What Makes a Grade ?
The Respective Contributions of Pupils, Schools and Peers in Achievement

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What makes a grade ?

- Educational inputs:
  - Pupil's background & Family background (Coleman 1966, …)
  - School quality (School resources, Card and Krueger, JEP 1996, Krueger, QJE 1999, Hanushek, JEL 1986, EJ 2003, Hanushek et al., ECA 2005, and Levacic and Vignoles, 2002); (Teacher training, Angrist 2001…)
  - Peers (Angrist et al. 2002, Hoxby 2000…).

What we are doing

- We use the National Pupils database, a comprehensive educational panel including all English pupils in State schools (i.e. not independent schools).
- We estimate the respective contributions of schools, peers and pupils in educational achievement.

Outline

- The English educational system
- The dataset
- Specification and Identification hypothesis
- Results and analysis of the respective contributions of pupils' backgrounds, peer effects and school quality.
- Concluding remarks

The English educational system

- Pupils enter primary school in the year in which they reach five.
- They go through the National Curriculum, Key Stages.
- End of each Key Stage: national examinations, anonymous and externally set and marked.
  - Key Stage 1 : 5 to 7
  - Key Stage 2 : 7 to 11
  - Key Stage 3 : 11 to 14
- Test scores are used for League tables, published on the web and in local newspapers.
- Policy relevance : Estelle Morris, the Education Secretary, resigned in 2002 for missing the target for Key Stage attainment.

The dataset

- **Comprehensive**: all pupils in state schools at the end of Key Stage 1, 2 and 3
- **Test scores** in English, Maths and Science.
- **Policy relevant**: examinations are externally set and marked.
- **Panel data**: Pupils and Schools can be followed over time.
- **Pupil characteristics**: Ethnicity, Gender, Free School Meal status, Special Educational Needs.
- **School status**: Community Schools, Voluntary Schools, Foundation Schools, Special Schools
- **Standardized test scores**: mean 50, Std. Dev. 10

The dataset

Key Stage	1	2	3	4
Age	7	11	14	16
Grade	2	6	9	11
Topics	Maths English	Maths English Science	Maths English Science	GCSEs
School types	Primary		Secondary	
	Infant	Junior		
	Infant & Junior			
	First or lower	Middle		
	First & Middle			
	Primary	Junior High		College
Cohorts	2000 1999 1998	2004 2003 2002 2001 2000 1999	2004 2003 2002 2001 2000	2004 2003 2002

		Number		Percentage
Number of Pupils		1 783 281	pupils	
Number of Schools		20 708	schools	
Number of Year-Groups		96 163	year-groups	
Sample Size		8 660 561		(100,00 %)
Of Which:				
Key Stage 1 observations		3 403 213		(39,30 %)
Key Stage 2 observations		5 257 348		(60,70 %)
Of Which :				
Key Stage 1:	1998	1 122 020		(12,96 %)
	1999	1 158 427		(13,38 %)
	2000	1 122 751		(12,96 %)
Key Stage 2:	2002	1 703 236		(19,67 %)
	2003	1 821 893		(21,04 %)
	2004	1 732 219		(20,00 %)

	Number	Percentage
Boy	4 413 066	(50,96 %)
Free School Meal	1 486 517	(17,16 %)
Special Educational Needs	1 966 563	(22,71 %)
English spoken at home	7 893 062	(91,14 %)

	Mean	(Std. Dev.)	Min.	Max.
All Test Scores	50,00	(10,00)	12,68	80,57
Key Stage 1 Test Scores	50,00	(10,00)	12,93	80,57
English	50,00	(10,00)	21,02	80,57
Maths	50,00	(10,00)	12,93	78,00
Key Stage 2 Test Scores	50,00	(10,00)	12,68	74,26
English	50,00	(10,00)	20,48	74,13
Maths	50,00	(10,00)	23,99	66,45
Science	50,00	(10,00)	12,68	74,26

Specification (1): Pure School and Pupil Effects

$$y_{i,f,t} = \theta_i + \psi_{J(i,t)} + D_{i,f,t}\delta + \varepsilon_{i,f,t}$$

- θ : Pupil effect
- ψ: School effect
- $D_{i,f,t}$: Controls (*f*: field)

Identification hypothesis (1-1)

- Identification constraint for pupil and school effects:
  - Effects can be compared when they lie in the same *mobility group*
  - Rule: pupil *i* and school *j* are in the same *mobility group* if pupil i attended school *j* once.
  - Proof of identification see Abowd, Creecy, Kramarz.
  - We find one large group encompassing more than 99.9% of the observations.

Identification hypothesis (1-2)

- Formally,

$$E(\varepsilon | i, J(i,t), D_{i,f,t}) = 0$$

- No omitted time-varying variable should both have an impact on test scores and be correlated with pupil/school effects.
- e.g. if unemployment shocks affect both mobility – leads to bad schools - and test scores – bad shock on y -, then the difference between bad and good schools will be overestimated

Issues in the School effects and Pupil effects model

- (I) Inputs can be time-varying – school composition, teacher quality, school resources.
- (II) Past achievement and/or past inputs matter.

Specification (2): School-Grade and Pupil Effects

$$y_{i,f,t} = \theta_i + \varphi_{J(i,t),G(i,t),t} + D_{i,f,t}\delta + \varepsilon_{i,f,t}$$

- θ : Pupil effect
- φ : School – Grade – Year effect
- $D_{i,f,t}$: Controls

Identification hypothesis (2-1)

- Identification constraint for pupil and school effects:
  - Effects can be compared when they lie in the same *mobility group*
  - Rule: pupil *i* and school-grade-year *j,g,t* are in the same *mobility group* if pupil i attended school-grade-year *j,g,t* once.
  - Proof of identification see Kramarz, Machin, Ouazad (same as AKM).
  - We find one large group encompassing more than 99.9% of the observations ???
  - With three cohorts, we expect three large groups; but repetitions, small but sizeable, connect these three groups

Identification hypothesis (2-2)

- Formally,

$$E(\varepsilon | i, J(i,t) \otimes G(i,t) \otimes t, D_{i,f,t}) = 0$$

- No omitted time-varying variable should both have an impact on test scores and be correlated with pupil/(school-grade-year) effects.
- e.g. if unemployment shocks affect both mobility – leads to bad schools - and test scores – bad shock on y -, then the estimated effects can be purged and the real effects estimated but ...

Specification (3): Contemporaneous and Past School-Grade and Pupil Effects

$$y_{i,f,t} = \theta_i + \varphi_{J(i,t),G(i,t),t} + \lambda\varphi_{J(i,t-1),G(i,t-1),t-1} + D_{i,f,t}\delta + \varepsilon_{i,f,t}$$

- θ : Pupil effect
- φ : School – Grade – Year effect
- $D_{i,f,t}$: Controls

Identification hypothesis (3-1)

- Identification constraint for pupil and school effects:
  - Effects can be compared when they lie in the same *mobility group*
  - Rule: pupil *i* and school-grade-year *j,g,t* are in the same *mobility group* if pupil i attended school-grade-year *j,g,t* once.
  - Proof of identification see Kramarz, Machin, Ouazad.
  - We find one large group encompassing more than 99.9% of the observations (same as before, due to repetitions)

Identification hypothesis (3-2)

- Formally,

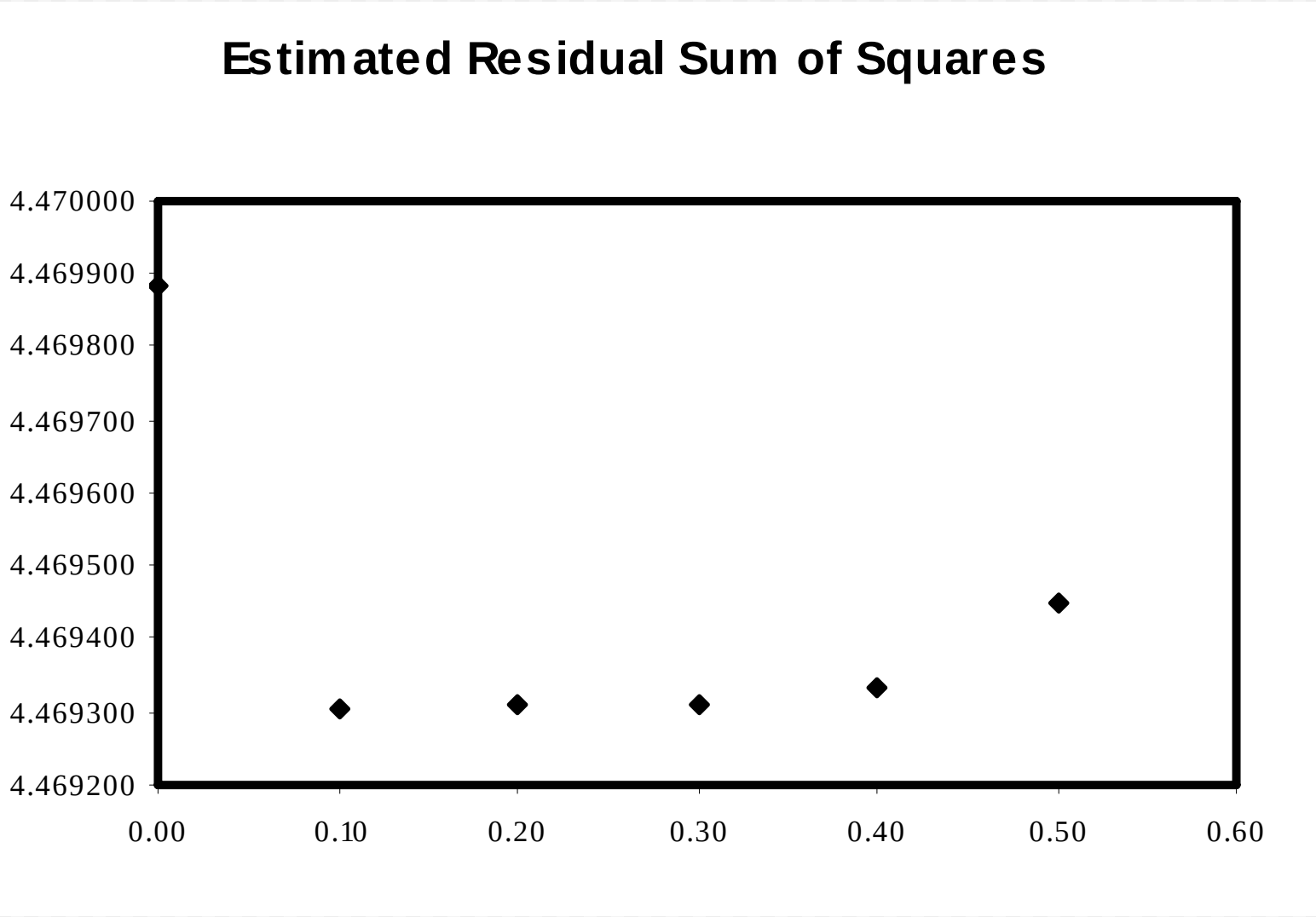
$$E(\varepsilon_1 \mid i, J(i,1) \otimes G(i,1) \otimes 1, D_{i,f,1}) = 0$$

$$E(\varepsilon_2 \mid i, J(i,t) \otimes G(i,t) \otimes t \text{ for } t = 1,2, D_{i,f,2}) = 0$$

- Unique difficulty up to now is the specification: the impact of schools on achievement is similar to high and low-grade students but unlikely to be a problem due to endogenous mobility

Estimation

- First two specifications, exactly ACK.
- Last specification, that includes past school-grade-year effects, is more complex:
  - The design matrix that relates a pupil to schools has more than one non-zero (one 1 and one λ)
  - The model is linear conditional on λ
  - It is estimated as such:


Estimated Residual Sum of Squares
4.470000
4.469900
4.469800
4.469700
4.469600
4.469500
4.469400
4.469300
4.469200
0.00
0.10
0.20
0.30
0.40
0.50
0.60

Decomposing year-group effects (1/2)

- Second-step specifications:

$$\varphi_{j,g,t} = \varphi_j + E(Z|j,g,t)\gamma + G_{j,g,t}\delta + \varepsilon_{j,g,t}$$

$$\varphi_{j,g,t} = \varphi_j + E(Z|j,g,t)\gamma_1 + E(\theta|Z,j,g,t)\gamma_2 + G_{j,g,t}\delta + \varepsilon_{j,g,t}$$

- E(Z|j,g,t) : vector of average exogenous pupil characteristics
- E(θ|Z,j,g,t) : vector of average pupil effects (conditional on observables)
- γ : reduced form contextual effect. It includes both the exogenous and the endogenous contextual effect.
- φ_j : school fixed effect

Decomposing year-group effects (2/2)

- Within school specification:

$$\varphi_{j,g,t} - \varphi_{j,.,.} = [E(Z|j,g,t) - E(Z|j)]\gamma + [G_{j,g,t} - G_{j,.,.}]\delta + \varepsilon_{j,g,t} - \varepsilon_{j,.,.}$$

- Variations in year-group composition within a school identify peer-effects, provided they are exogenous (Hoxby 2000, Gould Lavy Paserman 2005).
- In contrast to previous literature, the school effect is analysed *free of the pupil effect* (provided the specification is correct).

Correlation table: School Effects

Variable description	Mean	Std. Dev.	Simple Correlation with y	θ	θ^*	$\theta^{\perp}$	ψ
y Standardized grade	50,000	10,000	1,000				
θ, Pupil Effect	0,000	9,341	0,811	1,000			
θ^*, Observed individual heterogeneity	0,000	5,404	0,544	0,579	1,000		
$\theta^{\perp}$, Unobserved individual heterogeneity	0,000	7,619	0,608	0,816	0,000	1,000	
ψ, School Effects	0,031	1,941	0,121	-0,076	-0,008	-0,088	1,000
ε, Residual	0,000	4,630	0,465	0,000	0,000	0,000	0,000

- Large pupil heterogeneity, large school heterogeneity (std. dev. 5 times larger)
- Larger correlation between test scores and pupil effects.
- Note that the correlation of y and θ is underestimated since θ is measured with error (like usual regression with measurement error).

Correlation table: School-Grade Effects

Variable description	Mean	Std. Dev.	Simple Correlation with y	θ	θ^*	$\theta^\perp$	φ	Past φ
y Standardized grade	50.000	10.000	1.000					
θ, Pupil Effect	0.000	9.584	0.804	1.000				
θ^*, Observed individual heterogeneity	-0.094	5.500	0.544	0.564	1.000			
$\theta^\perp$, Unobserved individual heterogeneity	0.094	7.913	0.573	0.825	0.000	1.000		
φ, Year-Group Effect	-0.554	3.709	0.111	-0.345	-0.002	-0.417	1.000	
φ, Past Year-Group Effect	-0.756	3.774	-0.065	-0.369	-0.006	-0.441	0.649	1.000
ε, Residual	0.000	0.000	0.449	0.000	0.000	0.000	0.000	0.000

- Large pupil heterogeneity.
- School-grade heterogeneity is larger than school heterogeneity
- Large correlation between pupil effects and the test score

Correlation Table: Current and Past School-Grade effects (estimated λ=0.1)

Variable description	Mean	Std. Dev.	Simple Correlation with y	θ	θ^*	$\theta^\perp$	φ	Past φ
y Standardized grade	50.000	10.000	1.000					
θ, Pupil Effect	0.000	9.875	0.765	1.000				
θ^*, Observed individual heterogeneity	-0.142	5.554	0.543	0.552	1.000			
$\theta^\perp$, Unobserved individual heterogeneity	0.142	8.239	0.557	0.834	0.000	1.000		
φ, Year-Group Effect	-3.370	21.730	0.011	-0.149	0.000	-0.179	1.000	
φ, Past Year-Group Effect	-28.894	7.018	-0.051	-0.442	-0.007	-0.523	0.861	1.000
ε, Residual	0.000	4.469	0.450	0.007	0.000	0.000	0.000	0.000

- Past-school-grade effect only enters KS 2 results (mean has no clear meaning except progress for those who repeat, more on this later)
- Similar reason for large Stdev for the grade-school effect
- No correction for estimated effects

	School Effects	Year-Group Effects	Past YG Effect
Boy	**0.219**	**0.209**	**0.207**
	(0.011)	(0.012)	(0.013)
Free School Meal Status	**-4.113**	**-4.106**	**-4.190**
	(0.016)	(0.016)	(0.017)
English language	**1.655**	**2.210**	**2.757**
	(0.035)	(0.034)	(0.035)
Special Educational Needs	**-11.086**	**-11.269**	**-11.280**
	(0.016)	(0.015)	(0.015)
Month of Birth	**-0.278**	**-0.279**	**-0.281**
	(0.002)	(0.002)	(0.002)
Ethnicity			
Chinese	**2.769**	**3.014**	**3.043**
	(0.109)	(0.112)	(0.117)
Mixed	**-1.417**	**-1.527**	**-1.690**
	(0.042)	(0.045)	(0.047)
Indian	**0.695**	**0.983**	**1.289**
	(0.049)	(0.050)	(0.052)
White	Ref.	Ref.	Ref.
Bangladeshi	**-1.760**	**-1.723**	**-1.504**
	(0.072)	(0.070)	(0.073)
Black African	**-1.141**	**-1.595**	**-2.066**
	(0.058)	(0.054)	(0.056)
Pakistani	**-2.771**	**-2.292**	**-2.010**
	(0.051)	(0.049)	(0.051)
Black Other	**0.483**	**0.354**	**0.199**
	(0.083)	(0.084)	(0.087)
Other	**-0.166**	**-0.277**	**-0.388**
	(0.031)	(0.031)	(0.033)
Black Carribean	**-1.542**	**-1.779**	**-2.071**
	(0.050)	(0.050)	(0.052)
Other controls		Cohort dummies	
R-Squared	0.335	0.325	0.311
F Statistic	46,257.00	53,534.28	50,214.12
Number of Pupils	1,783,281	1,783,281	1,783,281

Analysis of pupil effects

- Free School Meal Status: the pupil effect is around 41% of a standard deviation lower.
- Gender: boys have only a moderately higher effect (better in maths & science, but weaker in English)
- The month of birth has a negative impact on the pupil effect.
- Ethnicities are ranked in the same way as in descriptive statistics

	Specification			
	Current School-Grade Effect		Past School-Grade Effect	
	$\varphi_{j,g,t}$ School-Grade Effect		$\varphi j,g,t$ School-Grade Effect	
	Coefficients for …		Coefficients for …	
	observables $z_{j,g,t}$	unobservables $E(\theta^{\perp}\|j,g,t,X)$	observables $z_{j,g,t}$	unobservables $E(\theta^{\perp}\|j,g,t,X)$
School Composition				
% with English as first language	**-1.267**	-0.007	**-1.454**	**-0.029**
	(0.196)	(0.009)	(0.187)	(0.004)
% with Free School Meal	0.197	0.003	**0.388**	**0.007**
	(0.139)	(0.005)	(0.134)	(0.002)
% with Special Needs	**2.686**	**0.027**	**3.531**	**0.016**
	(0.275)	(0.007)	(0.115)	(0.002)
% of Boys	**-0.341**	**-0.638**	**-0.571**	**0.003**
	(0.127)	(0.043)	(0.089)	(0.001)

Ethnic composition				
% Chinese	-0.455 (0.935)	**-0.012** (0.003)	-0.719 (0.941)	**-0.008** (0.003)
% Mixed	**1.069** (0.341)	-0.002 (0.007)	**1.547** (0.301)	**0.006** (0.002)
% Indian	**1.075** (0.457)	-0.015 (0.008)	**1.357** (0.456)	**-0.019** (0.004)
% White	Ref.	Ref.	Ref.	Ref.
% Bangladeshi	0.167 (0.755)	**-0.022** (0.008)	0.296 (0.750)	**-0.017** (0.007)
% Black African	0.002 (0.481)	0.003 (0.004)	-0.040 (0.497)	**0.010** (0.003)
% Pakistani	0.848 (0.482)	-0.004 (0.007)	**1.158** (0.501)	**-0.011** (0.005)
% Black Other	-0.024 (0.570)	-0.010 (0.005)	-0.125 (0.569)	0.003 (0.003)
% Other	**0.281** (0.120)	-0.004 (0.008)	**0.343** (0.111)	0.004 (0.003)
% Black Carribean	-0.410 (0.475)	0.005 (0.006)	-0.095 (0.480)	**0.023** (0.004)
School Fixed Effects	Yes		Yes	
Key Stage dummies	Yes		Yes	
Year dummies	Yes		Yes	
R-Squared	0.7614		0.99	

Analysis of school-grade-year effects (1)

- Introducing past school-grade effects increases (a lot) the R-square.
- The unobservable pupil effects in the school-grade matter (R-square goes from 0.61 to 0.76 in specification without past effects, from 0.30 without school effects).
- We have no clear intuition of what they mean, since we are not used to reason conditional on pupils' quality but...
- Note that

$$\Delta y = \varphi_2 - (1-\lambda)\varphi_1 + \Delta\varepsilon$$

Analysis of school-grade-year effects (2)

- The KS1 and KS2 school-grade effects are very highly correlated. Assume they are equal:

$$\Delta y = \lambda \varphi_1 + \Delta \varepsilon$$

- Then, we capture in the school-grade effects the students' ability to make progress:
  - Close to zero in average for the usual guy
  - Positive for those who come from an immigration background
  - Strong for those who repeated for some reason

Table A6 : School Effects Analysis

Baseline Specification	School Effects	Year-Group Effects		Past and Current Year-group Effects	
Peer Effects Specification	-	With Peers' observables	With Peers' observables and unobservables	With Peers' observables	With Peers' observables and unobservables
	Dependent variable : ψ_j School Effect				
School Status					
Community	Ref.	Ref.	Ref.	Ref.	Ref.
Voluntary Aided	**0.214** (0.002)	**-0.266** (0.048)	**1.143** (0.034)	**0.364** (0.044)	**1.303** (0.041)
Voluntary Controlled	**-0.375** (0.002)	**-0.266** (0.048)	**0.445** (0.050)	**-0.316** (0.052)	**0.582** (0.052)
Foundation	0.007 (0.004)	-0.007 (0.102)	**0.612** (0.112)	0.000 (0.103)	**0.776** (0.124)
Community Special	**-3.191** (0.009)	**-0.916** (0.194)	**-12.461** (0.219)	**-1.146** (0.309)	**-15.853** (0.188)
Non-Maintained Special	**-5.679** (0.066)	**-4.569** (1.006)	**-12.087** (0.693)	**-4.830** (1.004)	**-14.395** (0.742)
Foundation Special	**0.825** (0.028)	**-3.752** (1.129)	**-14.241** (0.450)	**-4.183** (1.162)	**-17.500** (0.406)
R-Squared	0.02	0.01	0.21	0.01	0.27
F Statistic	14523.01	25.70	435.52	25.62	815.76
Number of schools	20,708	20,708	20,708	20,708	20,708

Analysis of school effects

- Unobservable pupil effects explain a large fraction of the variance.
- Special needs schools have, as expected, very large and negative school effects.
- Their increase in magnitude is a manifestation of the negative correlation between pupil and school-grade effects.

Table A7 :School Mobility between ages 7 and 11 (using observations of English test scores)

School Effect at age 7 Quartiles of $\psi_{J(i,1)}$	**School Effect at age 11** Quartiles of $\psi_{J(i,2)}$ *Q1*	*Q2*	*Q3*	*Q4*	
Q1	**277,193**	38,216	32,106	17,968	365,483
	(62.02 %)	*(8.74 %)*	*(7.70 %)*	*(4.96 %)*	*(21.98 %)*
Q2	51,554	**276,071**	36,508	21,006	385,139
	(11.54 %)	***(63.12 %)***	*(8.76 %)*	*(5.80 %)*	*(23.16 %)*
Q3	53,467	50,163	**281,237**	30,321	415,188
	(11.96 %)	*(11.47 %)*	***(67.49 %)***	*(8.38 %)*	*(24.97 %)*
Q4	64,709	72,919	66,881	**292,731**	497,240
	(3.89 %)	*(4.38 %)*	*(4.02 %)*	***(80.86 %)***	*(29.90 %)*
	446,923	437,369	416,732	362,026	1,663,050
	(26.87 %)	*(26.30 %)*	*(25.06 %)*	*(21.77 %)*	*(100.00 %)*

Concluding Remarks (1)

- Results suggest that pupils are much more heterogeneous than schools. *(Around 1.5 and 2 times more variance)*
- Pupil effects are more correlated with test scores than School or School-Grade effects
- Variations in social composition -- observed and unobserved -- explain a large share of the variance in school-grade effects.
- Unobserved pupil effects explain a very large share of the explained component of school effects.
- This suggests a ranking of inputs: (i) pupil background and ability (ii) school composition (iii) school time-invariant inputs

Concluding Remarks (2)

- We will estimate:
  1. A model with separate grade-school-year effects (without using the connecting repeaters)
  2. The limited-mobility bias.
  3. The various pupil and school effects using techniques that correct for their estimated nature
  4. Various models of mobility to understand where identification comes from.