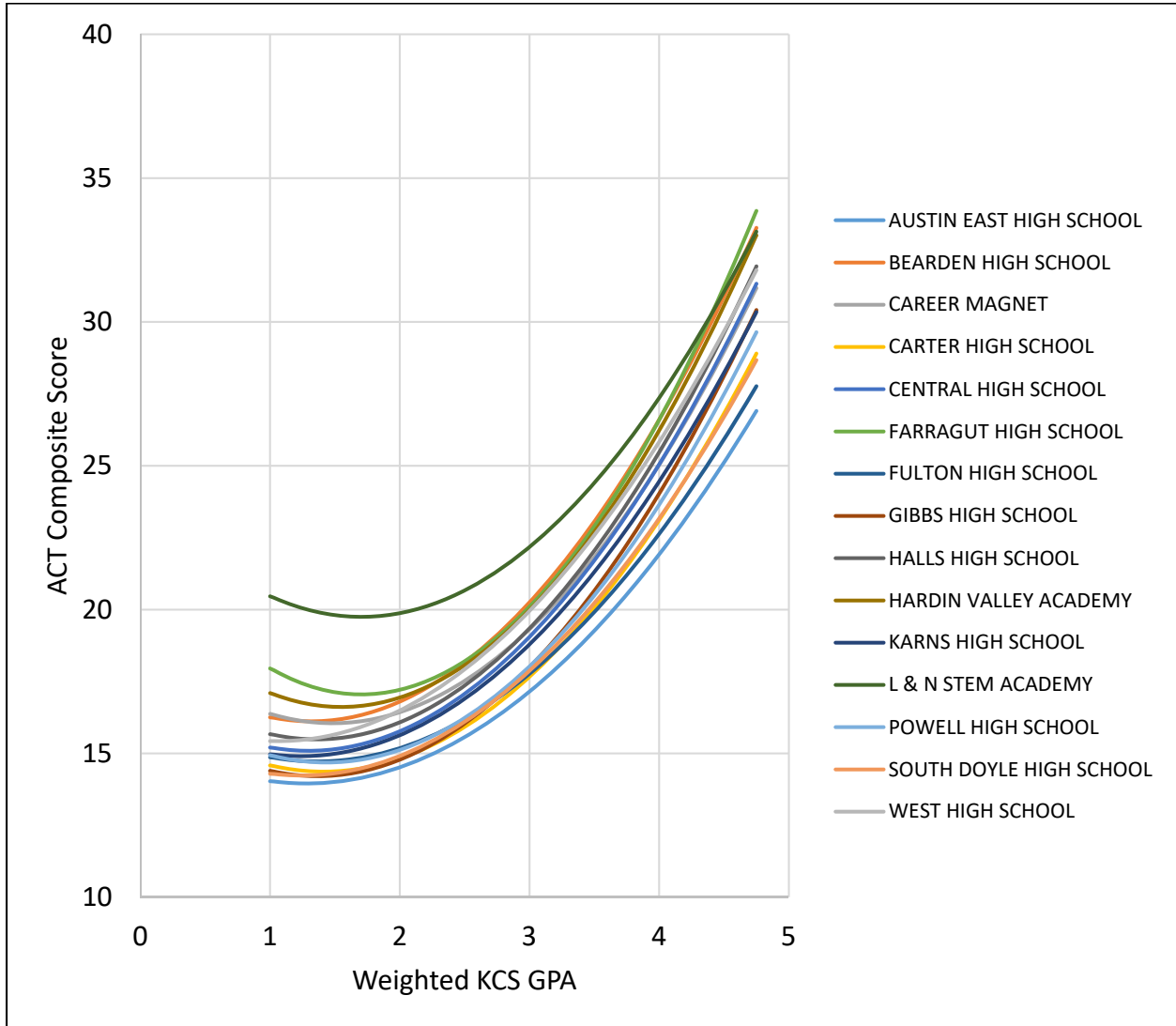

Figure 1: ACT Versus Weighted KCS GPA, YOG = 2017

Figure 1 indicates that there is school-to-school variation in ACT scores for a given GPA. If one assumes that ACT scores are standardized measures of student academic ability, Figure 1 provides evidence to support the hypothesis that grading policies vary between schools.

Results: 2-Year or 4-Year Post-Secondary Enrollment

The model estimating the probability of enrolling in a 2-year or 4-year post-secondary institution (that reports to the NSC) from the weighted KCS GPA is available in Equation 2.

Equation 2: 2 or 4-Year Post-Secondary Enrollment versus Weighted KCS GPA Model

$$ln\left(\frac{p_{enroll,2\ and/or\ 4-year}}{1 - p_{enroll,2\ and/or\ 4-year}}\right)_{ij} = \beta_{0j} + \sum_{s=1}^{5}\beta_s Demo_{sij} + \beta_6 YOG_{ij} + \beta_{7j}GPA_{ij}$$

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$
$$\beta_{7j} = \gamma_{70} + \mu_{7j}$$

The fixed effects for the 2-year or 4-year post-secondary enrollment versus weighted GPA regression are available in Table 3. The random effects are available in Table 4.

Table 3: 2 or 4-Year Post-Secondary Enrollment versus Weighted KCS GPA Fixed Effects

Fixed Effects	Estimate	Std. Error	z value	Pr(>|z|)
γ_{00}: Intercept (District-Level)	-3.40	0.25	-13.54	< 2e-16
$\beta_1 Demo_1$: Special Education (1=Yes)	-0.61	0.06	-10.03	< 2e-16
$\beta_2 Demo_2$: Economically Disadvantaged (1=Yes)	-0.36	0.05	-7.16	8.4E-13
$\beta_3 Demo_3$: Minority (1=Yes)	0.31	0.05	5.84	5.1E-09
$\beta_4 Demo_4$: English Language Learner (1=Yes)	-1.04	0.13	-8.06	7.7E-16
$\beta_5 Demo_5$: Gender (1=Male)	-0.14	0.04	-3.35	8.2E-04
β_6: YOG	-0.22	0.02	-14.51	< 2e-16
γ_{70}: GPA (District-Level)	1.70	0.06	29.62	< 2e-16

Table 4: 2 or 4-Year Post-Secondary Enrollment versus Weighted KCS GPA Random Effects

School	μ_{0j}: Intercept (School-Level)	μ_{7j}: GPA (School-Level)
Austin East High School	-0.81	0.11
Bearden High School	0.64	-0.04
Career Magnet	-0.02	0.02
Carter High School	-0.62	0.10
Central High School	-0.44	0.06
Farragut High School	1.51	-0.28
Fulton High School	-0.21	-0.07
Gibbs High School	-1.07	0.16
Halls High School	-0.20	0.10
Hardin Valley Academy	0.32	0.05
Karns High School	-0.34	0.05
L & N Stem Academy	1.85	-0.32
Powell High School	-0.72	0.19
South Doyle High School	-0.41	-0.02

West High School   0.61   -0.14

Figure 2 shows the probability of enrolling in a 2-year or 4-year post-secondary institution by GPA for non-special education, non-economically disadvantaged, non-minority, non-English language learner, female students with a 2017 year of graduation. Figure 2 indicates that there is school-to-school variation in the probability of enrolling in a 2-year or 4-year post-secondary institution for a given GPA.
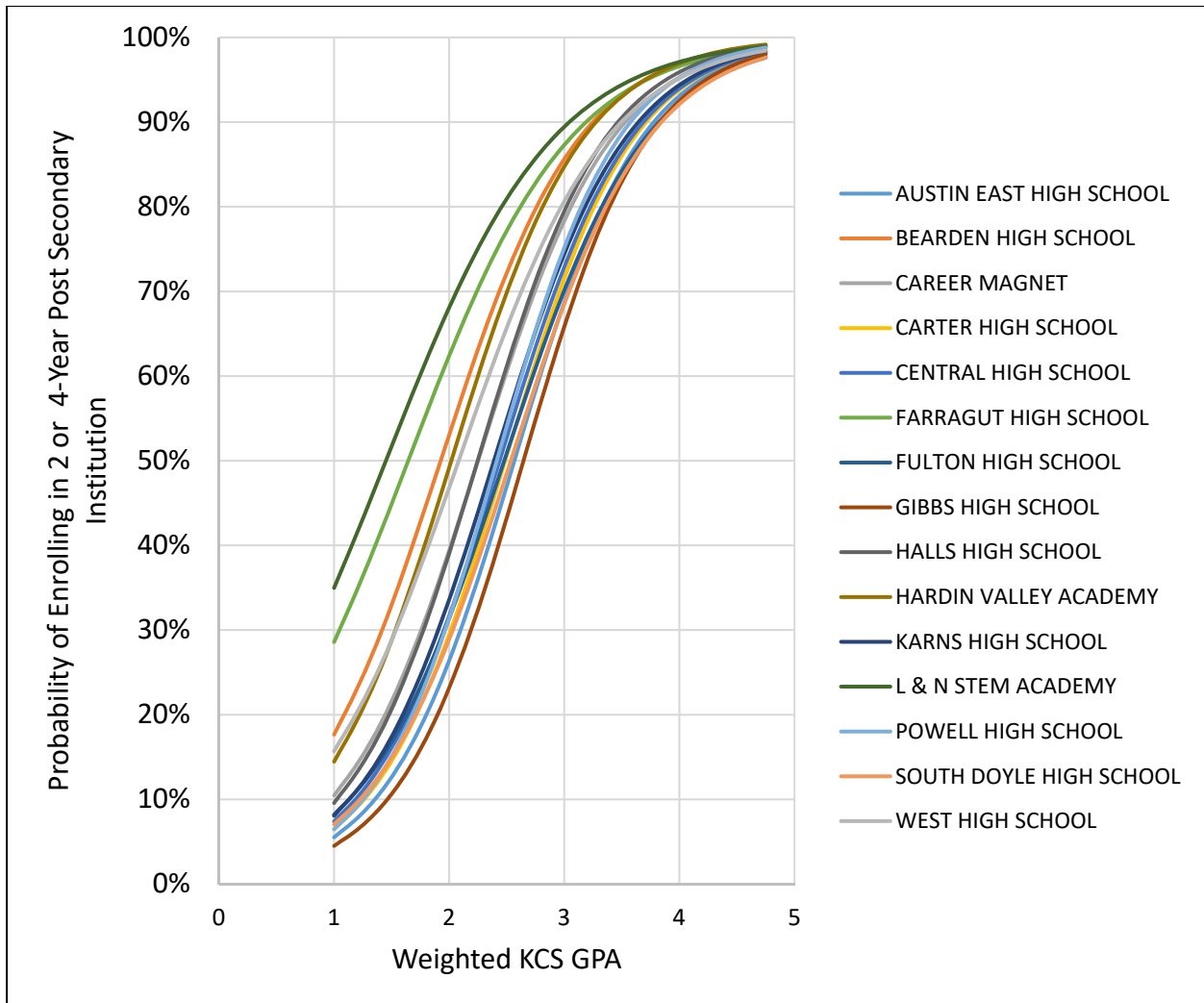

Figure 2: 2 or 4-Year Post-Secondary Enrollment versus Weighted KCS GPA, YOG = 2017

The model estimating the probability of enrolling in a 2-year or 4-year post-secondary institution (that reports to the NSC) from a student's most recent ACT score is available in Equation 3.

Equation 3: 2 or 4-Year Post-Secondary Enrollment versus ACT Model

$$ln\left(\frac{p_{enroll,2\ and/or\ 4-year}}{1 - p_{enroll,2\ and/or\ 4-year}}\right)_{ij} = \beta_{0j} + \sum_{s=1}^{5} \beta_s Demo_{sij} + \beta_6 YOG_{ij} + \beta_{7j}ACT_{ij}$$

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$

$$\beta_{7j} = \gamma_{70} + \mu_{7j}$$

The fixed effects for the 2-year or 4-year post-secondary enrollment versus ACT score regression are available in Table 5. The random effects are available in Table 6.

Table 5: 2 or 4-Year Post-Secondary Enrollment versus ACT Fixed Effects

Fixed Effects	Estimate	Std. Error	z value	Pr(>|z|)
γ_{00}: Intercept (District-Level)	-2.69	0.21	-12.93	< 2e-16
$\beta_1 Demo_1$: Special Education (1=Yes)	-0.40	0.06	-6.52	6.8E-11
$\beta_2 Demo_2$: Economically Disadvantaged (1=Yes)	-0.60	0.05	-12.44	< 2e-16
$\beta_3 Demo_3$: Minority (1=Yes)	0.34	0.05	6.64	3.2E-11
$\beta_4 Demo_4$: English Language Learner (1=Yes)	-0.59	0.12	-4.77	1.9E-06
$\beta_5 Demo_5$: Gender (1=Male)	-0.49	0.04	-12.60	< 2e-16
β_6: YOG	-0.16	0.01	-10.77	< 2e-16
γ_{70}: ACT (District-Level)	0.23	0.01	27.53	< 2e-16

Table 6: 2 or 4-Year Post-Secondary Enrollment versus ACT Random Effects

School	μ_{0j}: Intercept (School-Level)	μ_{7j}: ACT (School-Level)
Austin East High School	-0.18	0.01
Bearden High School	0.73	-0.02
Career Magnet Academy	0.12	-0.01
Carter High School	-0.30	0.01
Central High School	-0.59	0.01
Farragut High School	1.36	-0.04
Fulton High School	-0.38	0.01
Gibbs High School	-0.86	0.03
Halls High School	-0.51	0.02
Hardin Valley Academy	0.46	-0.01
Karns High School	-0.17	0.00
L & N Stem Academy	0.99	-0.03
Powell High School	-0.24	0.01
South Doyle High School	-0.50	0.01
West High School	0.09	0.00

Figure 3 shows the probability of enrolling in a 2-year or 4-year post-secondary institution by most recent ACT score for non-special education, non-economically disadvantaged, non-minority, non-English language learner, female students with a 2017 year of graduation. Figure 3 indicates that there is school-to-school variation in the probability of enrolling in a 2-year or 4-year post-secondary institution for a given ACT score.
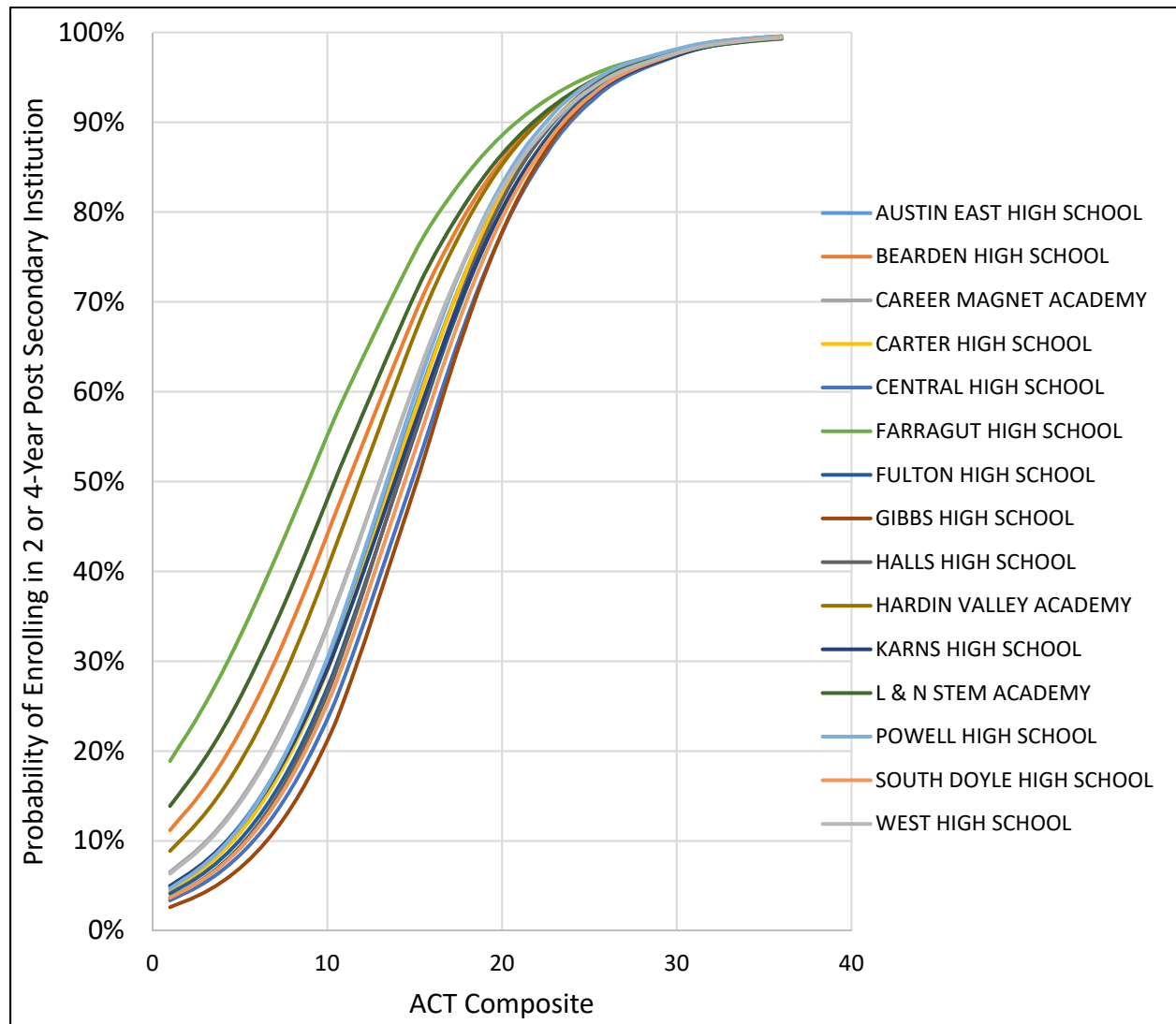

Figure 3: 2 or 4-Year Post-Secondary Enrollment versus ACT, YOG = 2017

The shape of the curves in Figures 2 and 3 suggests a similar amount of variation in GPA and ACT for a given probability of enrolling in a 2-year or 4-year post-secondary institution. The variation must be non-dimensionalized to make comparisons between the logistic curves. We will consider two non-dimensional measures. The first is a non-dimensionalized range (Range$_{nd}$) calculated per Equation 4.

Equation 4: Range_nd Calculation

$$Range_{nd} = \frac{Max_{@\ 50\%\ propability\ of\ attending} - Min_{@\ 50\%\ propability\ of\ attending}}{Median_{@\ 50\%\ propability\ of\ attending}}$$

The second non-dimensional measure is the quartile coefficient of dispersion (QCD). The QCD is calculated per Equation 5. The QCD is less likely to be influenced by extreme values since outliers are not excluded when calculating the QCD.

Equation 5: QCD Calculation

$$QCD = \frac{Quartile\ 3_{@\ 50\%\ propability\ of\ attending} - Quartile\ 1_{@\ 50\%\ propability\ of\ attending}}{Quartile\ 3_{@\ 50\%\ propability\ of\ attending} + Quartile\ 1_{@\ 50\%\ propability\ of\ attending}}$$

The GPAs and ACT scores corresponding to a 50% probability of enrolling in a 2-year or 4-year post-secondary institution can be found in Table 7 (for non-special education, non-economically disadvantaged, non-minority, non-English language learner, female students with a 2017 year of graduation). Table 7 also shows the QCD and Range_nd for ACT and GPA. The GPA-based Range_nd is 1.5 times larger than the ACT-based Range_nd. This finding suggests there is more variation in the GPA-to-2-year or 4-year post-secondary enrollment relationship compared to ACT. When the outlier schools are ignored, the QCD for the GPA-to-2-year or 4-year post-secondary enrollment relationship is 1.12 times that of the ACT.

Table 7: Comparison of School-to-School Variation when Predicting 2 or 4-Year Post-Secondary Enrollment

School	ACT	GPA
Austin East High School	14	2.57
Bearden High School	11	1.93
Career Magnet Academy	13	2.25
Carter High School	14	2.49
Central High School	15	2.44
Farragut High School	9	1.64
Fulton High School	14	2.48
Gibbs High School	15	2.65
Halls High School	14	2.25
Hardin Valley Academy	12	2.02
Karns High School	14	2.39
L & N Stem Academy	10	1.45
Powell High School	13	2.41
South Doyle High School	14	2.54
West High School	13	2.08
QCD	0.064	0.095
Range_nd	0.470	0.529

Results: 4-Year Post-Secondary Enrollment

The model estimating the probability of enrolling in a 4-year post-secondary institution (that reports to the NSC) from the weighted KCS GPA is available in Equation 2. The fixed effects for 4-year post-secondary enrollment versus weighted GPA are available in Table 8. The random effects are available in Table 9.

Table 8: 4-Year Post-Secondary Enrollment versus Weighted KCS GPA Fixed Effects

Fixed Effects	Estimate	Std. Error	z value	Pr(>|z|)
γ_{00}: Intercept (District-Level)	-6.90	0.22	-32.05	< 2e-16
$\beta_1 Demo_1$: Special Education (1=Yes)	-0.84	0.09	-9.76	< 2e-16
$\beta_2 Demo_2$: Economically Disadvantaged (1=Yes)	-0.29	0.06	-4.99	6.04e-07
$\beta_3 Demo_3$: Minority (1=Yes)	0.45	0.06	8.00	1.30e-15
$\beta_4 Demo_4$: English Language Learner (1=Yes)	-1.16	0.18	-6.59	4.29e-11
$\beta_5 Demo_5$: Gender (1=Male)	0.04	0.04	1.01	0.31
β_6: YOG	-0.25	0.01	-17.58	< 2e-16
γ_{70}: GPA (District-Level)	2.26	0.06	39.88	< 2e-16

Table 9: 4-Year Post-Secondary Enrollment versus Weighted KCS GPA Random Effects

School	μ_{0j}: Intercept (School-Level)	μ_{7j}: GPA (School-Level)
Austin East High School	0.41	-0.08
Bearden High School	-0.09	0.21
Career Magnet	-0.27	0.01
Carter High School	-0.39	0.01
Central High School	0.30	-0.18
Farragut High School	0.71	-0.01
Fulton High School	0.22	-0.10
Gibbs High School	-1.05	0.16
Halls High School	-0.02	-0.04
Hardin Valley Academy	-0.15	0.16
Karns High School	-0.15	-0.09
L & N Stem Academy	0.64	0.05
Powell High School	-0.82	0.09
South Doyle High School	-0.24	-0.04
West High School	1.06	-0.19

Figure 4 shows the probability of enrolling in a 4-year post-secondary institution by GPA (for non-special education, non-economically disadvantaged, non-minority, non-English language learner, female students with a 2017 year of graduation). There is less school-to-school variation at a given GPA in Figure 4 compared to Figure 2.
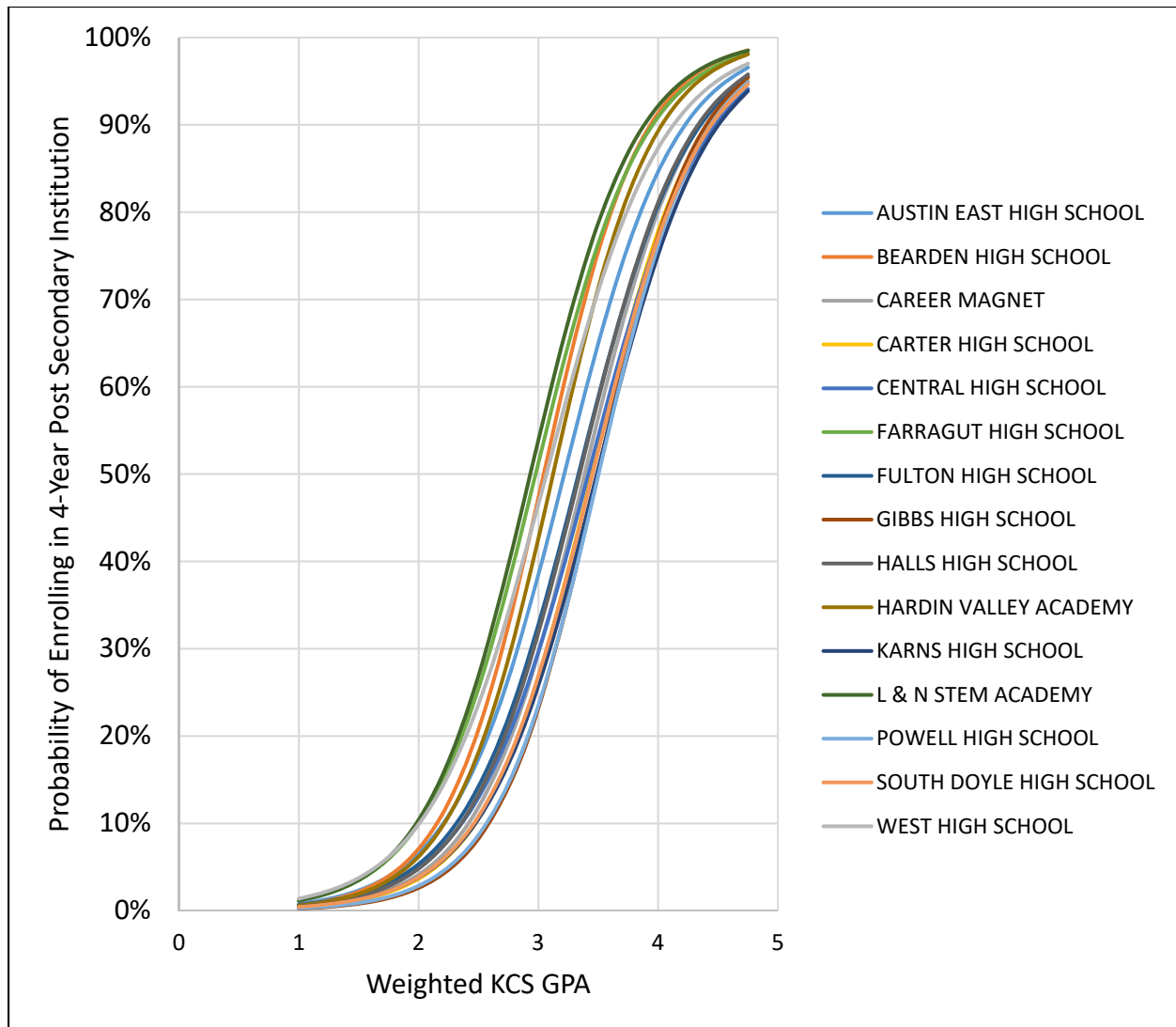
Figure 4: 4-Year Post-Secondary Enrollment versus Weighted KCS GPA, YOG = 2017

The model estimating the probability of enrolling in a 4-year post-secondary institution from a student's most recent ACT score is available in Equation 6. Screening models suggest that there is no school-level variation in the ACT slope estimates.

Equation 6: 4-Year Post-Secondary Enrollment versus ACT Model

$$ln\left(\frac{p_{enroll,2\ and/or\ 4-year}}{1-p_{enroll,2\ and/or\ 4-year}}\right)_{ij} = \beta_{0j} + \sum_{s=1}^{5}\beta_s Demo_{sij} + \beta_6 YOG_{ij} + \beta_{7j}ACT_{ij}$$

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$

The fixed effects for the 4-year post-secondary enrollment versus ACT regression are available in Table 10. The random effects are available in Table 11.

Table 10: 4-Year Post-Secondary Enrollment versus ACT Fixed Effects

Fixed Effects	Estimate	Std. Error	z value	Pr(>|z|)
γ_{00}: Intercept (District-Level)	-5.04	0.13	-38.54	< 2e-16
$\beta_1 Demo_1$: Special Education (1=Yes)	-0.76	0.09	-8.82	< 2e-16
$\beta_2 Demo_2$: Economically Disadvantaged (1=Yes)	-0.59	0.05	-10.85	< 2e-16
$\beta_3 Demo_3$: Minority (1=Yes)	0.49	0.05	9.25	< 2e-16
$\beta_4 Demo_4$: English Language Learner (1=Yes)	-0.62	0.17	-3.65	2.66e-04
$\beta_5 Demo_5$: Gender (1=Male)	-0.48	0.04	-13.09	< 2e-16
β_6: YOG	-0.15	0.01	-11.41	< 2e-16
γ_{70}: ACT (District-Level)	0.26	0.00	54.75	< 2e-16

Table 11: 4-Year Post-Secondary Enrollment versus ACT Random Effects

School	μ_{0j}: Intercept (School-Level)
Austin East High School	0.57
Bearden High School	0.21
Career Magnet	-0.27
Carter High School	0.04
Central High School	-0.34
Farragut High School	0.44
Fulton High School	0.14
Gibbs High School	-0.25
Halls High School	-0.26
Hardin Valley Academy	0.09
Karns High School	-0.37
L & N Stem Academy	0.00
Powell High School	-0.19
South Doyle High School	-0.04
West High School	0.23

Figure 5 shows the probability of enrolling in a 4-year post-secondary institution by ACT (for non-special education, non-economically disadvantaged, non-minority, non-English language learner, female students with a 2017 year of graduation). There is less school-to-school variation in Figure 4 compared to Figure 3.
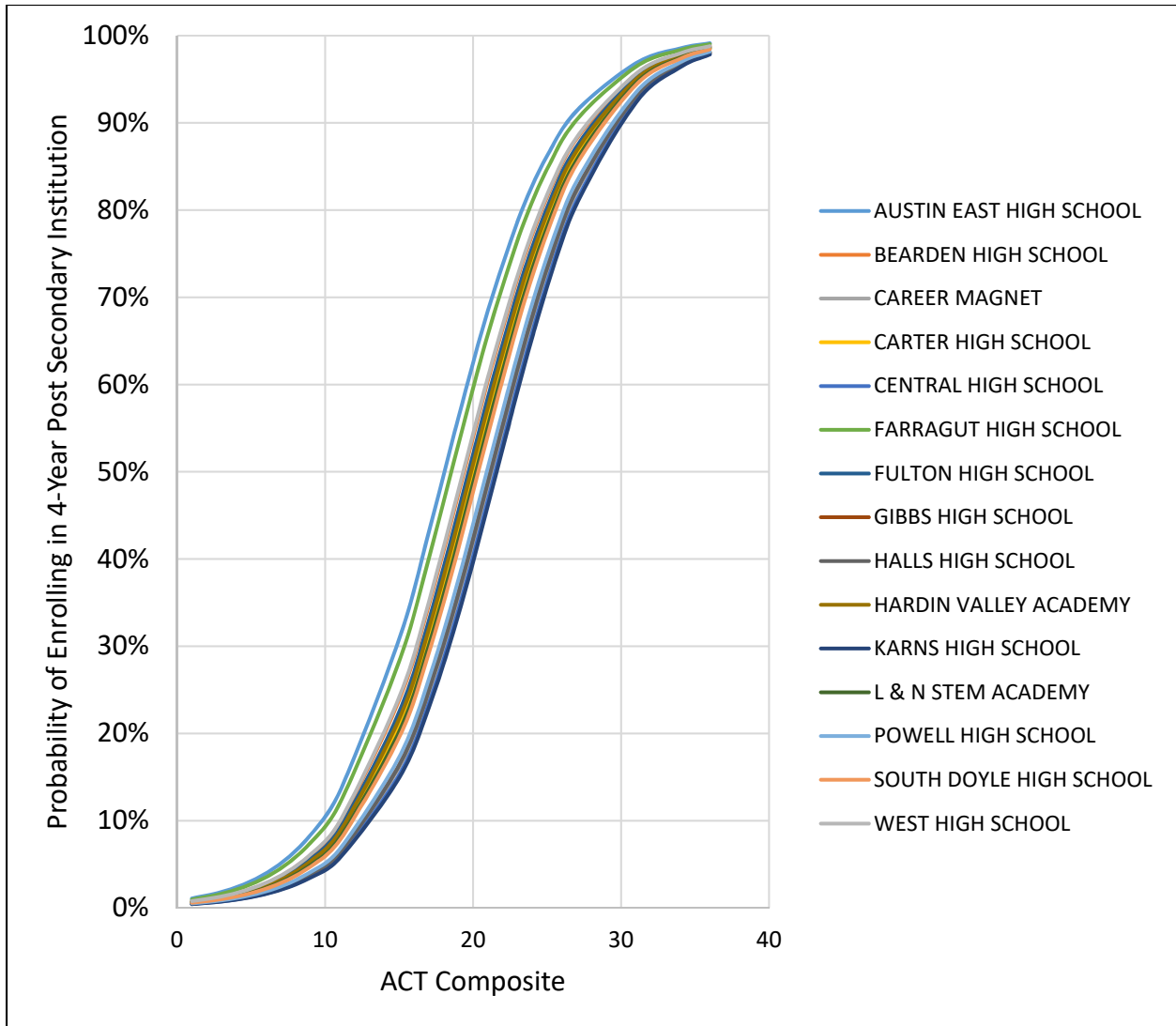
Figure 5: 4-Year Post-Secondary Enrollment versus ACT, YOG = 2017

The GPAs and ACT scores corresponding to a 50% probability of enrolling in a 4-year post-secondary institution can be found in Table 12 (for non-special education, non-economically disadvantaged, non-minority, non-English language learner, female students with a 2017 year of graduation). Table 12 also shows the QCD and $Range_{nd}$ for ACT and GPA. The GPA-based $Range_{nd}$ is nearly equal to the ACT-based $Range_{nd}$. The GPA-based QCD is 1.36 times the ACT-based QCD.

Table 12: Comparison of School-to-School Variation when Predicting 4-Year Post-Secondary Enrollment

School	ACT	GPA
Austin East High School	18	3.22
Bearden High School	19	3.04
Career Magnet Academy	21	3.38
Carter High School	20	3.45
Central High School	21	3.42
Farragut High School	19	2.98
Fulton High School	20	3.33
Gibbs High School	21	3.49
Halls High School	21	3.34
Hardin Valley Academy	20	3.12
Karns High School	22	3.49
L & N Stem Academy	20	2.93
Powell High School	21	3.50
South Doyle High School	20	3.45
West High School	19	3.07
QCD	0.040	0.054
$Range_{nd}$	0.174	0.174

Conclusions & Considerations

The results of this study suggest that ACT composites and GPAs exhibit similar levels of school-to-school variation when predicting post-secondary enrollment. District policymakers have historically assumed that similar GPAs had different ramifications regarding college-going rates among the different KCS high schools. This study suggests that the same is true regarding ACT composite scores.

Consider the composite ACT score of 21, which is used in the state accountability framework to determine if a student is college-ready. Among the class of 2016-2017, the regressed probability of enrolling in a 4-year institution for a student scoring a 21 on the ACT varies between 46% and 68% (for non-special education, non-economically disadvantaged, non-minority, non-English language learner, female students with a 2017 year of graduation, Table 13).

Table 13: Probability of Attending 4-Year College, Non-SpEd, non-ED, non-minority, female, Class of SY1617

School	Probability of 4-year College Enrollment
Austin East High School	68%
Bearden High School	60%
Career Magnet Academy	48%
Carter High School	56%
Central High School	47%
Farragut High School	66%
Fulton High School	59%
Gibbs High School	49%
Halls High School	49%
Hardin Valley Academy	57%
Karns High School	46%
L & N Stem Academy	55%
Powell High School	51%
South Doyle High School	54%
West High School	61%

School-to-school variation in the relationships between ACT composites and college-going may impact how policymakers view college readiness. A student scoring a 21 on the ACT is considered a "ready-graduate" by the state accountability framework. Analysis of our college-going trends suggests that a 21 may not be a meaningful college-going benchmark at all KCS high schools. KCS should document the opportunities "ready-graduates" who do not attend college pursue after high school. District and school leaders can tailor additional school-level programming to better support non-collegiate pathways for these students.

Works Cited

Allensworth, E. M. & Clark, K. (2020). High School GPAs and ACT Scores as Predictors of College Completion: Examining Assumptions About Consistency Across High Schools. Educational Researcher, 49(3), 198-211.

Noble, J. & Sawyer, R. (2002). Predicting Different Levels of Academic Success in College Using High School GPA and ACT Composite Score. ACT Research Report Series, 2002-4.