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I. Background

In May of 1970 the attorneys for plaintiff Julius W. Hobson brought suit in the United States District Court for the District of Columbia to seek an order requiring the Washington D.C. School Board to equalize expenditures per pupil, within a five percent range, among all the elementary schools in the system. (Hereafter we will refer to the case as Hobson v. Hansen II.)

This suit was the outgrowth of two previous actions. The first, Bolling v. Sharpe, a companion to the famous Brown v. Board of Education case, outlawed the legally segregated Washington school system, which existed prior to 1954. The second was Hobson v. Hansen I which, in 1967, outlawed the rigid ability grouping -- called the track system -- practiced in the D.C. schools. That order also required the shifting of teachers to promote faculty integration, and ordered the assignment of volunteering children from overcrowded black schools to white schools with excess capacity.

The judge in Hobson v. Hansen I was the Hon. J. Skelly Wright, who is also sitting in the current case. His 1967 opinion said that, in the presence of any de facto segregation in Washington schools, "...the minimum the Constitution will require and guarantee is that for their objectively measurable aspects these schools be run on the basis of real equality, at least unless any

inequalities are adequately justified."

The initial submission by plaintiffs in the current case noted that substantial inequalities in per pupil expenditures existed in 1970, that these inequalities were discriminatory by color and income, and that therefore the School Board was violating the above quoted dictum.

Early in the case, the court, recognizing that large schools are likely to have lower overhead costs per pupil than small schools, shifted the focus of the case from total expenditures per pupil to total teacher expenditures per pupil. Judge Wright then issued a formal "show cause" order to the D.C. School Board asking:

> ".....why the school board should not devise a plan to equalize within a five per cent variation expenditures for teaching costs out of regular funds among all District of Columbia elementary schools for the 1971 fiscal year."

As a result of these events, the School Board asked the authors to prepare an analysis of the underlying causes of variation in expenditures on teaching among D.C. elementary schools.

Highlights of our resulting analysis are presented in the rest of this article. Because our conclusions tended to support the School Board's side of the case, the analysis was subsequently submitted to the court as a technical affidavit in the defendent's submission of 18 January 1971. As of this writing Judge Wright has not yet issued a ruling in the case.

We report our analysis here because we feel it will be of general interest to economists, statisticians, and other quantitatively oriented social scientists.[1] It attempts to bring some simple tools of economics and statistics to bear on a pressing social issue. We hope also that it will serve to point up gaps in existing knowledge and thus help to guide future research on the economics of education. Finally, we think that a reading of our report will serve to instill in the reader a healthy skepticism against ready acceptance of positions taken by those who seem to be on the side of the angels.

II. Basic Issues in the Case

The proposed order in Hobson vs. Hansen II calls for the equalization (within a 5 percent range) of teacher expenditures per pupil among elementary schools in the D.C. School System. We take the general attitude that the parties on both sides of the case recognize and subscribe to ~~what we see as the~~ implicit objectives of this order: (1) elimination of discriminatory variation in the quality of schooling received, either by color or by income class, and (2) reduction in the amount of dispersion in schooling quality generally, even among children of the same racial and income groups.

As we see it, the major issue in this case is whether ordering equalization of teacher expenditures per pupil will in fact lead to, or even

[1] Especially so to those students interested in understanding the relationship between Civil Rights protest and the achievment of equality of treatment in the allocation of schooling resources. A recent study by Baron, "Race and Status in School Spending", Journal of Human Resources, VI,1,pp.3-24, examined this relationship in the context of Chicago elementary schools. He used expenditure variation changes to index quality of schooling variation changes over time. This procedure raises similiar kinds of questions to those raised by the proposed equalization order in this case.

help move in the direction of, the attainment of these two objectives.

Expenditures will measure quality of schooling variation if the expenditure differences reflect differences in teacher quality, class size (in ranges that matter for educational quality), and, again in such ranges, ratios of special teachers[3] to pupils.

However, expenditure variation can also be caused by the following three factors, in which case it will not reflect quality of schooling: longevity increments in teacher salaries that continue beyond the point at which additional experience stops contributing to teacher performance; differences in class size (pupils per classroom teacher) and ratios of special teachers to pupils within ranges that do not affect the quality of education received; and differences between small and large schools in the efficiency of special teachers.[4]

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[2]At this point it is worth mentioning that there is a much broader issue of social policy raised by this case that we are not addressing: viz., the appropriateness of using the courts to enforce equality of treatment in the distribution of public services. We do not take up this important issue of law and social policy in our paper. Also it is clear that the desire for equality of opportunity which invalidates benefit taxation for schooling is sufficiently widespread that we may assume it has influenced all the parties in this case. If we were wrong, one would have expected the defendants to have fought the case at least partially on the grounds suggested here. They have not.

[3] Special teachers in the D.C. elementary schools include both special subject teachers (e.g., history, math, etc.) and remedial type teachers (e.g., help slow readers). These teachers are not assigned specific classes but are itinerant between classes within a school, and even travel between schools in neighborhoods where schools are small.

[4]It should be kept in mind that quality of schooling variation could be pervasive and yet not be related to input characteristics explicitly purchased by the school system. Indeed the sources of such quality variation may not be readily quantified at all: teacher morale may be high because of a one-in-a-million principal; a teacher may stimulate some students and turn others off; etc. These types of intangible factors obviously cannot be equalized by expenditure equalization orders.

It is, of course, most likely the case that expenditure variation within the D.C. school system reflects, to some extent, both variations in quality and the effects of the above set of factors. However, it is crucial from the point of view of this case to get some idea of the relative importance of these two sets of factors. If quality of schooling is only a minor contributor to the observed spread in expenditures on teaching, then an equalization order, besides being an irrelevant and costly constraint to place on school system administrators, might have the perverse effect of increasing the amount of educational quality variation in the system.

There are a number of ways in which direct perverse effects may come about depending on the precise form of the production function for education. The results of our own production function analysis indicate that teacher experience stops contributing to teacher productivity after about six years, which is 10 years short of where longevity salary increments stop. Since we also show[5], in Section III, that only about 20 percent of the variation in average teacher salary across schools is associated with variation in the percent of teachers with less than six years of experience, clearly the scope for perverse effects is present. As a concrete example, consider a school with an above average share of very old teachers, a below average share of teachers with an intermediate range of experience (who are just as productive as the very old teachers), and an average share of young, inexperienced teachers. Assume also that this school has an average

[5]See Section III, A.

teacher-to-pupil ratio. Because of the excess share of very old teachers, this school would have above average per-pupil expenditures. Now, if this school, when ordered to equalize, were not able to adjust by trading its excess share of very old teachers for less expensive ones then it would have to make part of its adjustment by reducing the overall teacher to pupil ratio. This type of adjustment might lead to lower quality of instruction.

In addition to possible perverse effects on variation in quality, an equalization order might also operate to reduce the overall level of quality the D.C. system could obtain for a given expenditure outlay. This could come about, for example, if teacher recruitment became more difficult in the face of increased shifting around of teachers from year to year required by the need to abide by an equalization order.

Clearly, given these possibilities, some systematic investigation of the relationship between quality variation and expenditure variation is in order.

In the first part of our report we present a components-of-variation analysis (Section III) that breaks down the variation in teacher expenditures per pupil into parts attributable to variation in teacher experience, average class size, special subject teachers and other special teachers per pupil, and counselors and librarians per pupil. This part of our study in itself yields some suggestive results about the possible range of variation in edicational quality in the system, especially with regard to just how discriminatory this variation

might be.

Deeper insight into the true amount of quality variation in any educational system, however, requires detailed knowledge of just which ranges of values of educational resources like teacher experience and class size affect the quality of education received. We try to provide some of this knowledge in Section IV. We present both a summary of the results of previous studies as well as our own statistical analysis of the results of the city-wide sixth grade reading test administered in September of 1970.

Our report concludes with a summary of our findings as well as our recommendations with regard to the wisdom of imposing expenditure equalization on the D.C. school system (Section V).

III. Expenditure Variation and Resource Variation

A. All-schools Analysis

Table 1 presents rankings of 131 D.C. elementary schools by three measures: total teacher expenditures per pupil (henceforth, TTEPP), average teacher salary, and total number of teachers per 100 pupils. All measures refer only to pupils in regular classes in grades 1-6. Listed alongside each ranking are code numbers (1 through 131) which can be used to identify individual schools.[6]

TTEPP is defined as the sum of the salaries of classroom teachers, special subject teachers, special teachers of regular students, and

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[6]The data for this table and the rest of the report were generously furnished by Mr. Sidney Zevin of the D.C. elementary school system. We take this opportunity to thank him for his advice and for giving us insight into many of the pitfalls of using this data.

TABLE I

RANKINGS OF 131 D.C. ELEMENTARY SCHOOLS BY TOTAL TEACHER EXPENDITURES PER PUPIL (TTEPP), AVERAGE TEACHER SALARY, AND TOTAL TEACHERS PER 100 PUPILS

TTEPP

School code											
38	990	59	732	131	666	99	603	98	553	86	491
109	947	30	709	71	663	16	603	106	551	121	487
26	895	80	707	12	657	9	605	105	549	63	487
43	893	104	705	96	651	6	603	36	548	21	487
31	886	50	702	68	650	20	594	13	545	47	480
112	841	40	696	96	650	92	593	81	544	82	479
107	825	73	694	70	648	29	592	119	542	55	479
37	818	2	693	18	646	5	592	10	534	25	477
7	802	53	690	100	642	3	590	78	531	66	469
113	802	74	680	54	638	79	579	45	528	97	466
115	786	87	682	57	636	14	576	130	527	122	466
32	785	15	681	52	633	76	575	129	527	127	461
108	781	111	681	34	631	110	575	44	526	75	452
77	780	120	679	17	626	99	574	103	525	126	450
24	772	72	679	114	625	118	573	102	523	117	447
96	767	101	678	83	621	33	571	94	523	124	413
27	766	89	677	22	619	23	569	31	520	35	412
64	764	19	671	60	616	93	567	41	520	42	412
8	750	48	670	69	616	4	566	1	508	28	411
39	749	11	669	67	613	40	564	65	505	123	403
88	748	116	669	95	610	125	561	91	501	128	330
62	736	61	668	58	609	46	555	85	497		

Average Teacher Salary

43	13904	4	11977	17	11460	37	11059	86	10495
73	13723	115	11953	56	11447	118	11024	28	10482
51	13580	9	11917	61	11424	106	11013	98	10446
49	13139	112	11910	104	11420	19	10982	76	10411
62	13024	32	11899	6	11401	120	10931	35	10403
26	13012	111	11889	36	11378	72	10858	130	10257
27	12914	22	11879	21	11377	103	10914	129	10246
108	12639	127	11856	12	11364	44	10909	47	10215
39	12638	53	11847	14	11357	58	10892	97	10122
20	12602	71	11534	48	11349	45	10884	119	10112
77	12770	50	11816	13	11344	67	10871	6	10108
7	12577	105	11815	69	11329	65	10854	90	10033
3	12520	102	11803	29	11324	52	10802	70	9797
18	12475	54	11793	83	11308	100	10767	89	9723
2	12438	85	11775	95	11298	93	10762	23	9709
88	12402	60	11704	18	11286	25	10754	42	9664
34	12389	10	11698	57	11282	63	10741	126	9636
11	12383	107	11695	1	11268	113	10739	123	9633
59	12372	131	11670	116	11243	110	10735	91	9478
80	12337	125	11656	46	11240	87	10675	81	9420
66	12283	101	11510	92	11226	5	10660	82	9111
38	12212	15	11519	109	11224	66	10592	128	9005
24	12171	114	11515	79	11205	121	10572	122	8759
94	12147	96	11488	41	11203	31	10550	75	8743
78	12038	74	11483	33	11201	99	10540	124	8594
64	12034	84	11475	30	11195	55	10537	117	8308
40	12002								

Total Teacher-Per 100 Pupils

127	3.89	105	4.65	33	5.10	95	5.40	81	5.77	72	6.19
28	3.93	126	4.67	130	5.14	11	5.40	12	5.78	30	6.24
35	3.96	86	4.68	129	5.14	54	5.41	53	5.83	24	6.34
123	4.18	47	4.69	79	5.17	114	5.43	39	5.83	64	6.35
85	4.22	40	4.70	75	5.17	69	5.44	61	5.85	7	6.38
128	4.22	3	4.71	110	5.20	17	5.47	52	5.86	87	6.39
42	4.26	4	4.73	22	5.21	83	5.49	23	5.87	43	6.39
21	4.28	13	4.80	29	5.23	76	5.53	101	5.87	51	6.52
78	4.42	124	4.80	82	5.26	5	5.55	48	5.90	115	6.57
66	4.43	103	4.81	60	5.26	2	5.57	15	5.92	32	6.60
102	4.43	125	4.82	93	5.27	58	5.59	59	5.92	70	6.61
25	4.44	36	4.82	91	5.28	71	5.61	27	5.93	56	6.70
1	4.51	44	4.82	92	5.28	67	5.63	50	5.94	26	6.88
63	4.54	45	4.85	6	5.29	57	5.64	116	5.95	89	6.91
55	4.55	16	4.87	68	5.29	62	5.65	100	5.96	112	7.06
84	4.56	31	4.93	98	5.29	96	5.65	74	6.00	107	7.14
10	4.56	46	4.94	49	5.30	121	5.70	88	6.03	37	7.40
97	4.61	106	5.01	122	5.32	90	5.72	108	6.06	8	7.42
121	4.61	73	5.06	110	5.35	18	5.72	77	6.11	113	7.47
20	4.64	14	5.07	94	5.36	111	5.73	19	6.11	38	8.18
61	4.65	9	5.08	119	5.36	80	5.73	104	6.17	109	8.44
65	4.65	34	5.09	117	5.36	99	5.77	120	6.18		

(Table 1 continued)

WASHINGTON D.C. ELEMENTARY SCHOOLS BY CODE NUMBER

1. Aiton
2. Amidon
3. Barnard
4. Beers
5. Benning
6. Blow
7. Bowen
8. Brent
9. Brightwood
10. Brookland
11. Bryan
12. Buchanan
13. Bunker Hill
14. Burroughs
15. Burrville
16. Carver
17. Clark
18. Cook, J.F.
19. Crummell
20. Davis
21. Drew
22. Eaton
23. Eckington
24. Edmonds
25. Emery
26. Fillmore
27. Gage
28. Garfield
29. Gibbs
30. Giddings
31. Coding
32. Hardy
33. Harris
34. Hearst
35. Hendley (+ Hendley Annex 1 & 2)
36. Houston
37. Hyde
38. Jackson
39. Janney
40. Keene
41. Kenilworth
42. Ketcham (+ Ketcham Annex)
43. Key
44. Kimball
45. Kingsman
46. Lafayette
47. Langdon
48. Langston
49. LaSalle
50. Leckie
51. Lenox
52. Lewis
53. Logan
54. Lovejoy
55. Ludlow-Taylor
56. Madison
57. Mann
58. Maury
59. Merritt
60. Miner
61. Mott
62. Murch
63. Nalle
64. Nichols Ave.
65. Noyes
66. Orr
67. Oyster
68. Patterson
69. Payne
70. Peabody
71. Perry
72. Petworth
73. Plummer
74. Powell (+ Annex)
75. Randle High
76. Richardson
77. River Terrace
78. Rudolph
79. Shadd
80. Shepherd
81. Simmons
82. Simon
83. Slater
84. Slowe
85. Smothers
86. Stanton
87. Stevens
88. Stoddert
89. Summer
90. Sylvan
91. Takoma
92. Thomas
93. Thomson
94. Truesdell
95. Tyler
96. Van Ness
97. Walker-Jones
98. Watkins
99. Webb
100. West
101. Wheatley
102. Whittier
103. Wilson
104. Woodridge
105. Young
106. Bancroft
107. Bruce
108. Bundy
109. Cleveland
110. Cooke, H.D.
111. Garrison
112. Grimke
113. Harrison
114. Meyer
115. Monroe
116. Montgomery
117. Morse
118. Park View
119. Raymond
120. Seaton
121. Tubman
122. Birney
123. Congress Hts. (+ Annex)
124. Draper
125. Green
126. McGogney (+ Annex)
127. Moten
128. Savoy
129. Turner
130. Adams
131. Morgan (+ Annex)

special subject teachers, special teachers of regular students, and counselors and librarians, divided by students enrolled in grades 1 through 6. Teacher salary data are projections for FY 1971 made as of 15 September 1970. Student enrollment data (and the teacher quantity data used to compute average teacher salary) are as of 22 October 1970. All expenditure data refer to District of Columbia appropriated funds only. Kindergarten children and special students were excluded from the analysis. There was insufficient time to do a separate analysis for these children, and their class sizes and average teacher salaries are so different from regular grade 1-6 students that merging them is inappropriate.

The overall unweighted range of variation in the three measures in table 1 appears striking.[7] In TTEPP the highest school (38 = Jackson) received about 2.5 times more than the lowest school (128 = Moten). In terms of the two components of this variation, the relative variation in total teachers per pupil appears much the larger.

How much of this variation in TTEPP (or alternatively in its two components) represents quality of schooling variation? This of course is the $64 question, and we must approach it gradually. Table 2 presents a components of variation analysis that suggests the kinds of evidence needed to answer the big question.

The three main rows of table 2 (1, 2 and 3) give the weighted means of the three variables in table 1. Three measures of dispersion in

[7] This results partly from having no "benchmark" against which to evaluate this dispersion. Any large centralized system tends to exhibit in any year some amount of dispersion in resource allocation among its component units. Comparative system studies are clearly needed.

TABLE 2

TOTAL TEACHER EXPENDITURES PER PUPIL (TTEPP) AND COMPONENTS;

ANALYSIS OF VARIATION ACROSS ALL 102 SCHOOLS

1.	Mean TTEPP	$576.09
1A.	Standard deviation	$105.91
1B.	Standard deviation of the log of TTEPP	0.182
1C.	Variance of the log of TTEPP	0.033
2.	Mean Average Teacher Salary (ATS)	$11,156.51
2A.	Standard deviation	$1,033.73
2B.	Standard deviation of the log of ATS	0.095
2C.	Variance of the log of ATS	0.009
2A1.	Mean % of teachers with < 6 years exp.	39.1
2A2.	Standard deviation	12.3
2A3.	Mean % of teachers with ≥ 17 years exp.	18.6
2A4.	Standard deviation	9.8
3.	Mean Total Teachers per Pupil (TTPP)	(19.36)* 0.0516
3A.	Standard deviation	(2.65) 0.0072
3B.	Standard deviation of the log of TTPP	0.136
3C.	Variance of the log of TTPP	0.018
3A1.	Classroom teachers per pupil	(26.0) 0.0384
3A2.	Standard deviation	(2.43) 0.0036
3A3.	Special teachers per pupil	(100.7) 0.0099
3A4.	Standard deviation	(38.3) 0.0037
3A5.	Counselors and Librarians per pupil	(304.9) 0.0033
3A6.	Standard deviation	(102.2) 0.0011

*Numbers in parenthesis refer to means and standard deviations of pupils per teacher, the inverse of teachers per pupil.

each of these variables are then given (rows 1A, 1B, 1C. 2A, 2B, etc.). Finally, both average teacher salary and total teachers per pupil are themselves decomposed into measures of resources that we think are more closely related to quality of schooling. Additional details of table 2 are discussed later in the text.

What fraction of the total variation in TTEPP is due to variation in total teachers per pupil? In average teacher salary? A fairly rigorous answer can be given if we first shift to the logarithms of the variables. We can write for each school the identity:

TTEPP = ATS x TTPP,

where: ATS = average teacher salary, and

TTPP = total teachers per pupil.

Taking logarithms of each side, we have:

$$\log(TTEPP) = \log(ATS) + \log(TTPP) \quad .$$

Thus, in terms of the logs of the variables, TTEPP is a sum rather than a product of ATS and TTPP.

There is a well known statistical formula that relates the square of the standard deviation (called the "variance") of a variable to its additive components, as:

$$V(Z) = V(X) + V(Y) + 2\rho_{XY} SD_X \cdot SD_Y,$$

where ρ_{XY} = product moment correlation coefficient between X and Y

From this formula and the information in table 2, we can estimate that about 28 percent of the variation in the log of TTEPP is attributable to log ATS, 55 percent to the log of TTPP, and 17 percent to the

positive correlation between these two components across the 131 schools. Thus, we can say that TTPP is about twice as important as ATS in causing variation in TTEPP among schools in the D.C. system.

Having looked at the relative importance of total teachers per pupil and average teacher salary in influencing variation in TTEPP, we can now turn to examine the relationship between variation in these components and variation in the quality of schooling received.

First, consider average teacher salary, and the question of how much of the variation in this component represents variation in quality of schooling. We have tabulated for each D.C. school the percent of its total teachers who had less than 6 years of total teaching experience and the percent who had 17 or more years of total teaching experience. The means and standard deviations of these variables are presented in rows 2A1 through 2A4 of table 2.[8]

As we will document in section IV, what little empirical evidence is available does suggest that gains in teacher productivity attritutable to experience probably end sometime before the longevity steps end in the D.C. pay table. Based more on an intuitive hunch than empirical results, six years was selected as that amount of experience beyond which productivity increments with additional experience contributes nothing to productivity. This hypothesis implies that only that portion

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[8] We have ignored teacher degree-status variation in our analysis here because it turned out that variation in teacher experience plus the high correlation between experience and degree status explained practically all of the variation in ATS. Thus, independent variation in teacher degree status does not play a significant role.

of the variation in average teacher salary associated with variation in the percent of teachers with less than 6 years experience (let us symbolize this by $p^t < 6$) represents variation in real teacher quality

The simple product moment correlation coefficient between average teacher salary and $p^t < 6$ across all 131 schools is .459. The square of this value (called the coefficient of determination), is .210, and is the fraction of the variance in average teacher salary accounted for by variation in $p^t < 6$. Thus, by this analysis as much as 80 percent of the variation in average teacher salary (or approximately 26 percent of the variation in TTEPP) may have no effect on quality. However, the reader should hold back judgment on this finding until reading section IV.

Next let us turn to the total teachers per pupil (TTPP) concept and with our query about quality variation.

We have tabulated the three components of total teachers per pupil: classroom teachers per pupil, special subject plus other special teachers per pupil, and counselors plus librarians per pupil for each of the 131 schools. Rows 3A1 - 3A6 of table 2 give weighted means and standard deviations of each of these variables.

Since total teachers per pupil is itself a sum of these three components, we can apply our variance decomposition technique directly to these variables. If we square the relevant standard deviations in table 2 we estimate that 25 percent of the variation in total teachers per pupil is due to classroom teachers, 26.4 percent to special teachers, 2.4 percent to counselors-plus-librarians, and 46.3 percent to the joint positive correlation between the three components across schools.

Thus a finding of immediate interest[9] is that variation in special teachers per pupil is just as important as variation in classroom teachers in accounting for variation intotal teachers per pupil.

The figures in parentheses in the various rows of table 2 give the weighted means and standard deviations of the inverses of the measures described. Thus, for example, the figure 26.0 in Row 3A1 is the average number of pupils per class teacher. These turn out to be better for thinking about the ranges of variation that will influence the quality of schooling received.

Recalling the above mentioned property of the standard deviation, we can say that about two-thirds of the children in D.C. elementary schools are in classes with between 28.4 and 24.4 pupils, and practically all of the children are in classes within the range 31.2 to 22.0[10] This then is the heart of the issue: does it make a difference in the quality of instruction whether class size varies within this range? The findings presented in section IV suggest that this range of variation does not. However, reasonable men can differ in their interpretation of the evidence, and judgment should be withheld pending reading of section IV.

We turn now to variation is special teachers per pupil. Here, some striking empirical results on the degree of correlation between special teachers per pupil and enrollment, combined with some plausible a priori notions, strongly suggest that this variation is in fact attributable to efficiency in the utilization of special teachers time in larger schools.

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[9]This point had heretofore been submerged, in that only aggregate pupil teacher ratio analysis had been presented in the case.

[10]It should be noted that even the highest D.C. pupil-classroom teacher ratios appear to be quite moderate when compared to other large city school systems. Data from the office of Education show that the average ratio in the 15 largest school systems is 29.6.

Charts 1, 2, and 3 show scatter plots of the three component[11] teacher ratios against enrollment. The (X) symbols are schools east of the Park, the (0) symbols west.

Clearly the special teachers per pupil variable is much more closely correlated with school size than either classroom teachers or counselors plus-librarians. In addition the fact that special teachers in small schools tend to divide their time among several small schools provides the basis for an economy of scale model. This would provide an explanation for the observed tight correlation between special teachers per pupil and school size. It may well be (but this would require an intensive study of its own to verify) that a special teacher's travel time between schools is such that students in large schools receive just as much <u>classroom time</u> per special teacher as students in small schools do.

B. <u>Schools Grouped by Socio-Economic Variables</u>

Much of the animus behond the charges levied against the D.C. school system stems from the feeling that not only does the quality of schools vary significantly in the system but that it also tends to vary in a discriminatory way: worse for the black and poor, better for the white and rich. Indeed, much of the emotion in the case surrounds the expenditure differentials that appear when the schools are grouped in one particular way in order to reflect variation by socio-economic status; viz., schools east and west of Rock Creek Park.[12]

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[11] This refers to Rock Creek Park, which cuts through the District of Columbia. See note 12 below.

[12] Of the 131 schools in Washington, D.C., 13 are located in the predominantly white high-income neighborhoods west of Rock Creek Park. These schools have only 4% of the total D.C. elementary enrollment, but they also have 60% of all the non-Negro children in the system.

CHART 1

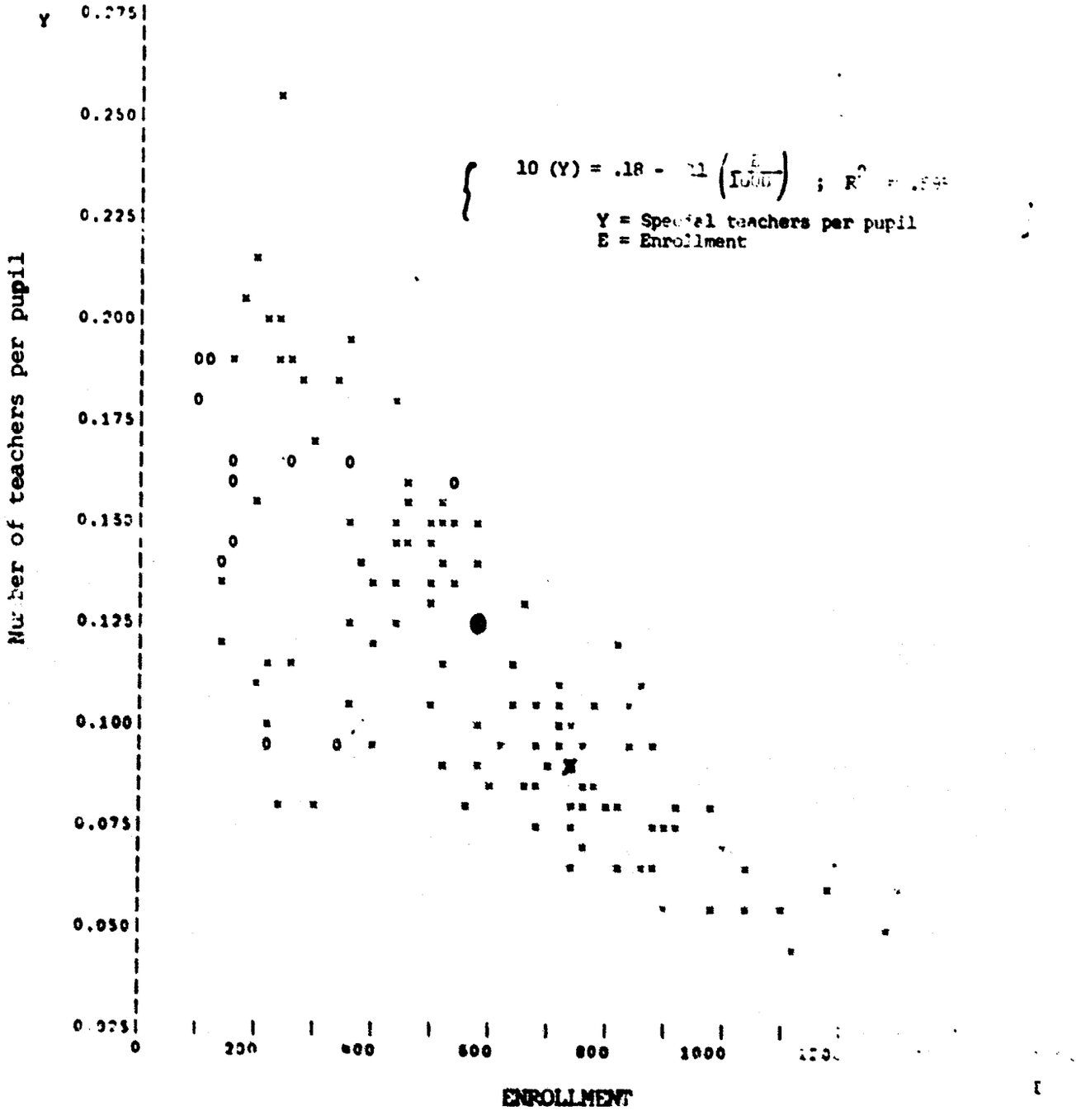
CLASSROOM TEACHERS PER PUPIL

(X) = East of Park
(O) = West of Park

CHART 2

SPECIAL TEACHERS PER PUPIL

(X) = East of Park
(O) = West of Park

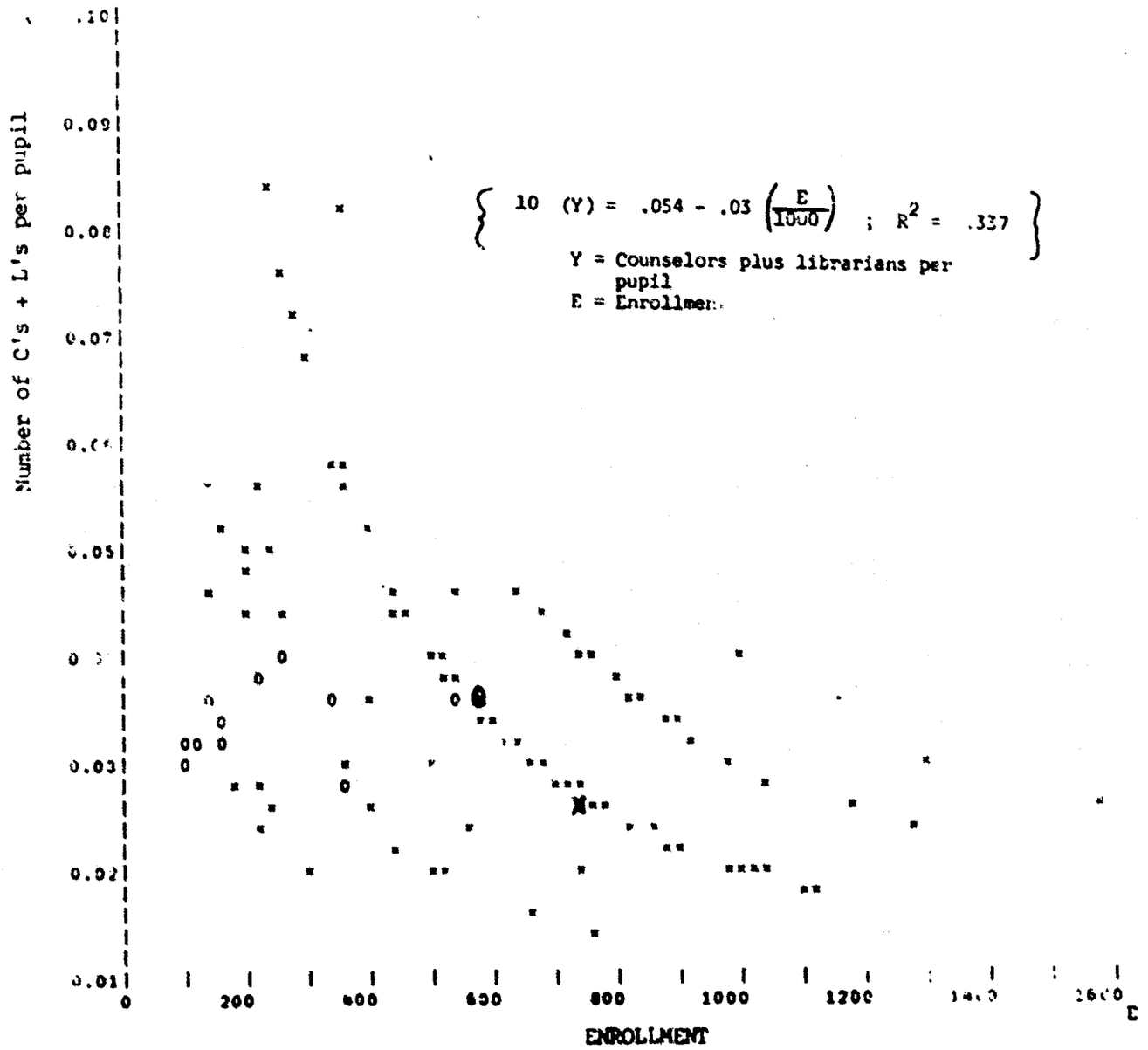


$$\begin{cases} 10\,(Y) = .18 - .21\left(\frac{E}{1000}\right) ; \; R^2 = .\text{[illegible]} \\ Y = \text{Special teachers per pupil} \\ E = \text{Enrollment} \end{cases}$$

CHART 3

COUNSELORS-PLUS-LIBRARIANS PER PUPIL

(X) = East of Park
(O) = West of Park



We will subject this grouping first to our components of variation analysis. However, there are other and perhaps more relevant ways that the schools and students can be grouped in order to study discriminatory variation by socio-economic status: all Negro students in the system vs. all non-Negro students; all needy lunch children in the system vs. all non-needy lunch children; schools east of the Park grouped by percent needy lunch quartile and by income quartile; schools west of the Park grouped by percent Negro. We will therefore consider each of these in turn.

(1) Schools East and West of Rock Creek Park.

The schools were divided into two groups: the 13 schools west of Rock Creek Park, and the 118 schools east of Rock Creek Park. Weighted (by school enrollment) TTEPP and the component measure values were computed for these two groupings. Results are shown in table 3.

Using procedures much simpler but analagous to what we did for all schools, we can decompose the observed $128.19 differential into the following components:

$55.43 due to average teacher salary differential

$62.19 due to total teachers per pupil differential

$10.57 due to interaction between component differentials.

A closer look at the anatomy of the $62.19 differential due to total teachers shows that fully $49.64 of it is due to a differential in special teachers per pupil and only $12.55 is due to the tiny classroom teachers differential. Thus, if one accepts the argument that special teachers per pupil variation is primarily due to true economies of scale, then it would appear that, as between sides of the Park, significant differentials in the quality of schooling do not emanate from the observed total teacher per pupil differential.

TABLE 3

TTEPP AND COMPONENTS;

SCHOOLS EAST AND WEST OF ROCK CREEK PARK

	East of the park	West of the park
Mean total teacher expenditure per pupil	$570.83	$699.02
Mean average teacher salary	$11,104.83	$12,183.33
% teachers with < 6 yrs. exp.	39.6	31.7
% teachers with ≥ 17 yrs. exp.	17.8	32.8
Mean total teachers/pupil	.0514	.057
Classroom teachers/pupil	.0384	.0394
Special teachers/pupil	.0098	.014
Counselors-plus-librarians/pupil	.003	.003
Pupils/all teachers	19.45	17.42
Pupils/classroom teacher	26.07	25.40
Pupils/special teachers	102.46	68.67
Pupils/counselors-plus-librarians	304.89	290.90

What can be said about the $55.83 part due to the average teacher salary differential? Our calculations indicate that the major difference in experience mix is not primarily with regard to the very young, inexperienced teachers--those with less than six years' experience--but with regard to teachers with very much longevity--17 years or more. These super-longevity teachers get paid much higher average salaries than teachers with between 6 and 16 years of experience, and they may not be any more productive. If that is the case, then only a small part of the average teacher salary differential between sides of the Park reflects a quality of schooling differential.

(2) Negro Children vs. Non-Negro Children.

Data on the numbers of Negro and non-Negro children in each of the 131 schools were obtained. These were used as weights to calculate our TTEPP and component figures for all Negro students in the D. C. system and then for all non-Negro students. Our procedure assumes that children of both races within a given school receive the same allocation of school resources.

The resulting calculations appear in table 4. Since it is well known that almost all the white children in the D. C. school system go to schools west of the Park, a particularly interesting finding is that the overall color difference in TTEPP is smaller than the Rock Creek Park differential (table 3). This reflects the fact that when schools west of the Park are grouped by percent Negro enrollment and the weighted averages of TTEPP are computed, a definite positive correlation between TTEPP and percent Negro shows up. This is shown in table 5. Thus west of the Park there is no evidence, even in terms of TTEPP, that quality of schooling varies in a discriminatory way by color.

TABLE 4

TTEPP AND COMPONENTS;
ALL NEGRO STUDENTS AND ALL NON-NEGRO STUDENTS

	All Negro students	All non-Negro students
Mean total teacher expenditure per pupil	$572.54	$640.08
Mean average teacher salary	$11,098.02	$11,629.74
% teachers with < 6 yrs. exp.	39.63	35.01
% teachers with > 17 yrs. exp.	18.01	27.41
Mean total teachers/pupil	.051	.055
Classroom teachers/pupil	.038	.038
Special teachers/pupil	.010	.013
Counselors-+-librarians/pupil	.003	.003
Pupils/all teachers	19.79	18.54
Pupils/classroom teacher	26.25	26.28
Pupils/special teachers	116.65	89.88
Pupils/counselors-+-librarians	340.95	308.37

(3) Needy Lunch Children vs., Non-Needy Lunch Children.

Using the same procedures as with the comparison of all Negro with all non-Negro, corresponding estimates were made for all needy lunch and all non-needy lunch children in the D.C. system. Table 6 contains the results.

An insignificant differential in TTEPP ($8) emerges in favor of needy lunch children as opposed to non-needy lunch children. This is not surprising, given the fact that TTEPP both east and west of the Park tends to rise as indices of socio-economic status fall (see tables 5, 7 and 8). This effect, on balance, tends to swamp any influence of the Rock Creek Park differential in TTEPP, since so few students are enrolled west as opposed to east of the Park.

Summary

Perhaps the main message of the foregoing material is that one is hard put to find any significant evidence of discriminatory variation in the quality of schooling.

When the schools are grouped east and west of the Park a significant differential in TTEPP does emerge. However, our components of variation analysis strongly suggests that little of this east-west differential in TTEPP is likely to reflect quality of schooling differentials.

Moreover, because of the lopsided distribution of the system between west and east of the Park, concentration on this highly symbolic grouping has obscured the fact that variation in TTEPP throughout the major part of the system is, if anything, reverse discriminatory in pattern.

However, there may be significant variation throughout the system generally in the quality of schooling received. As we have shown above, this all depends on the precise range of values of educational input variables (like teacher experience and class size) that affects schooling quality. We now turn to an examination of evidence on these issues.

TABLE 5

TTEPP AND COMPONENTS: SCHOOLS WEST OF ROCK CREEK PARK
GROUPED BY PERCENT NEGRO ENROLLMENT QUARTILES[13]

	Schools with % Negro of:			
	52.7 - 93.9	26.1 - 31.8	17.5 - 25.1	6.3 - 10.[illegible]
Mean total teacher expenditure per pupil	866.28	711.26	666.81	655.15
Mean average teacher salary	12,087.05	12,596.73	11,989.81	12,200.30
% teachers with < 6 yrs. exp.	45.4	33.3	25.9	28.8
% teachers with > 17 yrs. exp.	21.2	43.6	29.6	36.4
Mean total teachers/pupil	.0717	.0565	.0556	.0537
Classroom teachers/pupil	.0507	.0399	.0381	.0358
Special teachers/pupil	.0177	.0131	.0141	.0143
Counselors-+-librarians/pupil	.0032	.0034	.0034	.0036
Pupils/all teachers	13.95	17.71	17.98	18.62
Pupils/classroom teacher	19.71	25.05	26.22	27.93
Pupils/special teachers	56.31	76.23	70.98	69.83
Pupils/counselors-+-librarians	315.33	292.22	295.00	279.33

[13] Quartile values divide the distribution into approximately four equal parts. Thus since there are 13 schools west of the park there are 3 or 4 schools in each grouping.

TABLE 6

TTEPP AND COMPONENTS; ALL NEEDY LUNCH CHILDREN
AND ALL NON-NEEDY LUNCH CHILDREN

	All needy lunch children	All non-needy lunch children
Mean total teacher expenditure per pupil	$581.06	$573.10
Mean average teacher salary	$11,002.76	$11,200.56
% teachers with < 6 yrs. exp.	40.33	38.81
% teachers with > 17 yrs. exp.	17.01	19.41
Mean total teachers/pupil	.053	.051
Classroom teachers/pupil	.039	.038
Special teachers/pupil	.010	.010
Counselors+librarians/pupil	.003	.003
Pupils/all teachers	19.37	19.94
Pupils/classroom teacher	25.90	26.15
Pupils/special teachers	110.55	118.09
Pupils/counselors++librarians	338.88	339.45

TABLE 7

TTEPP AND COMPONENTS; SCHOOLS EAST OF THE PARK GROUPED BY PERCENT NEEDY LUNCH QUARTILES

	Schools with % needy lunch Children of:			
	60.7 - 99.5%	46.1 - 60.5%	24.7 - 45.0%	0.0 - 24.6%
Mean total teacher expenditure per pupil	598.08	583.32	548.76	566.18
Mean average teacher salary	$11,014.76	$10,924.78	$11,081.90	$11,353.42
% Teachers with < 6 yrs. exp.	39.8	39.2	43.6	35.1
% Teachers with ≥ 17 yrs. exp.	16.5	16.8	16.8	20.9
Mean total teachers/pupil	.0543	.0534	.0495	.0499
Classroom teachers/pupil	.0395	.0393	.0380	.0372
Special teachers/pupil	.0113	.0105	.0085	.0094
Counselors++-librarians/pupil	.0034	.0035	.003	.0032
Pupils/all teachers	18.42	18.73	20.19	20.05
Pupils/classroom teacher	25.30	25.45	26.30	26.89
Pupils/special teachers	88.37	94.70	117.78	105.97
Pupils/counselors++-librarians	289.63	281.80	331.92	308.69

TABLE 8

TTEPP AND COMPONENTS;

SCHOOLS EAST OF ROCK CREEK PARK

GROUPED BY ADJUSTED MEDIAN INCOME QUARTILES

	Schools with Adjusted Median Incomes of:			
	(Lowest) (2900 - 4450)	(4450 - 4975)	(4975 - 6000)	(Highest) (6000 - 13,17[illegible])
Mean total teacher expenditure per pupil	$ 595.44	$ 606.44	$ 536.00	$ 562.[illegible]
Mean average teacher salary	10,786.92	11,349.78	10,961.40	11,27[illegible].02
% Of teachers with < 6 yrs. experience	42.7	39.9	42.3	36.5
% Of teachers with ≥ 17 yrs. experience	15.3	19.3	14.9	21.5
Mean total teachers/pupil	.0552	.0534	.0489	.049[illegible]
Classroom teachers/pupil	.0401	.0389	.0377	.037[illegible]
Special Teachers/pupil	.0115	.0109	.0082	.00[illegible]
Counselors-plus-librarians/ Pupil	.0036	.0036	.0030	.003[illegible]
Pupils/all teachers	18.11	18.71	20.45	20[illegible]
Pupils/classroom teacher	24.93	25.69	26.49	26[illegible]
Pupils/special teachers	86.78	91.81	122.25	1[illegible]
Pupils/counselors-plus-librarians	279.78	276.84	335.91	[illegible]

IV. Evidence on Resource - Quality of Schooling Relations

A. Existing Evidence

As we have shown above, variation in experience mix, class size, and special teachers per pupil accounts for the variation in per pupil teacher expenditure among schools. We will first turn our attention to the relationship between teacher experience and cognitive achievement.

1. Teacher Experience. A priori, one might wonder how experience can fail to lead to more effective teacher performance, at least up to a point. It is important to recognize, however, that while individual teachers may improve with time, there may yet be no aggregate relationship between teacher quality and experience.

There are two possible reasons for this. First, new teachers may be better educated than old teachers were when they entered the system, due, perhaps, to the decline of teachers' colleges or to an upgrading of college education generally. If new teachers get 2% better each year and old teachers become 2% more effective every year due to experience, there will be no apparent relationship between experience and teacher quality.

Second, the best teachers may drop out after a few years. Speaking of new entrants into the teaching profession, Levin says, "... it appears that many of the most highly endowed of these individuals leave the schools within three years."[14] If this is true, new teachers' higher average ability may compensate for the improvement due to experience of the quality of teachers who stay more than three years. In this case there need be no aggregate association between teachers' experience and student performance.

[14] Levin, Henry M., "A Cost-Effectiveness Analysis of Teacher Selection," in The Journal of Human Resources, Winter, 1970, p. 33.

It is highly likely, however, that the relationship between quality and experience is of the type illustrated in figure 1, rising for the first few years of teacher service and then levelling out. Unfortunately, most of the papers we have seen attempt to approximate this "learning" curve by a straight line. In the event the productivity-experience profile is like that in figure 1, the linear approximation will bias the result toward insignificance.

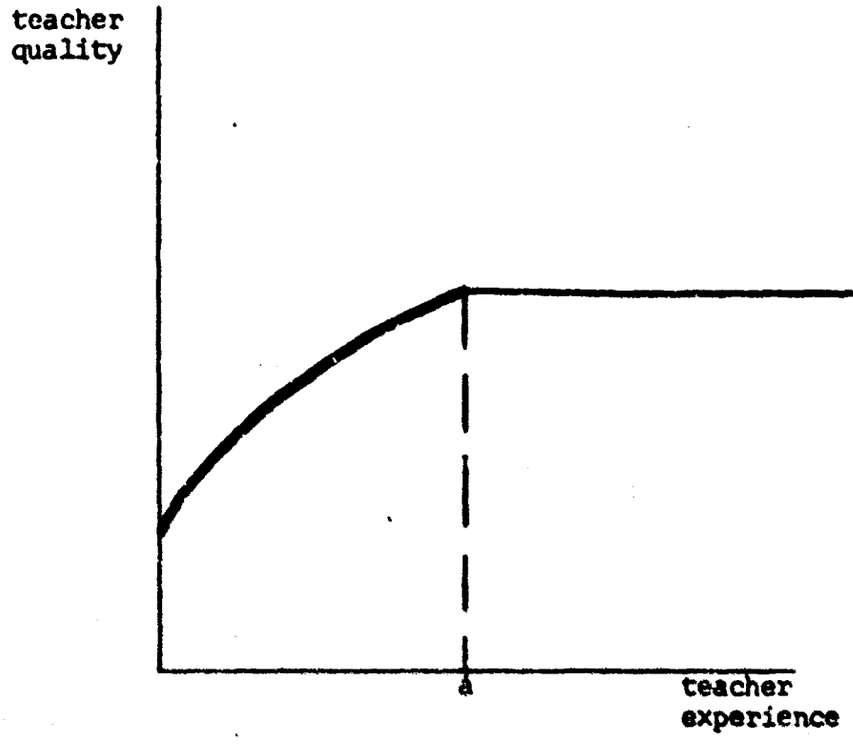


Fig. 1

Both Levin and Michelson, who found a positive impact of experience on output, seem to have used imposed linear forms.[15,16]

[15] Michelson, Shephan, "The Association of Teacher Resources with Children's Characteristics," in Do Teachers Make a Difference? U.S. Department of Health, Education, and Welfare, Office of Education, Bureau of Educational Personnel Development, p. 144.

[16] Levin, Henry M., "A New Model of School Effectiveness," in Do Teachers Make a Difference? U.S. Department of Health, Education, and Welfare, Office of Education, Bureau of Educational Personnel Development, 1970. He does not specify what precise form he uses, but it is probably either linear or log-linear. The criticism in the text is equally valid in either case.

Katzman, in his finding of a positive relationship between experience and achievement, used a slightly different form.[17] He describes the experience mix of teachers in a school by the percent of teachers with less than ten years of experience. He finds that a larger percentage of teachers with less than ten years of experience yields lower productivity. This tells us very little about the continuous relationship between output and experience described in figure 1 and thus suffers from the same flaw as the linear assumption mentioned previously. It is however, a step in the right direction, since this percentile approach will be more sensitive (have a higher correlation) to experience effects if in fact the underlying relation is as depicted in figure 1.

A large number of other studies that we reviewed tended to show that there was no necessary connection, ceteris paribus, between teacher experience and pupil achievement.[18,19,20,21,22,23] This finding strongly

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[17] Katzman, Martin T., "Distribution and Production in a Big City Elementary School System," in Yale Economic Essays, Yale University Press, New Haven, Connecticut, Spring 1968, p. 212

[18] Plowden, Bridget, Children and their Primary Schools, A Report of the Central Advisory Council for Education (England), Her Majesty's Stationary Office, London, 1967, volume 2, p. 215.

[19] Guthrie, James W., Kleindorfer, George B., Levin, Henry M., and Stout, Robert T., Schools and Inequality, The Urban Coalition, p. 275.

[20] Mayeske, George W. et al, A Study of Our Nation's Schools, U.S. Department of Health, Education, and Welfare, Office of Education, 1970, pp. 275-329.

[21] Hanushek, Eric, "The Production of Education, Teacher Quality, and Efficiency," in Do Teachers Make a Difference? U.S. Department of Health, Education, and Welfare, Office of Education, Bureau of Educational Personnel Development, 1970, p. 90.

[22] Hanushek, Eric, "Teacher Characteristics and Gains in Student Achievement: Estimation Using Micro-Data," paper presented at the American Economics Association meetings, December 1970, as yet unpublished, ~~will~~ appear in the American Economic Review Papers and Proceedings, May 1971, pp. 11, 15.

[23] Burkhead, Jesse, Input and Output in Large City High Schools, Syracuse University Press, Syracuse, New York, 1967, pp. 49-56, 81-84.

supported the School Board's position in Hobson v. Hansen, but we found it hard to believe. The statistical techniques used often biased the results in this direction and never shed light on the issue we cared about: the point where the learning curve (figure 1) flattens out. In addition, the variation in findings in studies of different school systems strengthened the belief that the best way to learn about the shape of the experience-productivity profile in the Washington schools was to study the determinants of student achievement in the Washington schools.

2. Pupil teacher ratios. Do variations in class sizes within the ranges we have documented contribute to quality of schooling variation? Many studies find they do not. Welch and the Plowden Report report a positive relationship between class size and performance.[24,25] Katzman concurs in this finding, though he finds that crowding has a negative impact on performance.[26] Welch finds what appears to be a significant negative relationship between numbers of staff per 100 pupils and the monetary returns to one unit of schooling. Plowden notes, "...(We) found, as other inquiries have done, an association between better work and larger classes..." The report qualified this by asserting that there were invariably other favorable circumstances associated with the larger classes to account for their superiority.[27]

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[24] Welch, Finis, "Measurement of the Quality of Schooling," in the American Economic Review, Paper and Proceedings, May 1966, p. 390.

[25] Plowden, Primary Schools, p. 181.

[26] Katzman, Big City School, p. 220.

[27] Plowden, Primary Schools, p. 181.

Burkhead finds no significant impact of class size on performance in Atlanta.[28] Raymond found that the student-teacher ratio bears absolutely no relationship to pupil achievement in West Virginia.[29] Levin says that "no rigorous study has shown a consistent relation between class size and achievement within the ranges of class size under consideration."[30] He also cites evidence that even drastic reductions in class size and student-teacher ratios show little effect on standardized achievement scores.[31]

Thus, the existing evidence is, at best, inconclusive on both the issue of where the "cut-off point" on the experience learning-curve comes and on just what ranges of class size variation influence quality of instruction.

B. An Analysis of D.C. Test Score Data

In September 1970 a reading achievement test was given to all 6th grade students. A multiple regression analysis of the across-school variation in these scores was performed in an attempt to add to our knowledge in this area. The following variables were included in the analysis:

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[28]Burkhead, Jesse, op. cit., pp. 69-72. He concludes that the ratio of faculty to students is of some significance in explaining tenth grade verbal scores, but this is not clear in his empirical section.

[29]Raymond, Richard, "Determinants of the Quality of Primary and Secondary Public Education in West Virginia," in The Journal of Human Resources, Volume III, Number 4, Fall 1968, p. 460.

[30]Levin, Henry M., "A Cost-Effectiveness Analysis of Teacher Selection," in the Journal of Human Resources, Winter, 1970, p. 27, see footnote 5.

[31]Fox, David J., "Expansion of the More Effective School Program," Evaluation of New York City Title I Educational Projects 1966-67, Center for Urban Education, New York, 1967, pp. 32-44.

Y = median 6th grade reading achievement test score

X_1 = percent of needy lunch children in total school enrollment

X_2 = median 2nd grade reading achievement test score

X_3 = other than regular D.C. expenditures per pupil

X_4 = ratio of all teachers to pupils

X_5 = a degree mix index

X_6 = number of pupils

X_7 = percent of teachers with less than 6 years experience

X_8 = percent of teachers with 7-10 years experience

X_9 = percent of teachers with 11-16 years experience

X_{10} = index of teacher inputs

X_{11} = number of teachers new to the school

X_{12} = teacher expenditure per pupil

X_{10}, the index of teacher inputs, is calculated along the lines suggested by our discussion in the previous section. An experience-productivity profile, f, is hypothesized; each teacher is weighted by the productivity gain assumed for his experience class; and the average of this experience input is calculated for each school. Analytically,

$$X_{10} = \frac{\Sigma_e f_e x_e}{\Sigma_e x_e} ,$$

where x_e is the number of teachers in an experience class and f_e is the assumed relative productivity of that experience class. We have divided teachers into twenty experience classes: 0, 1, 2, to 16 in 1 year increments, 17-20 years, 21-25 years, and 26 and

more years of experience. F is a vector which describes an assumed productivity profile. If Z is a column vector of the fraction of a school's teachers in each experience class, $X_{10} = FZ$ $F = (f_1, f_2, f_3 \cdots\cdots f_{20})$. We have used a number of different F's and compared their success in yielding X_{10}'s which explained variation in Y.

We hoped that variable X_1 would provide a control for variation in student input variables (I.Q., family environment, etc.). This is undoubtedly a very crude approach, and our results should be viewed accordingly. The analysis was restricted to schools east of Rock Creek Park. We did this in order to minimize the amount of intercorrelation between student input variables and our school input variables.

Second grade reading score, X_2, contemporaneous with our dependent variable, was used as a further indicator of the socio-economic status of the children in each school.

We use reading scores as the measure of educational output. The criticism may be raised that this is wrong or simplistic. Perhaps a number of outputs, including such things as student behavior and student attitudes, would be a more complete description of the output of the educational process. However, much of the work done on educational production functions (e.g., Hanushek, Burkhead, Plowden, Raymond, Katzman, and the California State Senate study[32]) presents single equation models that use cognitive variables, such as reading scores, as the educational output variable. The results of those researchers who

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[32] Senate Fact Finding Committee on Revenue and Taxation, "State and Local Fiscal Relationships in Public Education in California," Senate of the State of California, March 1965.

simultaneously estimated the production of cognitive and non-cognitive output variables were not notably different from single equation estimates arrived at by the same people with respect to the impact of school-related determinants of cognitive output.[33] Thus we feel justified in using single equation techniques in this case. Besides, we have no data on non-cognitive outputs. We recognize, however, the possible theoretical advantages of simultaneous estimation.

We were not able to use a measure of teacher verbal ability as an independent variable in our regressions, because we did not have the requisite data. Many people have found this to be a significant variable in explaining pupil achievement. For our purposes, however, the omission is probably desirable. We were not interested in estimating a "pure" experience effect, i.e., the effect of experience on the productivity of an individual teacher. Rather we wanted to measure the relationship at a point in time between the productivity of teachers with more experience and teachers with less experience. If teacher verbal ability is correlated with experience, as it may well be, inclusion of verbal ability in the regression would mask the contemporaneous relationship between experience and productivity.

We were interested in testing the hypothesis that teacher experience stopped yielding productivity gains after relatively few years against the hypothesis that teacher salaries accurately reflected teacher productivity.

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[33] See the articles by Levin and Michelson in Do Teachers Make a Difference?, op. cit.

To determine the explanatory significance of the teacher salary hypothesis, we ran a regression of the form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_5 + \beta_5 X_6 + \beta_6 X_{11} + \beta_7 X_{12}$$

The variable X_{11}, teachers new to the building, was included to test the hypothesis that it takes a while for a teacher to get used to a new school building assignment:

Variable	Coefficient	t-value
Constant	1.01	
X_1	-1.5×10^{-2}	-4.90
X_2	5.3×10^{-1}	3.92
X_3	-1.47×10^{-4}	-1.47
X_5	3.79×10^{-4}	1.16
X_6	2.23×10^{-5}	.09
X_{11}	-1.9×10^{-2}	-1.25
X_{12}	-3.62×10^{-5}	-0.06

Only the socio-economic variables were found to be important in this formulation. The non-D.C. expenditure variable has the wrong sign, indicating that it is negatively correlated with student status, and that the money is being spent in a compensatory fashion. Teacher experditure per pupil, holding degree mix constant, was notable for its lack of significance.

We neglected to include teacher/pupil ratio in this equation, and thus X_{12} is measuring the influence of the number of teachers as well as the effect of teacher salary. Unfortunately, we did not have time to include X_4 in this regression, but since X_4 did

not prove to be significant in any regression in which it was included, we feel that the t-value of X_{12} is a suitable test of the teacher salary hypothesis.

To test the contention that experience aids productivity for a limited number of years, we ran regressions of the form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_{11} + \beta_8 X_{12}$$

or $$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_{11} + \beta_8 F.$$

where we imposed F's of the form illustrated in figure 2.

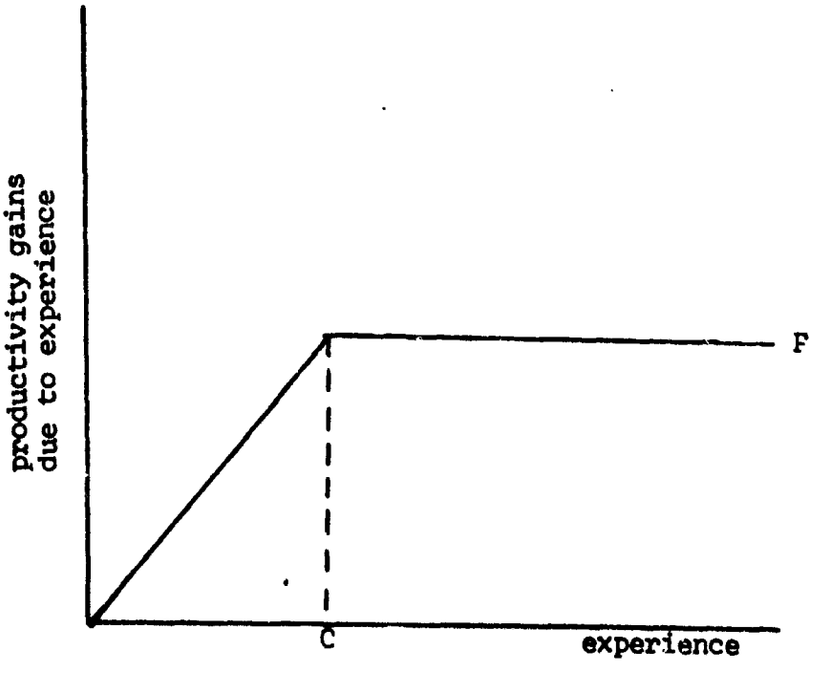

FIG. 2:

The value of C , the cutoff point at which experience ceased to yield returns, was varied from regression to regression. Once again we found the socio-economic variables to be important. Teacher/pupil ratios, degree mix, school size, and number of new teachers did not have significant coefficients. Our findings with respect to teacher experience follow.

C	t-value of coeff. of X_{10}	R^2 of Regression Equation
5	-1.38	.6492
6	2.14	.6592
7	2.19	.6600
8	2.17	.6596
9	2.05	.6578
10	1.96	.6565

Thus it would seem that there is support for the hypothesis that a cutoff point on the learning curve comes in the neighborhood of 6 to 8 years of experience exists.

Some confirmation of this was gained via a regression of the form:

$$Y = B_o + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 +$$

$$+ B_7X_{11} + B_8X_7 + B_9X_8 + B_{10}X_9$$

B_8, B_9, and B_{10} are designed to measure whether teachers in the experience classes delineated by X_7, X_8, and X_9 are significantly different in productivity than teachers with more than 16 years of experience. We found

Variable	Coefficient	t-value
X_7	-7.3×10^{-1}	-2.08
X_8	2.4×10^{-1}	0.38
X_9	-4.6×10^{-1}	-0.82

Only the teachers with 0-6 years of experience were found to be significantly less productive than those with 17 and more years of experience. The counter-intuitive sign of the coefficient of X_8 combined with its low t-ratio strengthens the belief that it should be taken as zero.

It seems then, that there is a case to be made that experience ceases to matter after 6 or 7 years and that, if anything should be equalized to move toward equal educational opportunity, it is the percent of teachers with less than 6 years of experience, not per pupil expenditures on teachers.

We tend to take this conclusion with a grain of salt, however. First, one must be wary in drawing conclusions from a variation in t-values between 1.96 and 2.14. Second, the regression which embodies the percent of teachers in various experience classes cannot be said to strongly support an assertion more sweeping than: teachers with zero to 6 years of experience are more inferior to teachers with more than 16 years of experience than any other experience group. This would be true even if experience contributed to productivity up to 16 years. Third, we experimented with regression forms that were designed to discriminate among experience-productivity profiles that approached an asymptote with varying degrees of rapidity. We found that the slower the asymptote was approached, the better the R^2. We can think of 3 possible reasons for this. 1) experience really does continue to matter for a long time; 2) experience does not matter at all (the limiting case of those used in this formulation was a flat line incorporating no productivity increases); and 3) since our observational units were schools, and most of the teachers are in the under-10 years of experience

category, with only 14 percent having more than 16 years of experience, we were discriminating among schools with differing proportions of their teachers in different experience classes under 10 years.

We do not feel that our data is strong enough to distinguish among these possibilities. We are tentatively willing to say that experience stops adding to productivity after 6-8 years and that pay increases overstate productivity gains after that point. These findings are consistent with the hypothesis used in section II to decompose the variation in average teacher salary into quality and non-quality components. However, we think that the tests we used would be more enlightening if applied to class-wide data and if the distribution of teacher experience in the sample were more uniform.

IV. Summary and Concluding Comments

As we noted at the outset, the United States District Court for D.C. has held that with regard to individual public schools:

> "The minimum the Constitution will require and guarantee is that for their objectively measurable aspects these schools be run on the basis of real equality...."

The difficulty in implementing this dictum is in defining just which "objectively measurable aspects" to focus on.

The plaintiffs in the case and Judge Wright have focused on teacher expenditure per pupil as a relevant index to equalize.

We have shown, however, that observable variation in teacher expenditures per pupil within the D.C. school system greatly overstates the variation in those tangible educational inputs that produce variation in the quality of schooling received.

Consider first the major component of expenditure variation--total teachers per pupil. A decomposition of this factor into classroom vs. special teachers (i.e., special subject plus special teachers of regular students) revealed, surprisingly, that variation in special teachers per pupil was slightly more important than classroom teachers per pupil in accounting for the overall variation in total teachers per pupil.

It was shown that there is a very close (negative) correlation between the size of a school's enrollment and the ratio of special teachers to enrollment. This empirical relation, we argued, is likely to reflect true "untainted" economies of utilization with regard to special teachers' time in larger schools.

Our analysis also revealed that about 2/3 of the children in the D. C. system are in classes with pupil classroom teacher ratios of between 24.4 and 28.4. No empirical studies of school inputs could isolate any effect within this range of class size on educational quality.

Turning now to the other component of variation in TTEPP, average teacher salary, our major findings were: (1) only about 20% of the variation in average teacher salary is associated with variation in the percent of teachers with less than 6 years of experience, and (2) empirical data do suggest that teacher <u>productivity</u> increments with experience cease before longevity salary increments do. These two findings suggest that the majority of the variation in average teacher salary across schools is not associated with teacher quality variation.

Plaintiffs in the case also claim that the D.C. School Board has violated the court's permanent injunction against discrimination in the operation of the D.C. public school system.

We feel that we have demonstrated quite convincingly that with regard to discriminatory variation, the situation is best described as "much ado about nothing." As we have shown in table 4, the expenditure differential between all Negro pupils and all non-Negro pupils comes to $67.54. However, since Negroes comprise 95% of all students in the D.C. system, an equalization order would have the effect of raising expenditures on the average Negro student by only $3.39. Also we have shown that an equalization order would actually, on balance, transfer expenditures from needy lunch children to non-needy lunch children. (See Table 6).

One cannot help but sympathize with the objectives of the plantiffs in this case. However, these good intentions will be of no avail if they are implemented by methods that will in fact bring about the reverse of what was intended. This then is the great danger of imposing an expenditure equalization order: it has a high probability of doing nothing to improve the situation., a smaller but still significant probability of making the situation worse, and only a very small probability of improving the situation. On balance, prudence would appear to dictate a more selective approach.