

significant adverse long-term effects. Our evidence also suggests that the optimal rate of 8<sup>th</sup> grade algebra-taking, in a population equivalent to that in CMS, is at or below the observed baseline rate around 50%.

More generally, this evaluation illustrates the hazards of basing policy initiatives on simple correlational evidence, without first taking steps to assess the validity of causal interpretation.

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Table 1: North Carolina Standard Course of Study Competency Goals (2003)

Course	Competency Goals
7 <sup>th</sup> Grade Math	<p>Understand and compute with rational numbers.</p> <p>Understand and use measurement involving two- and three-dimensional figures.</p> <p>Understand and use properties and relationships in geometry.</p> <p>Understand and use graphs and data analysis.</p> <p>Demonstrate an understanding of linear relations and fundamental algebraic concepts.</p>
8 <sup>th</sup> Grade Math	<p>Understand and compute with real numbers.</p> <p>Understand and use measurement concepts.</p> <p>Understand and use properties and relationships in geometry.</p> <p>Understand and use graphs and data analysis.</p> <p>Understand and use linear relations and functions.</p>
Introductory Mathematics (High School pre-Algebra)	<p>Understand and compute with real numbers.</p> <p>Use properties and relationships in geometry and measurement concepts to solve problems.</p> <p>Understand and use graphs and data analysis.</p> <p>Understand and use linear relations and functions.</p>
Algebra I	<p>Perform operations with numbers and expressions (exponents, polynomials).</p> <p>Describe geometric figures in the coordinate plane.</p> <p>Collect, organize, and interpret data with matrices and linear models.</p> <p>Use relations and functions to solve problems.</p>

Source: North Carolina, *NC Standard Course of Study*, 2003.

<http://www.ncpublicschools.org/curriculum/mathematics/scos/2003/k-8/index>, 1/12/12.

Table 2: Progression of math courses for two CMS cohorts

	1999/2000 cohort ( <i>n</i> =7,179)	2002/03 cohort ( <i>n</i> =8,076)
Proportion of cohort taking Algebra I in 7 <sup>th</sup> grade	11.0%	16.2%
Proportion of cohort taking Algebra I in 8 <sup>th</sup> grade	28.9	47.8
Conditional on taking Algebra I in 8 <sup>th</sup> grade:		
Proportion passing Algebra I EOC test in 8 <sup>th</sup> grade	87.5	80.5
Proportion enrolled in Geometry in 9 <sup>th</sup> grade	81.8	68.7
Proportion passing Geometry EOC in 9 <sup>th</sup> grade	65.5	45.7
Proportion enrolled in Algebra II in 10 <sup>th</sup> grade	74.0	61.4
Proportion passing Algebra II EOC in 10 <sup>th</sup> grade	63.7	47.6
Proportion enrolled in Algebra II by 12 <sup>th</sup> grade	82.4	73.6
Note: Cohorts are defined by the year in which they first enter 7 <sup>th</sup> grade. For purposes of analysis in this paper, grade-repeating students are re-assigned to their original cohort.		

Table 3: Correlates of Math Success Measures: OLS Estimates

Independent variable	Algebra I Test Scores	Pass Algebra I by 10 <sup>th</sup> grade	Pass Geometry by 11 <sup>th</sup> grade	Pass Algebra II by 12 <sup>th</sup> grade
Enrolled in Algebra I by 8 <sup>th</sup> Grade	0.197*** (0.031)	0.130*** (0.012)	0.104*** (0.011)	0.154*** (0.009)
Year entered 7 <sup>th</sup> grade (2000 omitted)				
2001	0.132*** (0.027)	0.039*** (0.011)	0.010 (0.016)	0.022* (0.010)
2002	0.047 (0.027)	0.015 (0.012)	-0.047** (0.016)	-0.033** (0.012)
2003	0.011 (0.025)	0.023 (0.012)	-0.045** (0.016)	-0.055*** (0.013)
2004	0.036 (0.029)	0.054*** (0.011)	-0.038* (0.016)	-0.031** (0.010)
2005	0.188*** (0.043)	0.103*** (0.022)	0.005 (0.017)	0.012 (0.013)
6 <sup>th</sup> grade math test score decile (lowest omitted)				
Second lowest	0.227*** (0.039)	0.155*** (0.019)	0.040** (0.015)	0.064*** (0.011)
Third lowest	0.403*** (0.043)	0.267*** (0.021)	0.096*** (0.017)	0.136*** (0.015)
Fourth lowest	0.617*** (0.047)	0.397*** (0.015)	0.180*** (0.023)	0.223*** (0.014)
Fifth lowest	0.796*** (0.035)	0.462*** (0.015)	0.298*** (0.018)	0.300*** (0.015)
Sixth lowest	0.998*** (0.035)	0.511*** (0.011)	0.411*** (0.015)	0.390*** (0.014)
Seventh lowest	1.227*** (0.043)	0.545*** (0.012)	0.560*** (0.019)	0.461*** (0.014)
Eighth lowest	1.510*** (0.046)	0.566*** (0.017)	0.674*** (0.018)	0.552*** (0.013)
Ninth lowest	1.828*** (0.046)	0.577*** (0.018)	0.750*** (0.019)	0.596*** (0.016)
Highest	2.445*** (0.051)	0.574*** (0.019)	0.813*** (0.018)	0.644*** (0.016)
<i>N</i>	36,308	36,790	36,790	36,790
Adjusted <i>R</i> <sup>2</sup>	0.608	0.343	0.431	0.304

Note: Standard errors, corrected for clustering at the decile-cohort level, in parentheses. Algebra I test score is taken from the student's first test administration. Course passage is defined as passing the state's standardized end-of-course test in that subject. Grade-retained students are kept with their original cohort.

\*\*\* denotes a coefficient significant at the 0.1% level, \*\* the 1% level, \* the 5% level.

Table 4: Instrumental Variable Estimates of the Impact of Acceleration into Algebra I in 8<sup>th</sup> Grade

Independent variable	Algebra I Test Score		Pass Algebra I by 10 <sup>th</sup> grade		Pass Geometry by 11 <sup>th</sup> grade		Pass Algebra II by 12 <sup>th</sup> grade	
	2SLS	BP	2SLS	BP	2SLS	BP	2SLS	BP
Enrolled in Algebra I by 8 <sup>th</sup> Grade	-0.364*** (0.094)	0.154 (0.117)	-0.027 (0.047)	0.184*** (0.030)	-0.493*** (0.097)	-0.111*** (0.023)	-0.273*** (0.069)	
<i>N</i>	36,308	36,790	36,790	36,790	36,790	36,790	36,790	
Adjusted <i>R</i> <sup>2</sup>	0.576	0.326	0.394	0.272				

Note: Standard errors, corrected for clustering at the decile-cohort level, in parentheses. Algebra I test score is taken from the student's first test administration. Course passage is defined as passing the state's standardized end-of-course test in that subject. Grade-retained students are kept with their original cohort. Sample is restricted to those students observed as seventh graders who take Algebra I at some point over the next five years. All models control for 6<sup>th</sup> grade math test score decile and cohort fixed effects, and instrument for Algebra I enrollment by 8<sup>th</sup> grade using a set of decile-by-cohort indicators. Columns headed "2SLS" are estimated by two-stage least squares; columns headed "BP" are estimated by bivariate probit.

\*\*\* denotes a coefficient significant at the 0.1% level, \*\* the 1% level, \* the 5% level.

Table 5: Instrumental Variable Estimates of the Impact of Acceleration into Algebra I in 7<sup>th</sup> Grade

Independent variable	Algebra I Test Score		Pass Geometry by 11 <sup>th</sup> grade		Pass Algebra II by 12 <sup>th</sup> grade	
	2SLS	BP	2SLS	BP	2SLS	BP
Enrolled in Algebra I by 7 <sup>th</sup> Grade	-0.392* (0.184)	-0.163 (0.215)	-0.067 (0.058)	-0.032 (0.039)	-0.064 (0.129)	
<i>N</i>	36,308	36,790	36,790	36,790	36,790	36,790
Adjusted <i>R</i> <sup>2</sup>	0.603	0.423		0.292		

Note: Standard errors, corrected for clustering at the decile-cohort level, in parentheses. Algebra I test score is taken from the student's first test administration. Course passage is defined as passing the state's standardized end-of-course test in that subject. Grade-retained students are kept with their original cohort. Sample is restricted to those students observed as seventh graders who take Algebra I at some point over the next five years. All models control for 6<sup>th</sup> grade math test score decile and cohort fixed effects, and instrument for Algebra I enrollment by 8<sup>th</sup> grade using a set of decile-by-cohort indicators. Columns headed "2SLS" are estimated by two-stage least squares; columns headed "BP" are estimated by bivariate probit.

\*\*\* denotes a coefficient significant at the 0.1% level, \*\* the 1% level, \* the 5% level.



Table 6: Instrumental Variable Estimates of the Impact of Acceleration into Algebra I in 9<sup>th</sup> Grade

Independent variable	Algebra I Test Score		Pass Algebra I by 10 <sup>th</sup> grade		Pass Geometry by 11 <sup>th</sup> grade		Pass Algebra II by 12 <sup>th</sup> grade	
	2SLS	BP	2SLS	BP	2SLS	BP	2SLS	BP
Enrolled in Algebra I by 9 <sup>th</sup> Grade	-1.016*** (0.280)	-0.463*** (0.164)	-0.551* (0.260)	-0.267** (0.084)	-0.647*** (0.195)	-0.169** (0.065)	-0.478** (0.172)	
N	36,308	36,790	36,790	36,790	36,790	36,790	36,790	
Adjusted R <sup>2</sup>	0.549	0.236		0.401		0.276		

Note: Standard errors, corrected for clustering at the decile-cohort level, in parentheses. Algebra I test score is taken from the student's first test administration. Course passage is defined as passing the state's standardized end-of-course test in that subject. Grade-retained students are kept with their original cohort. Sample is restricted to those students observed as seventh graders who take Algebra I at some point over the next five years. All models control for 6<sup>th</sup> grade math test score decile and cohort fixed effects, and instrument for Algebra I enrollment by 8<sup>th</sup> grade using a set of decile-by-cohort indicators. Columns headed "2SLS" are estimated by two-stage least squares; columns headed "BP" are estimated by bivariate probit.

\*\*\* denotes a coefficient significant at the 0.1% level, \*\* the 1% level, \* the 5% level.

Table 7: Verification Test using District with Similar Acceleration Policy (Guilford Co.)

Independent variable	Algebra I Test Score		Pass Algebra I by 10 <sup>th</sup> grade		Pass Geometry by 11 <sup>th</sup> grade		Pass Algebra II by 12 <sup>th</sup> grade	
	2SLS	BP	2SLS	BP	2SLS	BP	2SLS	BP
Enrolled in Algebra I by 8 <sup>th</sup> Grade	-0.353*** (0.065)	0.075 (0.187)	0.052* (0.020)	0.075 (0.187)	-0.090** (0.027)	-0.403*** (0.110)	-0.101*** (0.025)	-0.347*** (0.100)
N	23,937	24,171	24,171	24,171	24,171	24,171	24,171	24,171
Adjusted R <sup>2</sup>	0.599	0.291	0.291	0.431	0.431	0.278	0.278	0.278

Note: Standard errors, corrected for clustering at the decile-cohort level in 2SLS specifications, in parentheses. Bivariate probit models estimated with clustered standard errors failed to converge; conventional standard errors are reported in those specifications. Bivariate probit models drop observations in cells lacking variation in either outcome variable. Algebra I test score is taken from the student's first test administration. Course passage is defined as passing the state's standardized end-of-course test in that subject. Grade-retained students are kept with their original cohort. Sample is restricted to those students observed as seventh graders who take Algebra I at some point over the next five years. All models control for 6<sup>th</sup> grade math test score decile and cohort fixed effects, and instrument for Algebra I enrollment by 8<sup>th</sup> grade using a set of decile-by-cohort indicators. Columns headed "2SLS" are estimated by two-stage least squares; columns headed "BP" are estimated by bivariate probit. \*\*\* denotes a coefficient significant at the 0.1% level, \*\* the 1% level, \* the 5% level.

Table 8: Assessing the Validity of Falsification Tests

Independent variable	Dependent variable: Enrollment in Algebra I by 8 <sup>th</sup> grade		
	Wake County (Raleigh)	Forsyth County (Winston-Salem)	Cumberland County (Fayetteville)
Proportion of CMS students in same cohort/decile who take Algebra I by 8 <sup>th</sup> grade	-0.284 (0.166)	0.702* (0.323)	-0.391 (0.414)
<i>N</i>	34,610	14,930	14,754

Note: Equations are estimated by probit and include cohort and decile fixed effects. Standard errors, corrected for clustering at the cohort/decile level, in parentheses.

\* denotes a coefficient significant at the 5% level.

Table 9: Falsification Tests using Three Alternate Districts

Coefficient on 8 <sup>th</sup> grade Algebra I- taking rate in same decile/cohort, CMS in:	Dependent Variable			
	Algebra I test score	Pass Algebra I by 10 <sup>th</sup> grade	Pass Geometry by 11 <sup>th</sup> grade	Pass Algebra II by 12 <sup>th</sup> grade
Wake County	0.097* (0.046)	0.012 (0.015)	-0.127*** (0.027)	-0.040 (0.028)
Forsyth County	-0.081 (0.068)	-0.032 (0.033)	-0.044 (0.039)	-0.080 (0.043)
Cumberland County	-0.078 (0.067)	0.017 (0.035)	-0.020 (0.043)	0.018 (0.047)

Note: Standard errors in parentheses have been computed using the Murhpy-Topel (1985) method, as applied to two-sample two-stage least squares by Inoue and Solon (2010). All equations estimated by TS2SLS.

\*\*\* denotes a coefficient significant at the 0.1% level, \*\* the 1% level, \* the 5% level.

Table 10: Algebra Teacher Characteristics by School Year, Charlotte-Mecklenburg Schools

	1999/2000	2000/01	2001/02	2002/03	2003/04	2004/05
Number of Unique Teachers	183	222	198	249	228	228
Number of Sections per Teacher	2.038	1.905	2.051	2.378	2.232	2.031
Number of Students per Teacher	43.71	40.68	43.90	49.01	47.84	43.36
Enrollment-weighted mean characteristics						
Years of Experience	11.23	10.56	10.82	8.768	9.895	10.52
2 or Fewer Years' Experience	20.99%	26.85%	23.10%	31.57%	24.91%	27.14%
General Licensure Scores	0.217	0.183	0.138	0.097	0.217	0.100
<i>Number of Teachers with General Scores</i>	165	192	171	214	195	203
Math Licensure Scores	0.639	0.603	0.539	0.453	0.417	0.333
<i>Number of Teachers with Math Scores</i>	33	42	35	58	48	42

Note: Licensure test scores are standardized to have mean zero and standard deviation one for teachers taking the same test in the same year.

Table 11: Teacher Time Allocation in Charlotte-Mecklenburg Schools, 2001/02-2002/03

Subject Areas	2002/03		2001/02	
	Teacher Sections	Percentage	Teacher Sections	Percentage
Mathematics	961	79.1%	838	72.9%
Pre-Algebra & Lower Level	198	16.3%	393	34.2%
Algebra I	428	35.2%	251	21.8%
Geometry	66	5.4%	58	5.0%
Algebra II & Higher Level	79	6.5%	62	5.4%
Other Mathematics	190	15.6%	74	6.4%
Language	163	13.4%	201	17.5%
Science	34	2.8%	48	4.2%
Social Studies	26	2.1%	31	2.7%
Other Subjects	31	2.5%	31	2.7%
Total Observations	1215	100%	1149	100%

Note: Sample consists of teachers assigned to at least one section of Algebra I in 2002/03 who also appear in CMS course assignment records for 2001/02. "Other Mathematics" includes Technical Math I & II, Discrete Math, Integrated Math I & II, and Special Topics in Mathematics. "Other Subjects" includes computer science, health and physical education, vocational education, non-classroom activities (such as SAT preparation) and miscellaneous.

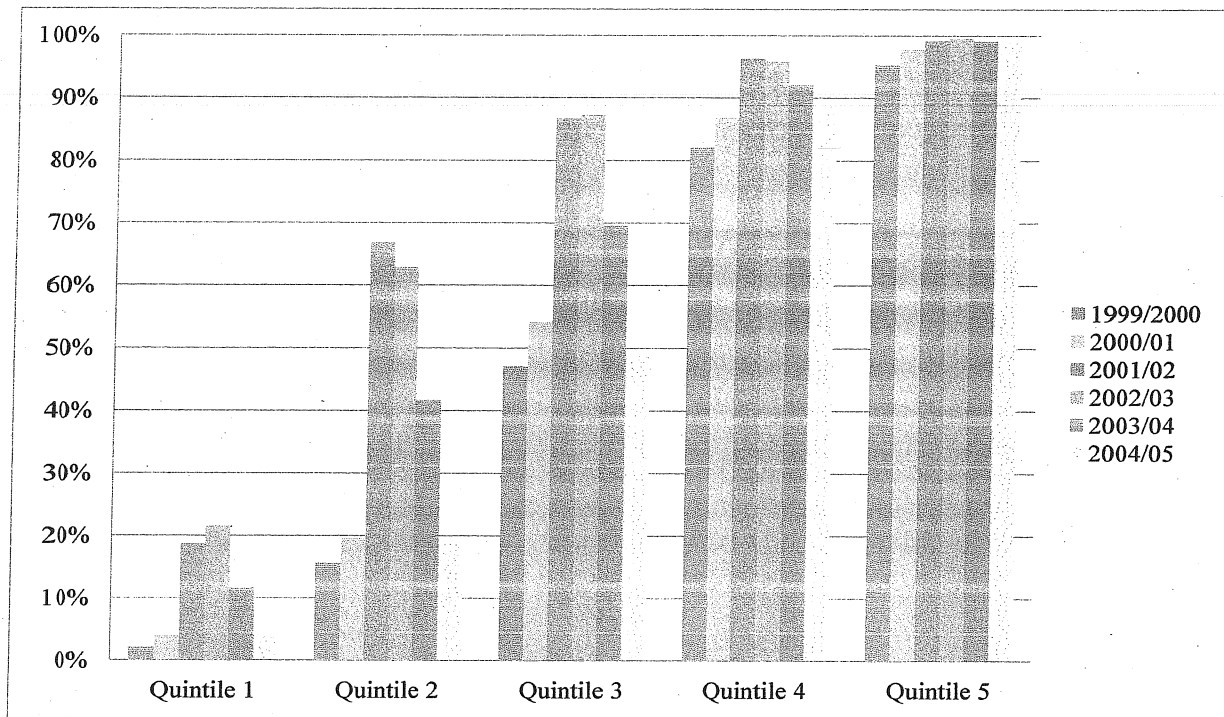


Figure 1: Probability of taking Algebra I by 8<sup>th</sup> grade, by 6<sup>th</sup> grade math test score quintile and year entering 7<sup>th</sup> grade, Charlotte-Mecklenburg Schools.

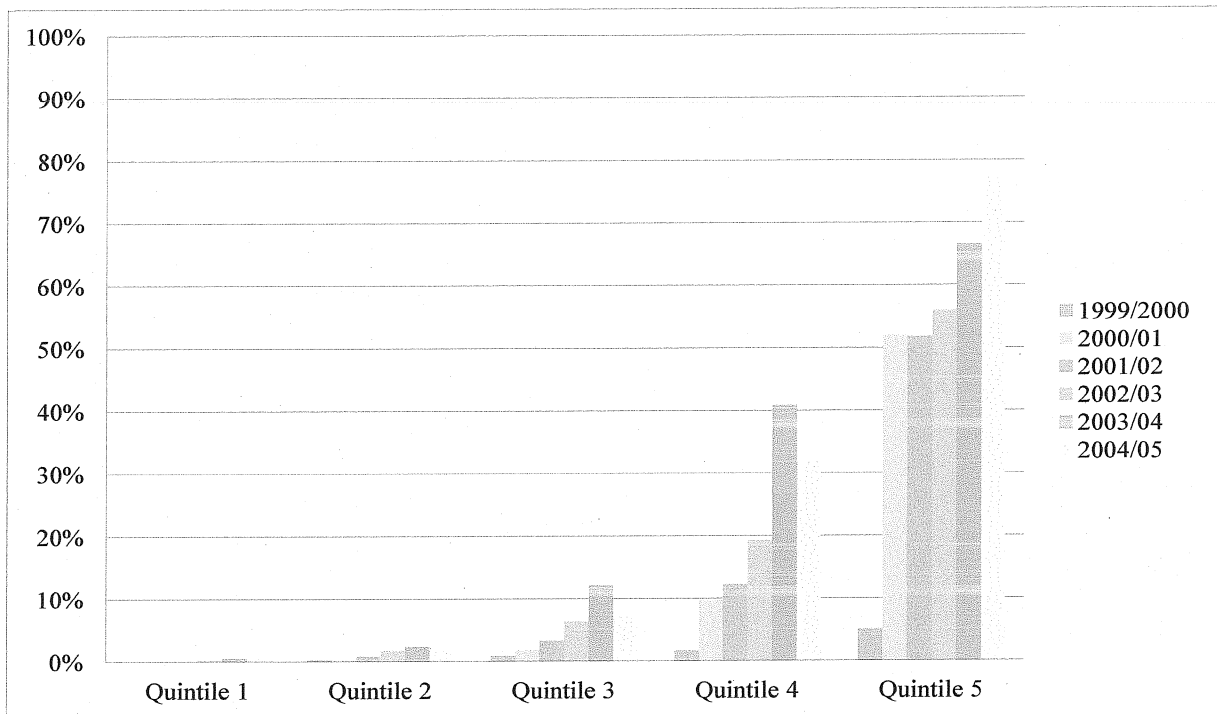


Figure 2: Probability of taking Algebra I by 7<sup>th</sup> grade, by 6<sup>th</sup> grade math test score quintile and year entering 7<sup>th</sup> grade, Charlotte-Mecklenburg Schools.



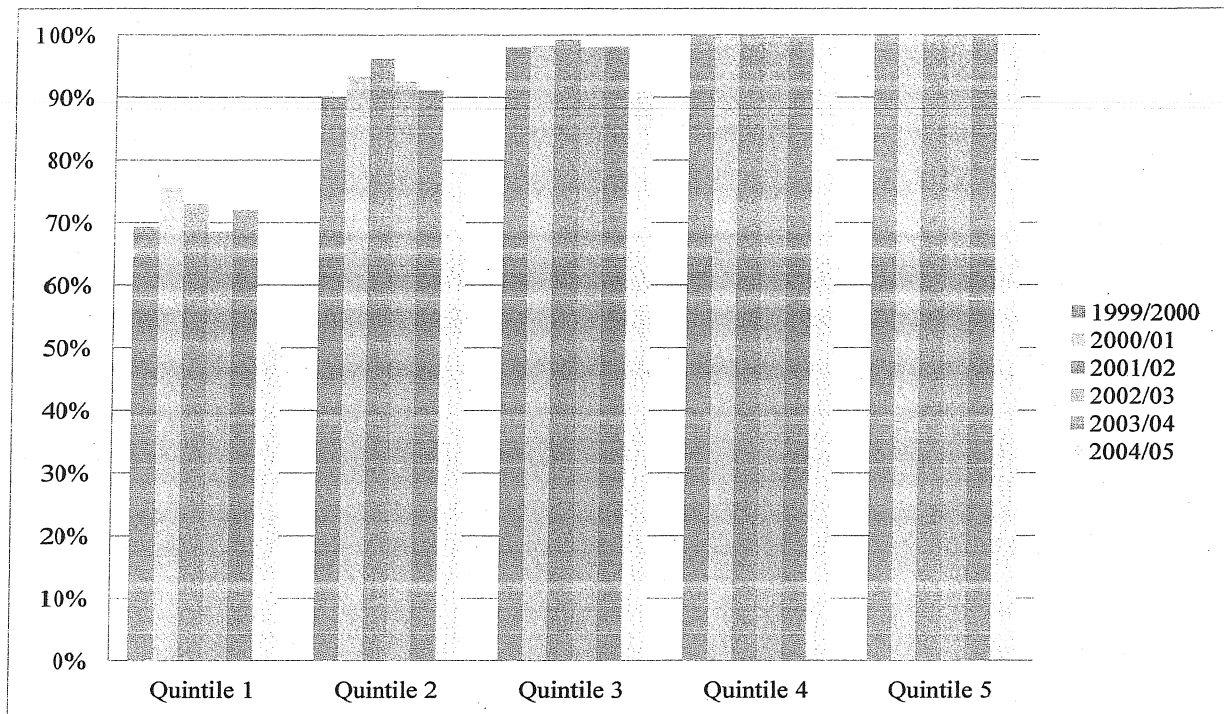


Figure 3: Probability of taking Algebra I by 9<sup>th</sup> grade, by 6<sup>th</sup> grade math test score quintile and year entering 7<sup>th</sup> grade, Charlotte-Mecklenburg Schools.

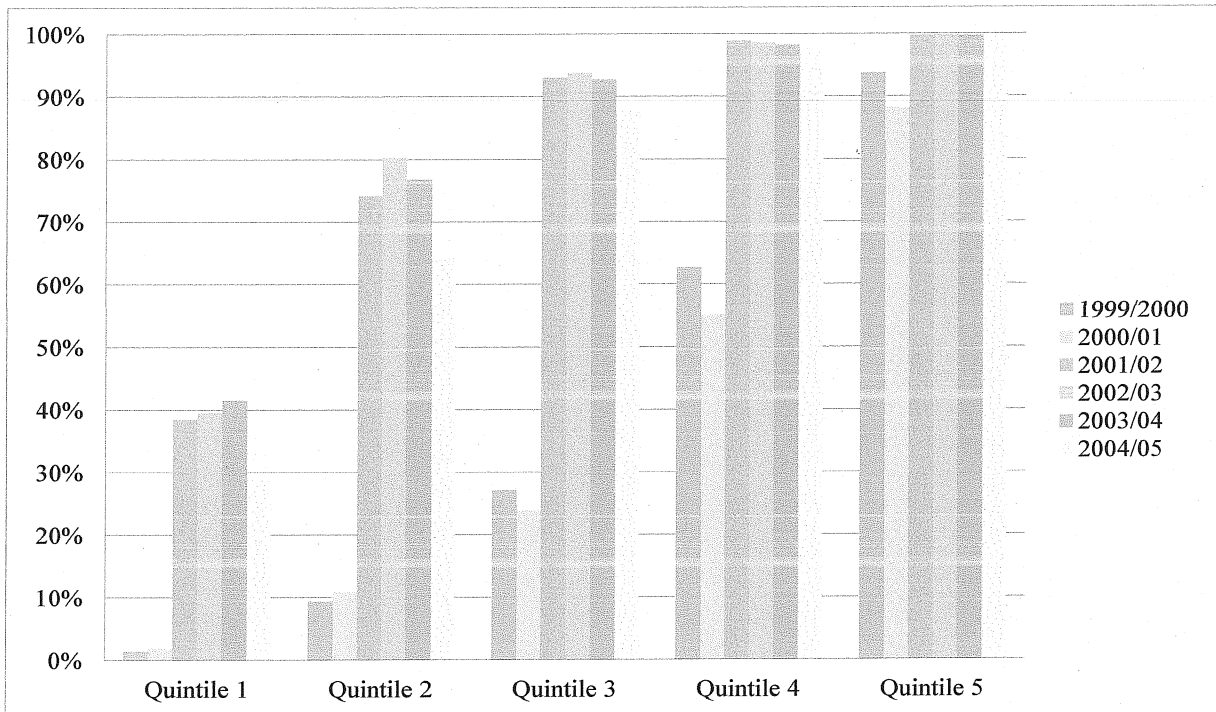


Figure 4: Probability of taking Algebra I by 8<sup>th</sup> grade, by 6<sup>th</sup> grade math test score quintile and year entering 7<sup>th</sup> grade, Guilford County Schools.

Table A1: Summary Statistics for Dependent Variables

School District	Algebra I test scores	Pass Algebra I by 10 <sup>th</sup> grade	Pass Geometry by 11 <sup>th</sup> grade	Pass Algebra II by 12 <sup>th</sup> grade
CMS	-0.121 (1.050)	72.7%	48.5%	49.5%
Wake County	0.583 (0.953)	87.3%	68.4%	66.1%
Guilford County	-0.212 (1.033)	76.0%	49.8%	52.2%
Forsyth County	0.022 (1.021)	74.2%	52.1%	50.8%
Cumberland County	-0.074 (0.910)	70.2%	45.5%	44.8%

Note: In each district, sample is restricted to those students observed consistently for a period of 6 years beginning in 7<sup>th</sup> grade, and who take Algebra I at some point during this period. Mean and standard deviation reported for test scores, sample proportion for all other variables.