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Authors

Stimson, David H.
Thompson, Ronald P.

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OPERATIONS RESEARCH
AND THE SCHOOL BUSING PROBLEM

by

David H. Stimson and Ronald P. Thompson

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ABSTRACT

Linear programming and other operations research techniques have been used to assist school administrators in desegregating their school districts by assigning students to schools to achieve racial balance and by designing school bus routes to effect the student assignment. An example of a way linear programming may be used to help achieve racial balance in schools is examined in some detail. Educational issues that lie behind the controversy over busing students are discussed in order to place the operations research techniques in a larger context. Viewed in this context suggestions are made about the changes needed in operations research studies to make them more useful to school administrators, planners, and policy makers.

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INTRODUCTION

It may seem surprising to find operations researchers with their computers in the midst of such a controversial issue as school busing. However, as operations researchers apply their techniques in the solution of social problems it is inevitable that they become involved in controversy. For this reason operations researchers not only need technical competence but also must have insight into the conflicting values that are at the heart of so many social problems.

Busing of school children out of their neighborhoods in order to achieve racial balance in public schools is an emotional and explosive issue. Newspaper stories and magazine articles reflect the tensions that the busing issue has aroused.[1] In cities throughout the United States arguments about busing, neighborhood schools, and desegregation often dominate the local political scene. The controversy surrounding busing has made it an important factor in state and national elections as well. The variety of judicial rulings, the complexity of the legal points raised, the political ambitions of elected officials at all levels of government, and the decision-making processes of local school boards have all contributed to the controversy over busing. Its racial and class components have made it one of the most divisive issues of the day.

One reason operations researchers have become involved in school busing is that linear programming and routing problems are important classes of problems studied in operations research. Hence, the assignment of students to schools to achieve racial balance may be viewed as an interesting variation of well-studied problems and an opportunity for application of well-developed techniques. Another reason for the presence of operations researchers is that many school administrators call upon them for assistance when they face court orders to desegregate their school districts. Since in most instances desegregation requires busing of school children, administrators find it convenient to turn to operations researchers for help in quickly checking the numerous plans for desegregation to determine the effect of each plan on the racial composition of the schools within their districts and to estimate the amount of busing required by each plan.

This paper is divided into four sections. The first is a brief summary of the operations research literature on the school busing problem. The second presents a hypothetical example of the use of linear programming to achieve racial balance in a school district. This example goes further than what is found in the operations research in that it includes the use of sensitivity analysis and the dual of the linear programming problem. Six linear programming models based on this example are analyzed and the ways in which operations research techniques may be helpful to school administrators and planners are discussed. The third section gives other perspectives on the school busing problem by presenting some of the policy considerations discussed in the

educational literature on busing that are not dealt with in the
operations research literature. The fourth section views the use
of operations research in the school busing problem in the light
of the educational literature discussed in the third section, and
examines the role of operations research in dealing with educational
and societal issues. Finally, there is an appendix summarizing
major Supreme Court decisions, Congressional legislation, and
federal administrative actions related to the school busing problem.

I. OPERATIONS RESEARCH STUDIES OF SCHOOL BUSING

The interest in applying linear programming and other operations research and computer techniques to the busing of school children began in the late 1960's. The authors of many of the studies had experience in assisting school districts with their busing problems (5, 7, 14, 27, 58, 63, 70, 71, 75, 81, 82, 88, 120, 121, 126, 129, 130).

For the most part, the operations research studies tend to emphasize one of two things: the use of linear programming to assign students to schools to achieve racial balance or the use of other operations research techniques to design bus routes and schedules to transport students to schools. In addition to using linear programming, some of the researchers drew upon basic operations research work on the delivery problem, the truck dis-patching problem, the warehouse location problem, and network flow problems (23, 44, 52, 57, 62). From references cited in the school busing articles it appears that one impetus to the studies was the prior application of some of the same operations research techniques to the problem of redrawing political boundaries within states (53, 69, 72, 92, 168, 183).

Another group of operations research studies that deal with designing routes and schedules for bus companies are pertinent

to the subject of transporting students (46, 85, 87). Although

not cited by those who have worked on the school busing problem,

they could be used. Interestingly, the first issue of <u>Management</u>

<u>Science</u> carried an article on bus scheduling (55). The increase

in sophistication that has occurred since 1954 in the application

of operations research to bus scheduling may be seen by comparing

the 1954 study to those published in the past few years cited
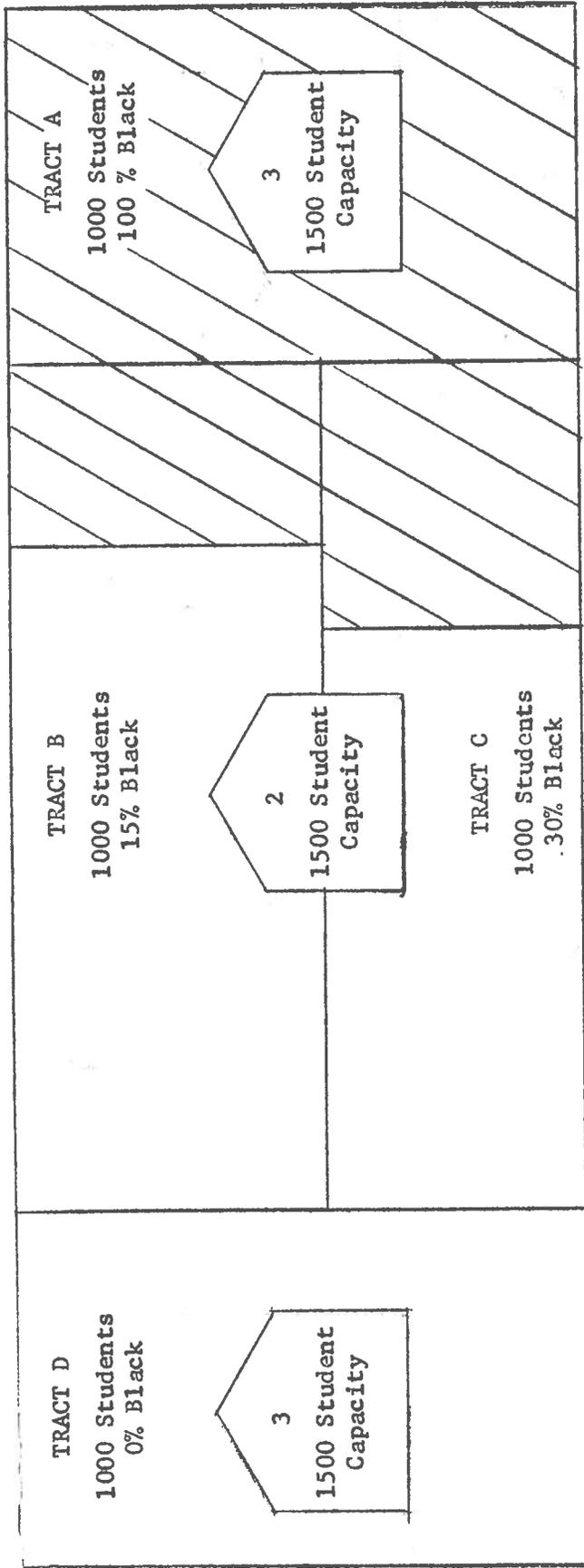
above.

In summary, the operations researcher who wishes to assist

a school district in its plans to bus students to achieve racial

balance has a great deal of good work to draw upon.

II. AN EXAMPLE OF THE USE OF LINEAR PROGRAMMING TO ACHIEVE RACIAL BALANCE

The hypothetical example in this section illustrates how linear programming may be used in the school busing problem.[2] Six models are presented to show how different formulations of the problem affect the solution and how the solution may be helpful to school administrators and planners. Other features of linear programming analysis such as sensitivity analysis and the solution to the dual linear programming problem are included to provide information for administrative decision making beyond what has been provided in the literature.

The hypothetical school district shown in Figure 1 is divided into four tracts or neighborhoods (A, B, C, and D) each containing 1,000 elementary school children. The percent of black students in tracts A, B, C, and D are 100, 15, 30, and 0, respectively. Each of the three schools in the district has a capacity of 1,500 students. Because of officially intended school segregation or because of housing patterns, school 1 could be all black and schools 2 and 3 could be all white.

Tract A is the district's black ghetto. The socioeconomic level increases as one moves toward tract D, which is all white and contains the highest income families residing in the district. Tracts B and C are transitional areas between the two

TRACT A — 1000 Students, 100 % Black — School 3, 1500 Student Capacity

TRACT B — 1000 Students, 15% Black — School 2, 1500 Student Capacity

TRACT C — 1000 Students, .30% Black

TRACT D — 1000 Students, 0% Black — School 3, 1500 Student Capacity

BLACK STUDENTS

WHITE STUDENTS

SCHOOL

BUSING DISTANCE (MILES)

School	Tract A Black	Tract B Black	Tract B White	Tract C Black	Tract C White	Tract D White
1.	0*	2.50	5.00	2.80	5.50	8.00
2.	4.00	3.25	3.00	2.80	2.25	4.00
3.	8.00	6.80	4.00	6.40	3.60	0*

*It is assumed that black students in Tract A attending School 1 and white students in Tract D attending School 3 are not bused to school.
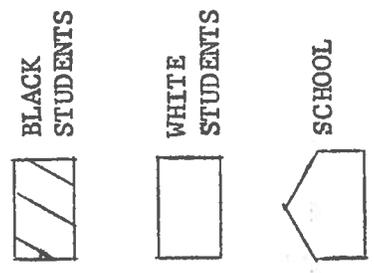
Figure 1

Hypothetical School District

extremes. This hypothetical school district has demographic and socioeconomic characteristics similar to those found in many school districts (15).

Six models are studied to investigate the effects of several factors: (1) assuming homogeneous distribution of races in tracts B and C, rather than the segregated distribution shown in Figure 1, (2) changing the required minimum and maximum constraints upon percent of black students in each school, and (3) comparing two different objective functions. In all six models the ojbective function is in terms of distance bused or squared distance bused. Other objective functions could have been formulated in terms of transportation costs or student travel time. However, distances are usually easier to calculate and approximate the results that would be obtained by using costs or travel time. In the six models the distance traveled by students was measured from the center of a given tract or that part of a tract occupied by a single racial group to each school. The use of a straight line approximation appears reasonable in light of the sensitivity analysis performed.

The six models were run on an IBM 360-65 computer using a revised simplex LP algorithm. The optimum solution for each model consists of each variable's activity level, dual values associated with the constraints, and a sensitivity analysis of the coefficients of the variables in the objective function and of the right-hand-side constants (the exogenous flows) in the constraint equations.

The basic features of the six models are:

Models 1 and 2 – Homogeneous distribution of races in tracts B. and C. (That is, contrary to Figure 1, it is assumed that the black students are spread evenly throughout the two tracts.) Upper bound on percent of black students in each school is 50.

Lower bound on percent of black students is 10 in Model 1 and zero in Model 2. Objective function minimizes total distanced bused.

Models 3 and 4 – Nonhomogeneous distribution of races in tracts B and C. (That is, the black students are distributed as shown in Figure 1.)

Upper bound on percent of black students in each school is 50.

Lower bound on percent of black students in each school is 10.

Objective function minimizes total distance bused in Model 3 and minimizes total squared distance bused in Model 4.

Models 5 and 6 – Nonhomogeneous distribution of races in tracts B and C. Racial distribution in each school conforms more closely to overall racial distribution in the school district.

Upper bound on percent of black students in each school is 40.

Lower bound on percent of black students in each school is 30.

Objective function minimizes total distance bused

in Model 5. In Model 6, integration is achieved
through two-way busing, a variation of the plan
used in the Berkeley, California, school district.[3]
In Model 6, black and white students in each
tract are equally divided between grades K-3 and 4-6.

The formulation and notation adopted here of the linear
programming problem to allocate students to schools to achieve
racial balance follows that of earlier studies (27, 70).

x_{ijk} - number of students of race k in tract i assigned to school j

d_{ijk} - distance students of race k in tract i travel to school j

α_{ik} - percent of students of race k in tract i

p_i - total number of students in tract i

s_j - maximum student capacity of school j

ϵ_{jk} - upper bound on the percent of students of race k assigned to school j

δ_{jk} - lower bound on the percent of students of race k assigned to school j.

In the above models only two races are considered: black
and white. Although the notation allows any number of races to
be considered, limiting the study to two races permits some simpli-
fication of notation.

α_i - percent of black students in tract i

ϵ_j - upper bound on the percent of black students assigned to school j

δ_j - lower bound on the percent of black students assigned to school j

The formulation of the linear programming problem for
Model 3 illustrates the use of the notation.

The objective is to minimize distance bused:

$$\sum_{i=1}^{4} \qquad \sum_{j=1}^{3} \qquad \sum_{k=1}^{2} \qquad d_{ijk}x_{ijk}$$

where d_{ijk} is measured from the center of each racial group in tract i to school j.

Several constraints are imposed upon the system that:

1. Assign every student to a school

   a) Black students

$$\sum_{j=1}^{3} \qquad x_{ij1} = \alpha_i P_i \text{ for each } i$$

   b) White students

$$\sum_{j=1}^{3} \qquad x_{ij2} = (1 - \alpha_i)P_i \text{ for each } i$$

2. Limit student assignments to the school capacity

$$\sum_{i=1}^{4} \qquad \sum_{k=1}^{2} \qquad x_{ijk} \leq s_j \text{ for each } j$$

3. Constrain the racial composition of the schools

   a) Specify an upper limit on the number of black students assigned to school j

$$\sum_{i=1}^{4} \qquad x_{ij1} \leq \epsilon_j \sum_{i=1}^{4} \qquad \sum_{k=1}^{2}$$

   x_{ijk} for each j

   For computational purposes this may be written

$$\sum_{i=1}^{4} \qquad (1- \epsilon_j) x_{ij1} - \epsilon_j x_{ij2} \geq 0 \text{ for each } j$$

   b) Specify a lower limit on the number of black students assigned to school j

$$\sum_{i=1}^{4} \qquad x_{ij1} \geq \delta_j \sum_{i=1}^{4} \qquad \sum_{k=1}^{2} \qquad x_{ijk} \text{ for each } j$$

   For computational purposes this may be written

$$\sum_{i=1}^{4} \qquad (1-\delta_j) x_{ij1} - \delta_j x_{ij2} \geq 0 \text{ for each } j$$

4. Restrict the solution to nonnegative values

$$x_{ijk} \geq 0$$

In a school district with a fixed budget or maximum transportation allowance, an additional equation might be added to the linear programming model to handle this constraint.

$$\sum_{i=1}^{4} \quad \sum_{j=1}^{3} \quad \sum_{k=1}^{2} \quad c_{ijk} d_{ijk} x_{ijk} \leq K$$

where c_{ijk} is the cost per mile for busing a student from tract i to school j, and K is the maximum budget allocation for busing students within the school district. Of course, the way of handling such a constraint would vary depending upon such things as whether the school board purchased or leased buses, the details of the leasing arrangement, and so on.

The linear programming model may also consider desired socioeconomic and achievement balances as well as racial balance in assigning students to schools. The parameters α, ε, δ, d and the variable x are redefined as follows:

α_{iklm} - fraction of students of race k, socio-economic level 1, and achievement level m in tract i

ε_{jklm} - upper bound on the percent of students of race k, socio-economic level 1, and achievement level m assigned to school j

δ_{jklm} - lower bound on the percent of students of race k, socioeconomic level 1, and achievement level m assigned to school j

x_{ijklm} - number of students of race k, socioeconomic level 1, and achievement level m in tract i assigned to school j

d_{ijklm} - distance students of race k, socioeconomic level 1, and achievement level m in tract i travel to school j

Still other factors may be considered in the linear programming model of the school busing problem. For example, a

limit may be set on the maximum distance a student may be bused or on the maximum time a student may spend on a bus.

Some of the limitations and assumptions of the linear programming model should be mentioned. The operations researcher makes a large number of value judgments in specifying the model. After deciding to use linear programming rather than some other approach, he must define the set of activities and the set of items, select the objective function, and specify the constraints. Personal judgment enters into all of these tasks.

Certain aspects of education may be difficult to quantify and state as mathematical equations. Ordinarily, these are simply omitted from the linear programming model. For example, Koenigsberg pointed out that quality of education is not dealt with in the usual mathematical formulation of the school busing problem. It is implicitly assumed that the school facilities in the district are equal and that the staffs of the various schools are equally competent (82).

One basic assumption of the linear programming model, proportionality, may not correspond too well with the system being modeled. Proportionality means that to double the activity level one simply doubles all the corresponding flows for the unit activity level. In economic terms this is the same as assuming constant returns to scale. This assumption may often be violated in the school busing problem. As Heckman & Taylor state, "It may not be ten times as costly to transport ten students [as to transport one student] since economies of scale may result in a lower per student cost" (71, p. 15).

The mathematical nature of the method of solving linear programming problems imposes restrictions on the number of activities that may appear in the solution. In order to solve a linear programming problem the inverse of a matrix must be obtained. Because only square matrices have inverses this means that the number of activities in the final solution depends upon the relative number of items and activities in the problem. If there were 25 items and 100 activities, the mathematics of solving the problem requires that there be no more than 25 activities in the solution.

Thus, at the end of it all the operations researcher has the "optimal" solution to a problem in which the parameters, constraints, and so forth were not optimally determined and where his assumptions are not necessarily realistic in terms of the problems facing the administrator. Hence, the solution to a linear programming model of a school busing problem or any other problem should not be viewed as the solution to the problem. Rather it should be judged for its usefulness in a specific situation.

Analysis of the Six Models

Analysis of the six models shows: (1) the effect of changing racial composition of schools upon the number of students bused and the total distance bused, (2) the effect of assuming that races are homogeneously distributed within a tract, (3) the effect of using linear and squared distance bused in the objective function, (4) the effect of two-way busing on distance bused, (5) the effect of the relative number of black and white students

requiring busing, (6) the effect of analysis using the dual, and
(7) the effect of sensitivity analysis.

Although the magnitude of the variables or the differences
among models may not appear to be large in the analysis of this
simplified example, the results are more significant in actual
busing situations. However, the complexity of actual situations
obscures the points that the analysis of these six models illus-
trates. Table 1 gives the optimum assignments of students to
schools for each of the six models.

The end results of linear programming studies of the school
busing problem usually are the assignment of students to specific
schools and the amount or cost of busing required. School admin-
istrators need these basic data to desegregate their districts.
But that is not all that can be gained from linear programming
studies. Analysis of the six models provides further interesting
data for school administrators and planners.

Effect of changing racial composition of schools upon the number of students bused and total distance bused

A comparison of Models 3 and 5 indicates that if the min-
imum percent of black students in each school is increased from
10 to 30 and the maximum percent decreased from 50 to 40, the
number of students bused and the total distance bused are increased.
In Model 3, 2,250 students are bused a total of 8,347 miles,
while in Model 5, 2,430 students are bused a total of 10,421 miles.
These figures confirm the intuitive conclusion that as desegre-
gation brings the percent of black students in each school closer
to the percent of black students in the community, the total

TABLE I

SCHOOL ASSIGNMENTS FOR SIX LINEAR PROGRAMMING MODELS

School Assignments

Students Not Bussed in ( )

SUMMARY DATA

Models	Number of Students	Tract A to School 1	Tract A to School 2	Tract A to School 3	Tract B to School 1	Tract B to School 2	Tract B to School 3	Tract C to School 1	Tract C to School 2	Tract C to School 3	Tract D to School 1	Tract D to School 2	Tract D to School 3	Students Bussed	Percent of Students Bussed	Total Students Bussed	Total Bussing Distance (Miles)
No. 1 Homogeneous Assumption -- Linear Distance $\epsilon=.5$ $\delta=.1$	1450 black	(618)	271	111	132	18			300					832	57	2382	8177
	2550 white				750	100			700				(1000)	1550	61		
No. 2 Homogeneous Assumption -- Linear Distance $\epsilon=.5$ $\delta=0$	1450 black	(618)	382		132	18			300					832	57	2382	7733
	2550 white				750	100			700				(1000)	1550	61		
No. 3 Nonhomogeneous Distribution -- Linear Distance $\epsilon=.5$ $\delta=.1$	1450 black	(750)	250			39	111		300					730	48	2250	8347
	2550 white				750	100			700				(1000)	1550	61		
No. 4 Nonhomogeneous Distribution -- Squared Distance $\epsilon=.5$ $\delta=.1$	1450 black	(750)	250			150			189	111				700	48	2250	8352
	2550 white				750	100			700				(1000)	1550	61		
No. 5 Nonhomogeneous Distribution -- Linear Distance $\epsilon=.4$ $\delta=.3$	1450 black	(567)	433				150		21	279				883	61	2433	10421
	2550 white				850				700				(1000)	1550	61		
No. 6 Nonhomogeneous Distribution -- Linear Distance -- Two-way Busing $\epsilon=.4$ $\delta=.3$	725 black Grades K-3			186						150				725	100	3000	13285
	725 black Grades 4-6		314				75		150					225	31		
	1275 white Grades K-3	(500)			11	64			150				(500)	775	61		
	1275 whites Grades 4-6				425	121	304	350	350			500		1275	100		

ϵ = upper bound on percent black students in each school

δ = lower bound on percent black students in each school

distance bused increases. However, linear programming does what intuition cannot do. It specifies the number of additional students to be bused and the total number of additional miles bused. Of course, in communities where busing has been used to preserve segregated schools, desegregation may well reduce the total amount of busing.

Effect of assuming that races are homogeneously distributed within a tract

Model 1 (homogeneous distribution) and Model 3 (nonhomogeneous distribution) illustrate the effect upon student assignments if homogeneous distribution of black students within tracts is assumed when such is not the case. From a visual inspection of tracts B and C in Figure 1, it is evident that the homogeneous assumption does not hold. The black students are concentrated at one end of each tract. In both cases, the linear programming routine assures that the four schools within the district achieve the required racial balance. However, as shown in Table 1, there is considerable difference in the assignment of students to schools. Hence, the demographic composition of each school district needs to be known in order to formulate the appropriate linear programming model.[4]

Effect of using linear and squared travel distance in the objective function

The use of squared distances in the objective function has the effect of restricting the number of students who are bused long distances to school. For example, in comparing Model 3 (linear distance) with Model 4 (squared distance) the number of

black students transported from tract B to school 3 decreased
by 111 students when distance squared instead of linear distance
was used in the objective function. This difference is a result
of the relatively long distance (6.8 miles) from tract B to school
3. However, there is a trade-off between the number of long bus
rides and the total distance traveled by all students. Although
the use of squared distances in the objective function reduces
the number of long bus rides, it also increases the total distance
traveled by all students. That is, total distance bused in Model 4
is greater than in Model 3. This result contradicts an intui-
tive reaction that the use of squared distances in the objective
function would decrease the total distance traveled by all students
through the elimination of long bus rides by some students.

Effect of two-way busing on distance bused

In Models 5 and 6, the effects of implementing a varia-
tion of the Berkeley plan -- using two-way busing to achieve
community racial composition in each school -- are investigated.
Although two-way busing increases the amount of busing beyond that
required by other busing plans to achieve a desired racial balance,
supporters of two-way busing argue that such a plan treats all
students equally. Everyone must be bused to school some time
during his grade school education. Schools are designated kinder-
garten to third grade (K-3) or fourth grade to sixth grade (4-6).
The student who walks to his neighborhood school for grades K-3
is bused to another school for grades 4-6.

In Model 6 schools 1 and 3 are the neighborhood schools
for tracts A and D respectively. School 1 is designated 4-6

and school 3 is designated K-3. Because the hypothetical school district in Figure 1 has only three schools, some modifications of two-way busing are necessary. Tracts 3 and C have no neighborhood schools and school 2 has grades K-3 and 4-6. In the example in this paper, regular busing (Model 5) resulted in 10,421 total student miles of busing, while two-way busing (Model 6) resulted in a total distance of 13,285 miles.

Presumably the decision to implement two-way busing should be based on the judgment that the increased benefits offset the additional costs. Administrators, school boards, and ultimately the voters are faced with a value judgment on the use of school district funds.

Effect of the relative number of black and white students requiring busing

Because the school district has a majority white student population (2,550 white and 1,450 black students), it might be expected that more white students than black students would have to be bused to meet the required integration objectives. This expectation is borne out in each of the six models.

The unexpected result is that an equal or greater percent of white than black students is bused in each model in order to satisfy the desegregation policies adopted for the district. The result may be simply an artifact of this particular example. However, if this situation occurs in an actual school district, a political problem arises. In a school district with an elected school board, will the board members, elected by the majority race, jeopardize their positions in the next election by imposing a desegregation plan that requires a perceived greater burden upon

the majority than the minority race? In reality, it appears that
most desegregation has come about by redrawing school boundaries,
one-way voluntary busing, open enrollment, and other devices which
in general have placed the burden of being bused on the black
students.

Effect of analysis using the dual

Associated with any primal linear programming problem
is another linear programming problem called its dual. Of interest
to planners and administrators is the economic interpretation
of the solution to the dual linear programming problem. Each of
the constraint equations represents the demands upon a "resource"
and for each "resource" the solution of the dual linear program-
ming problem gives a shadow price, cost, or value to be associated
with a change of one unit in the quantity of the "resource" available
(43, 67). Wagner's definition is a good one.

> The optimal value of a dual variable indicates how much
> the objective function changes with a unit change in the
> associated right-hand-side constant, provided the current
> optimal basis remains feasible (174, p. 140). [Underlined in
> original]

The solution of the dual linear programming problem con-
tains information about each constraint in the school district
example that may help an administrator or planner. The constraints
are the number of students, the school capacities, and the racial
composition of the schools. An examination of the solution of
the dual for Model 3 reveals some interesting results. Similar
analyses could be made for the other models.

TABLE 2

Dual Values of Constraints in Model 3

Constraints	Dual Values (Miles)
1. Assign every student to a school	
a. Black students	
Tract A	4.00
Tract B	3.25
Tract C	2.80
Tract D (No black students in Tract D)	
b. White students	
Tract A (No white students in Tract A)	
Tract B	3.00
Tract C	2.25
Tract D	0.39
2. Limit student assignments to school capacity	
School 1	1.00
School 2	0
School 3	0
3. Constrain the racial composition of the schools	
a. Specify an upper limit on the number of black students assigned to a school	
School 1	6.00
School 2	0
School 3	0
b. Specify a lower limit on the number of black students assigned to a school	
School 1	0
School 2	0
School 3	3.94

a. Assignment of every student to a school

The dual values represent the change in the total distance
bused by a change in the total number of black or white students
in the district. For example, if a student moves into the school
district the dual value represents the resulting increase in total
distance bused. If a student moves out of the school district
or begins attending a private school, the dual value represents
the resulting decrease in total distance bused. Had costs of
transportation been used in the objective function the dual value
would represent the change in transportation costs.

In all cases, the linear programming formulation requires
that every student be assigned to a school. That means that all
the assignment constraints are binding constraints and the dual
values associated with them are not zero. In Model 3, for example,
an additional black student in tract A increases the total distance
bused by 4 miles. As Table 1 shows, school 1 in tract A is already
at the maximum percent for black students. Hence, an additional
black student would have to be bused to a school in another tract.

b. School capacities

The dual values represent a measure of the effect upon
the total distance students are bused by a change in the student
capacity of a school. The solution to the dual indicates those
schools whose capacity limitations have the most significant effect
upon total distance bused; that is, it indicates the schools whose
facilities could be expanded in order to reduce total distance
bused. The administrator could compare the value imputed to the
relaxation of the capacity constraints to, say, the cost of using
portable classrooms to expand the capacity of the school.

In Model 3, school 2 has only 1,389 students assigned to it although its capacity is 1,500. Hence there is excess capacity. One would suspect the value of the dual would be zero because adding or subtracting one unit of capacity at this school would be of no value. That is, the change in capacity would not affect the total distance bused or the assignment of students to schools. And zero is what Table 2 shows as the value of the dual. Another way of putting it is to think of the capacity of the school as a resource. In this example, not all of the resource is used. Economists would say that this resource is a free good and thus its imputed value is zero.

In contrast, in Model 3 the capacity of school 1 is fully utilized. It is a binding constraint. The value of the dual associated with this capacity constraint is 1.0. The value represents the amount by which the total distance bused would change by modifying the restriction on the school capacity by one unit. If the maximum capacity were increased to 1,501 from 1,500, the total distance bused would be reduced by 1 mile, that is, from 8,347 to 8,346.

c. Racial composition of the schools

The dual values represent the change in the total distance bused by a change in the limits of the percent of black students assigned to each school.

In Model 3 the upper limit on the number of black students assigned to school 1 is a binding constraint and has a dual value of 6.0, the reduction in the distance bused if the constraint could be relaxed one unit. As Figure 1 shows, school 1 is in the

all-black tract A. Hence, if one more black student could attend school 1, he would not have to be bused to a school in another tract.

In Model 4 the lower limit on the number of black students in school 3, the school in the all-white tract, is a binding constraint. Its dual value is 36.833. If the lower limit on the number of black students at school 3 were reduced by one student, the total distance bused, which is in units of distance squared in Model 4, would be reduced by 36.833.

Effect of Sensitivity Analysis

Sensitivity analysis investigates the effects of changes in various parameters of the linear programming model upon the optimal solution. Administrators and planners alike often want to know the effect of changes in such parameters as number of students, school capacity, distance bused, and so on. Also, because the values of the parameters are seldom known with certainty, the effect of errors of measurement of parameter values upon the optimal solution is of interest. Sensitivity analysis may be used to specify the range within which the right-hand-side constants (the exogenous flows) may vary without changing the set of basic variables in the current optimal solution and the range within which the coefficients of the variables in the objective function may vary without changing the set of basic variables or their levels in the current optimal solution. Tables 3 and 4 reflect such sensitivity analysis done on the constants and coefficients one at a time in Model 3. The effects of many other changes may be studied by sensitivity analysis. A further discussion of

TABLE 3

Sensitivity Analysis for Right-Hand-Side Constants in Model 3

Constraint	Constant Used in Linear Programming Model	Range within which constant may vary without changing the set of basic variables in the optimal solution
1. Assign every student to a school		
a. Black students		
Tract A	1000	750-1111
Tract B	150	111-261
Tract C	300	0-411
Tract D (No black students)	—	
b. White students		
Tract A (No white students)	—	
Tract B	850	750-961
Tract C	700	489-811
Tract D	1000	0-1350
2. Limit student assignments to school capacity		
School 1	1500	1389-1700
School 2	1500	1389-Infinity
School 3	1500	1111-Infinity
3. Constrain the racial composition of the schools		
a. Upper limit on black students (maximum 50%)		
School 1	750	650-1000
School 2	695	589-Infinity
School 3	555	111-Infinity
b. Lower limit on black students (minimum 10%)		
School 1	150	0-750
School 2	139	0-589
School 3	111	11-146

this important topic is found in Hadley (67), Dantzig (43), Wagner (174), and Hillier and Lieberman (73).

Table 3 shows how the right-hand-side constants in each of the fifteen constraints in Model 3 may vary without changing the set of basic variables in the current optimal solution. An administrator could use sensitivity analysis of the constraints involved in assigning every student to a school to see how the racial composition in a tract could change without changing the overall assignment pattern relating races, tracts, and schools. For example, as long as the number of black students in tract B ranges from 111 to 261 the set of basic variables in the current optimal solution will not change. Of course, if the level of a variable in the current optimal solution changes, the numerical value of the optimal solution will change. As Table 1 shows, in the current optimal solution to Model 3 no black students are bused from tract A to school 3, from tract B to school 1, or from tract C to schools 1 or 3; no white students are bused from tract B to school 3, from tract C to schools 1 or 3, or from tract D to schools 1 or 2. Sensitivity analysis lets the administrator know that as long as the number of black students in tract B ranges from 111 to 261 the above statements based on Table 1 remain true.

Table 3 also shows that the capacity of school 3 may vary from 1,111 to infinity without changing the set of basic variables in the current optimal solution. This information together with information from Table 2, which shows a dual value of zero for this constraint (that is, school 3 has unused capacity), indicates

to the administrator that the number of students of specific races living in specific tracts assigned to specific schools will not change as long as the capacity of the school stays above 1,111.

Table 4 shows how each of the eighteen coefficients in the objective function in Model 3 may vary without changing the set of basic variables in the current optimal solution or their levels. Of course, any change in the coefficient of a basic variable that has a positive value in the current optimal solution will change the numerical value of the solution.

An administrator might be interested in investigating various routes between a particular tract and a school where each route has a different travel distance. With sensitivity analysis, the range of distance can be found within which the travel distance between the tract and school may vary without affecting the assignment of students. For example, Table 4 shows that as long as the distance that black students in tract B attending school 3 are bused varies between 3.25 and 6.85 miles the set of basic variables in the current optimal solution is not affected. The actual distance is 6.80 miles. If this distance were 6.90 miles the solution obtained using 6.80 miles would not be an optimal solution. A new solution with a new student assignment pattern would have to be calculated. Similar statements could be made about the other distances that students are bused.

In summary, linear programming and other operations research techniques are valuable to school administrators in dealing with a wide range of problems related to the desegregation of

TABLE 4

Sensitivity Analysis for Coefficients in Objective Function in Model 3

Race	From Tract	To School	Coefficient Used in Linear Programming Model (Distance in Miles)	Range within which Coefficient may vary without changing the set of Basic Variables in the Optimal Solution (Distance in Miles)
B	A	1	0	0-2.00
W	A	1	No white students in Tract A	
B	A	2	4.00	2.00-4.45
W	A	2	No white students in Tract A	
B	A	3	8.00	7.55-Infinity
W	A	3	No white students in Tract A	
B	B	1	2.50	0-Infinity
W	B	1	5.00	0-6.25
B	B	2	3.25	3.20-6.50
W	B	2	3.00	1.75-4.394
B	B	3	6.80	3.25-6.85
W	B	3	4.00	2.606-Infinity
B	C	1	2.80	0-Infinity
W	C	1	5.50	4.25-Infinity
B	C	2	2.80	0-2.85
W	C	2	2.25	0-3.50
B	C	3	6.40	6.35-Infinity
W	C	3	3.60	1.856-Infinity
B	D	1	No black students in Tract D	
W	D	1	8.00	2.394-Infinity
B	D	2	No black students in Tract D	
W	D	2	4.00	0.394-Infinity
B	D	3	No black students in Tract D	
W	D	3	0	0-3.606

school districts.[5] Busing routes, size of buses, school capacities,
and different desegregation plans may be studied for their impact
on the cost of busing and the amount of busing. The impact of
proposed new school locations and the expansion of existing schools
on current transportation arrangements may be studied by putting
the locations and capacities in the linear programming model and
observing their effects upon the assignment of students to schools
and the total distance students are bused. The effect of split
school sessions and staggered starting times of schools or classes
on transportation costs may be investigated. The effect of
future student body size and distribution on size and composition
of the school bus fleet may be studied. Such information will
also help the school district in its deliberations on whether to
buy or lease school buses or to contract for bus service. The
effects of a change in the maximum allowable walking distance
on transportation costs may also be evaluated. Answers to questions
that concerned groups raise about the effects of desegregation
and of alternative busing plans may be answered more rapidly.

The data base developed for the linear programming model
should be useful in various school planning and operating activ-
ities. For example, these data together with demographic fore-
casts may be used to investigate future demands on the school
system with regard to the location and capacity of schools and the
need for teachers.

As quantitative methods are used more and more in local
government operations, school administrators and their staffs need
to learn more about the advantages and disadvantages of such techniques.

The linear programming model for school busing is a good technique for showing school administrators what operations research can do. It provides an excellent introduction to model building because of its linear and additive structure. It is easy to see what parts of reality can be captured by the model and what parts are lost. It is easy to see the assumptions built into the model that make its solution relatively simple but that distort the real situation. The data requirements and costs of data collection are also relatively easy to specify.

III. ISSUES IN THE EDUCATIONAL LITERATURE
ON DESEGREGATION

The literature on desegregation in the schools shows how
complex the problem of busing is. The voluminous literature about
busing contains many studies that correlate various factors but
the evidence in the studies about causation or remedy fails to
convince.[6] Given the bewildering variety of conclusions in the
many studies, the questions that may be raised about the way the
studies were conducted, the problems of statistical inference,
the omission of the implications of the studies for administrative
action, and so forth, one may use the literature to justify any
of a wide variety of administrative actions or to find reasons to
criticize almost any proposed administrative action.

It is important for operations researchers to know about
some of the concerns of educators if the researchers want their
recommendations implemented. It is also necessary to know about
the educational issues that lie behind the controversy over busing
to place the operations research studies in a larger context.

Although there are many aspects to the school busing problem
the educational literature seems to concentrate on two things:
identifying who or what is to blame for the relatively poor scores
of black students on standard achievement tests, and assessing the
effects of desegregation in the schools on student performance

and social attitudes. In addition, the public press and to some
extent articles in the education journals deal with the problem
of school finance, of which the cost of busing is a part. This,
of course, is a reflection of the immediate and continuing concern
of school officials, school board members, politicians, and the
general public over how public education is to be financed. These
and other topics discussed in the literature reflect the ferment
and controversy going on in education today.

Who or what is to blame

A discussion of various explanations regarding who or
what is to blame for the relatively poor performance of black
students on standard achievement tests provides insight into the
complexities underlying the school busing problem. Administrative
actions based on some of the explanations are now being taken.
It is important to recognize that which explanation is used as
a basis for action determines which persons or groups will be
affected.

One explanation of why black students on the average
score lower on tests than white students is that the black students
are culturally deprived. Schools, teachers, and educational
institutions are not to blame. The reason for the students'
low test scores is their lower-class family, home, and culture.

An implication of the cultural deprivation argument is
that the schools do not have to change. The logical administrative
response to cultural deprivation is to provide compensatory
educational programs. A higher level of academic performance
will be achieved by giving a little extra to those children who

through no fault of their own are culturally disadvantaged. Then these children will be able to compete on more equal terms with the middle-class children whom the existing educational system presumably serves well. How well the system serves even the middle class is debatable. Moreover, evaluations of compensatory education programs cast some doubt on their ability to significantly improve student performance (65, 132, 159, 172). It should, however, be noted that the evaluations themselves have been subject to criticism (185).

A second explanation, closely related to cultural deprivation, is that the parents are to blame. Parents who directly involve themselves with their children's education by reading to them, taking them to libraries, talking to them, and otherwise providing cognitive stimulation and support for intellectual accomplishment, raise their children's level of achievement. Presumably middle-class white parents are better at these activities or have more time for them than poor black parents. The solution is to train the poor parents to behave toward their children in the way middle-class parents do (29).

A third explanation is that the schools are to blame because they fail in their efforts to teach children from low-income families, both white and black. Because the percent of black families with low incomes is far greater than the percent of black families in the total population, the failure of the schools in teaching children from low-income homes explains the lower test scores, on the average, of black students. Those who favor this explanation argue that whatever effect the home

environment may have on children, the schools create additional deprivation. Black students fall further behind as they progress through grade school and high school. Ryan puts it this way:

> For the fact is that the Negro child learns less not because his mother doesn't subscribe to The Reader's Digest and doesn't give him colored crayons for his third birthday, but because he is miseducated in segregated slum schools. (136, p. 464)

The works of Clark (24), Kozol (84), and Kohl (83) support this explanation.

Although educators don't like the third explanation, Gans believes that it is supported by available research. He suggests three reasons for the failure of schools: (1) difficulties experienced by predominantly middle-class teachers in teaching lower-class students, (2) use of inexperienced teachers or substitutes to staff ghetto schools, and (3) racial segregation of ghetto schools (59). If reason one is correct, the remedy lies in changing graduate schools of education. If reason two is correct, the remedy lies in changing the educational establishments of large metropolitan areas. Needless to say, such changes will not be made without major fights. If the third reason alone is correct, then desegregation is the solution.

Several of those who believe schools are to blame are quite specific about what to do. The onus is on the teachers. If children don't learn, out go the teachers (2, 24, 137, 184). Although blaming the teachers is one part of blaming the schools, enough has been written about the effect of teachers on student performance to warrant giving it separate consideration. Several studies emphasize that the teacher's attitude and expectation of

student success or failure (the self-fulfilling prophecy) is the
key to student achievement (2, 65, 83, 84, 134).

Differences between the language of the ghetto and
"standard classroom" English are another aspect of the explana-
tion that the teachers are to blame. A controversial issue here
is whether children from the lower end of the socioeconomic scale
are deficient in linguistic capabilities ("verbal deprivation")
compared to those higher on the socioeconomic scale or whether
they simply have different but equally effective linguistic
capabilities. The two points of view have different implications
for education. If the child is deficient, change the child. If
the child is different, change the educational procedure (122).
Whichever view may be correct, the pronunciation, usage, meaning,
and patterns of words used by ghetto children do present problems
in communication with middle-class teachers. Such teachers often
presume ghetto children are not intelligent and do little to help
them learn (28, 182). One implication of the explanation based
on linguistic differences is that with teachers who could deal
with the difference in language, quality education could be achieved
without desegregation.

However, putting all the blame on the teachers may be
unfair. Studies of metropolitan school districts indicate that
teachers as well as students are trapped and manipulated by the
educational system (133, 182).

A fifth explanation for low test scores of black students
attributes the cause to failings of our society. Gans calls this
societal inadequacy. He believes that until low-income non-white

persons are admitted to first-class citizenship, even the most

supportive home environment or the best schools are powerless

to help these children significantly. Society must promise the

child a useful function after graduation if going to school is

to make sense to him (59). One of the findings of the Coleman

Report[7] is consistent with this explanation. Of all the variables

measured in the survey by Coleman and his colleagues three expres-

sions of student attitude and motivation -- student's interest in

school, his self-concept, and his sense of control over his own

destiny -- showed the strongest relation to achievement (40).

Needless to say, the major societal reform suggested by Gans will

take the energies of large numbers of persons many years to accom-

plish.

Jensen's explanation for the poor performance of many

black children is based on genetic factors. Blacks test about one

standard deviation (15 IQ points) below whites on IQ tests.

Jensen believes that genetic factors play an important part in this.

He suggests that we must devise new teaching methods that apparently

would emphasize rote learning (77). However, as Cronback pointed

out, Jensen has little to say about the policies he would expect

us to follow if we were to accept his empirical conclusions (41).

This is a grave deficiency in Jensen's study. One implication

that could be drawn is that not only is there no educational

reason for desegregation but there is a "scientific" reason for

segregated education for blacks. Students taught by rote methods,

as Jensen suggests, would not be equipped to cope with a changing

world. Thus, blacks would seem destined to fill those positions

not requring cognitive skills. No wonder there has been so much controversy surrounding Jensen's work.

Still another way of explaining the low test scores of black students is to blame the tests themselves. Tests are culturally biased in favor of the middle class (e.g. 50, 79). Therefore, black children who speak the language of the ghetto and Chicano children whose home language is not English do not do as well on tests devised for predominantly white middle-class students. Indeed, black and Chicano children who are not mentally retarded have been shunted into special classes for the mentally retarded because of low scores on IQ tests (100, 138, 139, 140, 142, 147, 153).

Since the use of standardized tests continues to be viewed by administrators and others as a generally acceptable way to measure student performance and school effectiveness, much effort is devoted to formulating test questions that are not culturally biased. Some organizations like the Educational Testing Service, with a financial stake in the use of tests, hire minority persons as consultants to help prepare "better" tests (110). Of course, one implication of this is that it is all right to use IQ tests and standardized performance tests to sort students into various boxes that may result in their being denied entrance to certain schools or programs.

One other explanation concerns the effects of nutrition on the performance of children in school. A recent survey by Birch concludes that nutritional factors may significantly affect performance of students in the classroom and on achievement tests.

Inadequate diet leads to depressed intellectual ability and failure in learning. Inadequate nutrition for a mother during pregnancy may adversely affect the fetus; inadequate nutrition for a child over a period of years may result in physical and mental stunting of the child. Even missing one breakfast may result in a student's apathy and lack of attention in class that day (9).

Because black children comprise a disproportionate number of poor children with poor diet, the observed difference in the average test scores between black and white students could be caused by nutritional factors. Remedies range from having individual schools provide nutritious meals for students to national programs to raise the income of the poor. The educational process, however, would not have to change.

Although many different explanations are given for the relatively poor performance by black students on standard tests, there is still much to be learned about factors that cause different levels of performance among children.

Effects of desegregation in the schools

The Supreme Court's ruling in 1954 that officially sanctioned separate education facilities are inherently unequal makes it important to consider the effects of desegregation as reported in the literature. As one might expect, there is disagreement.

One finding of the Coleman Report is that the mixing of social classes, and not the mixing of races _per se_, is a key factor influencing the performance of black children in the schools (40). Wilson's study came to the same conclusion (186).

Coleman and his colleagues, in assessing factors related to student achievement in such skills as reading, writing, calculating, and problem solving found that the attributes of fellow students (e.g., their social class, their family's educational background, and their educational aspirations) accounted for far more variation in the achievement of black students than any attributes of the schools themselves (e.g., physical facilities, guidance counseling, reduced class size, and special programs).[8]

Coleman suggests that middle-class schools influence test scores of "deprived background" children through providing a social environment that is more demanding and more stimulating. That is, students from educationally deprived backgrounds do better in schools where their fellow students come from backgrounds strong in educational motivation and resources.[9] Moreover, there are no adverse effects on the children with strong educational backgrounds. Coleman did point out, however, that association of "deprived background" children with middle-class children does not guarantee equal educational opportunity (31, 32).

Thus, in Coleman's view, desegregation of school districts that results in the children of the poor entering predominantly middle-class schools should have a beneficial effect upon the test scores of the poor. It follows then that if children from poor families are to mix with middle-class children, it is necessary in most communities to mix black with white, for there are not enough middle-class black children to achieve the desired mix of social classes in all-black schools.

In contrast to the Coleman Report, Armor reported that a series of studies found that black students bused to suburban schools made no significant gains on standard achievement tests as compared to other black students who stayed at inner-city schools (6). However, some scholars have criticized Armor's paper as having drawn overly broad conclusions on the basis of incorrect interpretations and narrowly selected data involving only a relative handful of students (117).

Katz, in his review of the evidence of the effects of desegregation on the academic performance of black students, found that desegregation brought about a number of influences favorable to improved performance as well as a number of influences conducive to poor performance (80).

Thus, the evidence to date on whether or not desegregation in and of itself improves the academic performance of poor black children is inconclusive.

Change in social attitude is another effect of desegregation in the schools. Desegregation is considered important not only because of its effect on individual performance of students but also because of its influence on social attitudes and human values. Coleman distinguishes between the goal of providing equal educational opportunity to all students and the goal of desegregation of schools as a way to achieve a viable, multi-racial society (32, 34, 36). The assumption underlying the latter goal is that if the members of different races meet and learn about each other, prejudice will be reduced. The members of the National Advisory Commission on Civil Disorders agree with this

assumption in their support of integration:

> We support integration as the priority education strategy because it is essential to the future of American society.... It is indispensable that opportunities for interaction between the races be expanded (173, p. 32).

Some years ago in his study of prejudice, Allport questioned whether merely assembling persons without regard for race, color, or religion would destroy stereotypes and develop friendly attitudes. He suggested that other conditions such as pursuit of common goals, equal status contacts, and the sanctioning of the contacts by law or other institutional supports are necessary (3).

Although Coleman thought that in the long run desegregation should be expected to have a positive effect on achievement of black students he did point out that education in desegregated schools could have more than one outcome. At its best, it can develop attitudes appropriate to the integrated society these students will live in; at its worst, it can create hostile camps of Negroes and whites in the same school. Thus, there is more to "school integration" than merely putting Negroes and whites in the same building, and there may be more important consequences of integration than its effect on achievement (40, pp. 28-29).

The United States Commission on Civil Rights suggested that one way for parents to evaluate busing is to ask if the education at the end of the trip will be as good or better than the education their children now receive (172). On this point Wildavsky saw quite different outcomes possible.

> Consider the drive to achieve school integration by busing children to different parts of the city. If such integration is accompanied by huge efforts to create equality of educational achievement among black and white, all

praise is due. But if black children continue to read poorly, race hatred may well increase. Black radicals will then be certain to condemn the liberal integrationists who have against left them and their children holding an empty bag (184, p. 4).

Overall, the evidence to support the assumption that desegregation will be beneficial and will help achieve interracial harmony is mixed. After surveying the literature Carithers concluded that there was no general agreement about the effects of interracial contacts on attitude change. He reported that some studies found heightened tolerance, some heightened resistance, some no change (19). Chesler came to a similar conclusion (20). The discussion between Eiseman and Pettigrew illustrates the complexity of the issue. Their exchange stresses the effects of the intervening variable, the condition under which the contact is made (48, 49, 123, 124). Armor (6) and Glazer (64) reported a worsening of race relations following desegregation of schools.

Other considerations

In many metropolitan areas opportunities for contact between races are being reduced. For a variety of reasons whites continue to move to the suburbs and the inner city schools become increasingly black (127, 166). Desegregated schools become resegregated. Because of low income, discrimination in housing, and the opposition to putting low-income housing in the suburbs, blacks and other minorities find it very difficult to move to suburbia.[10] Facing this situation and still desiring desegregated education, some educators have advocated educational parks (171) or regional busing across school districts (172). Obviously large scale busing of children would be required to carry out either of these two schemes.

The idea that seating poor black students next to middle-class white students is the key to quality education for blacks is rejected by some black leaders.[11] Wilson Riles, the black Superintendent of Public Instruction for the State of California, was quoted as saying, "Don't sell me integration on the basis of learning. That's an insult" (179). He challenges the assumption that blacks can learn only if they sit next to whites. He believes that desegregated education is necessary as a means of achieving an integrated society.

However, some blacks have become disenchanted with attempts to desegregate schools (26, 66, 167). Viewing the years of resistance by whites to the 1954 Supreme Court decision and seeing that it is usually black children who are bused, the black community has begun to reconsider its commitment to desegregation (163). Faced with various rebuffs and by administrative devices such as ability tracking which result in segregated classes within desegregated schools (4, 93, 144, 172), the alternative of excellent though segregated schooling is being given serious consideration.[12] Piven and Cloward argue that it makes sense to give up on attempts to desegregate schools in urban areas at least for the time being and to concentrate efforts on improving the quality of education in existing, segregated schools (127). The National Association for the Advancement of Colored People seems to have recognized this situation at its 1971 national meeting. Roy Wilkins was quoted as saying, "There ought to be just as good schooling in an 80 per cent black school as in an 80 per cent white school" (179). Many school districts in metropolitan areas will have an opportunity

to test Wilkins' hypothesis because the percent of non-white
students is increasing. For example, in Oakland, California,
non-whites made up 74 percent of the public school students in
1970, up sharply from 56 percent in 1963.

School districts also face the problem of how to obtain
money to pay for quality education, whether segregated or dese-
gregated. Stories about financial crises in school districts
across the country appear regularly in the mass media. For example,
the Wall Street Journal headlined a recent story, "As Taxpayer
Rebellion Persists, Money Crises Grow in U.S. Schools" (177).
The financial crisis is probably more acute in large cities which
are becoming more and more the home of the poor, the elderly,
and the minorities. Campbell has documented that expenditures
per student are considerably more in the suburbs than in the city
and that the gap is widening (18).[13] If the busing of students
to achieve racial balance adds to the cost of running a school
district, the financial problem is exacerbated.

There is some evidence that money makes a difference.
Although the Coleman Report found little relationship between
school resources and student performance, Bowles states that his
re-analysis of Coleman's data shows that significant gains in
black students' achievement levels could be made by directing
additional resources to their education (11). Shanker argues
that before we accept the slogan that "money is not the answer,"
we ought to try the money approach just once (159). Along the same
line Clark and Schrag argue that desegregation is, more than
anything else, a political attempt to win white hostages to

black education. As long as white students are in a school the officials of the school district will see to it that the school has more resources and better teachers than if it were an all-black school (26, 157).

The increasing percent of non-white students in large cities and the financial plight of these cities create difficult problems for educational administrators, planners and teachers striving to provide quality education and to desegregate schools. We seem to be asking the schools to solve single handedly problems that are really societal problems. Not only are schools expected to provide quality education for all but they are also to solve our racial problems, eliminate juvenile delinquency, and so on. And the schools are to do all these tasks with little if any additional money. As will be argued in the next section, unless other major segments of society make significant changes in policies that affect income distribution, employment, and housing, even monumental efforts by schools will not be enough to solve societal problems. Schools cannot be the sole change agents for society.

IV. OPERATIONS RESEARCH RECONSIDERED

This paper shows that there are differences between
operations researchers and educators in how they define and deal
with the school busing problem. In brief, operations researchers
use linear programming and other techniques to derive efficient
means of achieving desegregation. That is, they provide an
"optimal" solution to the problem of how to assign and transport
students to schools so that various races are brought together
in certain proportions at specified schools. This physical bring-
ing together of races is a necessary but not sufficient condition
for achieving integrated education. However, many school admin-
istrators and teachers are trying to do more than desegregate schools.
They are contributing to the solution of the racial as well as
the educational problems thrust upon them by society. These
teachers and administrators are trying to achieve quality, inte-
grated education.

Though hard to define, the concept of integrated education
implies a school experience that lays the foundation for intelli-
gent participation in society, and helps prepare students to under-
stand their society and its workings and to participate fully in a
world rich in human diversity. Integrated education should also
be an experience that prevents the development of racial fears

and prejudices which may arise through lack of contact with and information about other races. Thus desegregation is a spatial concept while integration has other dimensions besides space such as relative status and power, consideration, and caring. One only needs to recall that blacks have been physically close to whites from slavery days to the present time as servants, nursemaids, housekeepers, and so on. But we would not call such association evidence of a racially integrated society.

In dealing with achieving the goal of integrated education one really takes on a big system. Integration requires willingness to change on the part of teachers, administrators, students, and other concerned groups. And change is often a painful process. It takes place, if indeed it does occur, over time. Desegregating school districts has proved to be a difficult task. To go from desegregated to integrated education may be more difficult still. As Cohen pointed out, integration is politically viable only on the assumption that it is in the interest of whites to reduce the status disparity between themselves and blacks (29). There is certainly no easy solution to the problem of how to create a multi-racial society.[14] Racism existed in this country before the Revolution and it grew with the Republic (78, 187).

To attempt to deal with a problem of this magnitude is an extremely ambitious and difficult task. But as Churchman said, "The joy of OR is that it is in the center of the deepest mysteries of the human race, because, academically speaking, it has taken on the whole system" (22, p. 53).

Operations researchers have tended to treat the use of
linear programming and other techniques to solve the problem of
busing students to achieve racial balance as if this problem
could be separated from the rest of the school system and from
other societal problems. Because of the tendency of operations
researchers to deal with the school busing problem as an assign-
ment and routing problem they have neglected other aspects
of busing including certain long-run considerations. For example,
as indicated in the previous section, some desegregated schools
are becoming resegregated as white parents move to the suburbs or send
their children to private schools. In such cases, linear program-
ming studies to achieve racial balance through busing may be
irrelevant to the problems now faced by metropolitan school dis-
tricts. The creation of larger school districts for educational
parks or other regional arrangements might create even bigger
educational bureaucracies than we now have (e.g., 125). From the
descriptions given by Rogers and Wasserman of the bureaucracy
that runs the New York City school system, any solution that would
tend to create such a bureaucracy should be scrutinized very
carefully (133, 182).

If operations researchers define their role as that of solving
a desegregation problem rather than an integration problem, they
will consider their task finished once the assignment of students
to achieve racial balance has been made and the routing to carry
out the assignment has been specified. But the desegregation of
schools brings other problems to the surface. For example, enlarg-
ing a school district to encompass black inner-city schools and

white suburban schools may result in a desegregated school district.
However, it is not clear that such a change by itself would achieve
integrated education.

The extent of the emotions aroused over busing children
indicates that opposition to a bus ride out of a neighborhood is
not the only factor at work. In actuality, busing has been going
on for decades, starting even before there were buses. The horse
and buggy was the first school bus (90). In the South busing was
widely used for the express purpose of maintaining a segregated
school system (21, 89, 178). In rural areas throughout the
United States large numbers of children have been and are being
bused to consolidated schools. In urban areas busing continues
to be used to relieve overcrowded schools and to help handicapped
children. In fact, the amount of busing now being done to
achieve racial balance is small compared to the amount of busing
done for other purposes (112.5, 115). What is new is the nation-
wide controversy over busing. This suggests that the real issue
is not busing itself but the proposed mixing of races and socio-
economic classes.[15]

As pointed out in the previous section, both good and bad
outcomes are possible in desegregated schools. It is hard to
argue that operations researchers have no responsibility to help
assure a good outcome. Just as the concept of value-free social
science is difficult to maintain, so is the concept of value-free
operations research. Having decided to study the school busing
problem rather than some other problem, and being compensated
for it, the operations researcher would seem to have some respon-
sibilities beyond presenting a computer printout to school officials.

Even the formulation of a problem within the deterministic
framework of linear programming involves many value judgments.
For example, each of the six linear programming models presented
in the second section of this paper has a different solution,
yet each solution is optimal for the problem as formulated.
Which one is "correct?"

The authors of articles on the use of operations research
techniques for redrawing political boundaries within states are
quite frank about the way their computer programs may be used
for partisan purposes. Nagel states that his program is designed
to implement the value judgments of those responsible for reappor-
tionment. He further notes that it should appeal to incumbent
legislators because it has features built into it for minimizing
change and preserving incumbents in office (92). Garfinkel
and Nemhauser discuss various constraints that could be introduced
into their program in order to maximize the number of "safe"
districts, minimize the number of incumbents who will lose their
present seats, or guarantee one political party a victory in an
election. They also point out that constraints could be used
that would have the opposite effect; for example, constraints
could guarantee a close election (60). Implicitly or explicitly,
value judgments are included in the operations research studies
done for school districts and in the linear programming routines
for assigning students to schools to achieve racial balance.

What more could or should operations researchers do?
Several things are possible in addition to explicitly dealing with
the value judgments involved. Operations researchers could take

on the responsibility for the implementation of the results of their studies. The oft-quoted remark that if one wants to learn how a system works he should try to change it applies to the operations researcher dealing with problems in educational systems.

The way the desegregation of Berkeley's school system was planned illustrates the explicit handling of value questions and the need to consider implementation as an integral part of an operations research study. In Berkeley, the neighborhoods rather than individual students were used as the basic units in planning for desegregation. Although school officials realized that a linear programming solution based on individual students would achieve the desired racial balance with less busing, the retention of the neighborhood concept was an important factor in gaining community acceptance. Children of the same age in a neighborhood go to the same school. Two-way busing, another feature of the Berkeley plan, means that all students are bused at some time. As the earlier discussion of Model 6 pointed out, two-way busing results in more busing. However, two-way busing appeals to a sense of fair play and equal treatment of community members. In brief, consideration of the specific features of the Berkeley community led to a desegregation plan that was implemented. In addition, the retention of the neighborhood concept and the idea of equal treatment were also designed to get more parents involved in school affairs. This involvement was seen as a way to achieve some of the goals of integrated education (42).

Another step operations researchers could take which is closely related to the one above is to study the larger systems within which the school busing problem is embedded. In order

to make predictions about the outcome of desegregation plans and to implement the results of research studies, knowledge of these larger systems is needed.

For example, a very real obstacle to implementation may be the resistance to change of the educational establishment itself. This complex is made up of graduate schools of education; sellers of educational programs, devices, equipment, books, and so forth; and the state and local educational bureaucracies with their control over funds, hiring, and licensure. Many of the findings of the Coleman Report and those of the other studies cited in this paper are very threatening to the educational establishment which has put its faith in physical facilities, curriculum, tracking, guidance counseling, increased teachers' salaries, special programs, reduced class size, enlarged libraries, and so forth. Change will not be easy for the large bureaucracies that educate the teachers and run the school districts. Persons closely connected with education have emphasized the need to shake up the educational establishment in order to change schools. Their recommendations include street academies, open schools, experimental schools, federal regional schools, mini-schools, magnet schools, community control, local accountability, the voucher plan, incentive schemes, and so forth (8, 10, 25, 32, 45, 47, 51, 54, 56, 61, 76, 160, 170, 171, 173).

Operations researchers have not studied the extent to which the structure of the educational complex affects its performance. They could make a real contribution by tracing out the systemic effects of the various recommendations just mentioned. Presumably

some of the skills operations researchers bring to the analysis of problems are the ability to identify key variables, build a model that specifies the relationships among these variables, and evaluate the consequences of adopting various alternatives in terms of some measure of system performance based on goals pursued. The problems of desegregation and integrated education pose a severe test to the abilities of operations researchers.

Looking at the larger systems within which the busing problem is embedded helps ensure that action taken at lower levels is consistent with higher level criteria. Otherwise, changes may not improve overall system performance. Sometimes this approach causes quite a difference in how a proposed solution to a problem is evaluated. For example, one reason for public school education is that it facilitates transactions, and transactions on the school bus are certainly a part of the educational process. Because of tracking and other administrative devices within the school the school bus may be more desegregated or "open" than the classroom. In such a case an "obvious" objective function of the linear programming formulation of the school busing problem -- minimize the total time spent on the bus -- may not be the correct one. Because of the education taking place during the bus ride one could speculate that, within limits of course, one should maximize the time spent on the bus.

Evaluating plans that rely on improved teacher performance to bring about improved student performance requires consideration of the larger system. No doubt improvement in teaching could bring about improvement in student performance, but a look at the larger

system reveals some obstacles. Rewards within the educational system are so structured that good teachers are rewarded by leaving the classroom. Advancement comes by moving out of teaching and into the administrative hierarchy, not by performing well in the classroom and staying there. One may speculate that plans that do not come to grips with how the different groups involved perceive and act upon the rewards and penalties contained in such plans will have little chance of success.

As operations researchers deal with larger systems they move into the arena of social policy. In fact, operations researchers appear to welcome the opportunity to help solve important social problems.[16] A note of warning should be sounded. Operations researchers have to realize that they may be criticized and their suggestions misrepresented if they venture into policy questions concerning desegregation and integration in the public schools. One operations researcher who helped school officials develop a busing plan to desegregate their district found himself testifying in court and subject to stiff cross-examination as a result of a law suit brought to block the proposed desegregation of the school district (74).[17] Operations researchers may even be attacked by the President of the United States. Consider these excerpts from President Nixon's broadcast on busing:

> Many have invested their life's savings in a home in a neighborhood they chose because it had good schools. They do not want their children bused across a city to an inferior school just to meet some social planner's concept of what is considered to be the correct racial balance -- or what is called "progressive" social policy.... I realize that my program will not satisfy the extreme social planners who insist on more busing even at the cost of better education (149).[18]

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There is much that can be done at various levels within the educational system to improve its performance if operations researchers move beyond the limitations imposed by the desegregation point of view. However, not all the problems of education can be resolved within the system no matter how hard it is shaken or changed. Some educational problems are so closely linked to other major societal problems that they cannot be resolved without making changes in other parts of society. Wildavsky suggests that the way to solve some of the educational problems is to first solve some economic problems. Specifically he states that educational policies cannot be separated from employment and income policies. (Housing policies should be added to his list.)[19]

> We have learned some hard lessons. Every time we try to deal with problems of race we end up with symbolic gestures that infuriate everyone and please no one. Why? The American dilemma is a compound of racism suffused with class differences. Since America appears to be richer in economic resources than in brotherly love, it would be natural to tackle economic problems first. Few of us expect a quick solution to the lesser problems posed by large class differences among white people. None is surprised that upper-class whites do not integrate with their lower-class racial cohorts. Yet we persist in following policies that attack racism before economic equality has begun to be established. The result is that neither poverty nor racism is diminished. Disheartened by the magnitude of the change required in racial behavior, unwilling to recognize the full extent of the resources required to improve economic conditions, we are tempted to try a lot of small programs that create an illusion of activity, ferment, and change. But nothing much happens. Confusion is rampant because it looks to some (mostly white) like so much is being done, and to others (mostly black) that nothing is happening. Hence the rival accusations of black ingratitude and white indifference. It is apparent that we should abandon symbolic policies that anger whites and do not help blacks and should concentrate instead on programs that will materially increase the well-being of poor people in the United States. Programs should be large rather than small, and provide tangible benefits to many citizens, not symbolic rewards for a few (184, p. 5).

However, the failure to solve racial problems, including the failure to achieve integrated education, should not surprise us. Rather it should suggest that some individuals and groups benefit by the existence of racism, class differences, and unequal access to educational and job opportunities, and that schools serve other functions than education.

Therefore, operations researchers who study the field of education should consider not only the problems involved in providing equal educational opportunity for children but also the real and immediate problems of millions of adults who because of discrimination or lack of formal education are excluded from many opportunities of life.

And the operations researchers should go even further. Suppose that the "democratization" of education comes to pass; that the rich and poor, the black and white, women and men all receive quality education as far as their abilities will take them; that money, staff, and facilities somehow become available; and that there are no financial, class, or racial barriers to higher education. Then suppose that blacks, women, and other minorities are not discriminated against in employment. What will be the result? Will there really be enough interesting jobs for all? We could find ourselves in the ironical position of facing a problem that some underdeveloped countries now face: what to do with an alienated class of unemployed and underemployed intellectuals. Perhaps another question we should be asking and that operations researchers should be trying to answer is, How will we ever all find satisfaction in an advanced technological society?

To recapitulate, operations research studies of the school busing problem such as those cited in the second section of this paper have helped administrators of school districts devise plans to desegregate their districts and to comply with court orders to end segregation. Studies of busing help to improve student transportation whether the busing is done to eliminate segregation or for other reasons. In addition, linear programming and other techniques are useful in specifying how proposed educational innovations such as educational parks and regional school districts, which entail considerable busing, can be implemented. Operations research studies in these areas are needed. School officials cannot wait for the restructuring of society to make their jobs easier.

If operations researchers are to do more than use standard techniques to solve what are essentially middle management problems in the public sector they will have to address the larger questions of public policy as well. These questions involve substantial amounts of "politics" and change. As Savas pointed out, if operations researchers don't do this then new disciplines such as policy science will (156). An implication of this challenge to the adequacy of present-day operations research to aid in the solution of significant public problems is that the education of operations researchers in universities will have to change. Otherwise, operations researchers will end up by asking public officials, "Why don't you give us some easy problems to solve, like putting a man on the moon?"

APPENDIX

The Judicial, Legislative, and Executive Branches of Government in the School Busing Controversy

Judicial decisions, congressional legislation, and federal administrative guidelines affecting school desegregation increase in number almost daily. A few highlights enable one to place the school busing problem in the context of actions by the three branches of government. Of course, the rapidity of change in this area makes any accounting incomplete almost as soon as it is written.

The landmark judicial decision was the 1954 United States Supreme Court ruling the the Brown v. Board of Education of Topeka case. In that ruling the Court asked the following question, "Does segregation of children in public schools solely on the basis of race, even though the physical facilities and other 'tangible' factors may be equal, deprive the children of the minority group of equal educational opportunities?" The Court answered this question in the affirmative, and went on to conclude that "in the field of public education the doctrine of 'separate but equal' has no place. Separate educational facilities are inherently unequal" (347 U.S. 483). One year later the Court stated how its 1954 decision was to be implemented. The Court ordered that the plaintiffs be admitted to public schools "on a racially

nondiscriminating basis with all deliberate speed" (349 U.S. 294).

For many decades the southern states had dual school systems created by laws against the mixing of races in public schools. This "de jure" segregation was ruled unconstitutional in Brown v. Board of Education. Elsewhere in the United States segregation in schools was largely the result of housing patterns. This "de facto" segregation was considered outside the jurisdiction of the courts. While politicians and school administrators, especially those outside the South, might deplore "de facto" segregation, they need do nothing about it. Of course, from a child's viewpoint the effect of segregation is quite independent of its origin.

In the years following the 1954 Supreme Court decision, the South resisted desegregation; the North tried to ignore it. Neither the executive nor legislative branches of government moved forcefully to eliminate segregation. And segregation in public schools continued. In 1967 the U.S. Commission on Civil Rights in their report, Racial Isolation in the Public Schools, stated:

> In the Nation's metropolitan areas, where two-thirds of both the Negro and white population now live...seventy-five percent of the Negro elementary students...are in schools with enrollments that are nearly all-Negro (90 percent or more Negro), while 83 percent of the white students are in nearly all-white schools. ...In Southern and border cities, although the proportion of Negroes in all-Negro schools decreased since the 1954 Supreme Court decision... a rising Negro enrollment, combined with only slight desegregation, has produced a substantial increase in the number of Negroes attending all-Negro schools. (p. 199)

The Supreme Court repeatedly reaffirmed the findings of Brown v. Board of Education in many cases that came before it.

The continuing resistance to school desegregation in the South led the Court to amplify its earlier rulings. In 1968 in <u>Green v. County School Board</u> the Court struck down a "freedom of choice" desegregation program that operated to preserve a dual school system (391 U.S. 430). As a result, many southern communities were required to pair schools, redraw attendance zones, and shift students and teachers around to achieve desegregation (<u>New York Times</u>, February 15, 1970, p. E2). In 1969 in <u>Alexander et al. v. Holmes County Board of Education et al.</u>, the Court stated that continued operation of racially segregated schools under the standard of "all deliberate speed" is no longer permissible. School districts were ordered to immediately terminate dual school systems based on race and to operate only unitary school systems (396 U.S. 19).

The <u>Swann v. Charlotte-Mecklenburg Board of Education</u> decision of April 20, 1971, was another legal landmark. While not requiring that every school reflect the racial composition of the community and even permitting the existence of a small number of all-black schools in a racially mixed school district, the Supreme Court specifically stated that busing is a legitimate tool to achieve desegregation (402 U.S. 1 -- Preliminary Print). As in all Supreme Court decisions on school desegregation the ruling applied to "de jure" segregation only, not to "de facto" segregation.

Then on January 10, 1972, the federal district court in Richmond, Virginia, became the first court to desegregate schools by removing the barrier that separates a city from its suburbs. The court found that because the school board built its facilities

and arranged its zones so that school attendance was governed
by housing segregation, it was operating in violation of the
United States Constitution. The court ordered that the city school
system (about 70 percent black) be consolidated with those of
two suburban counties (about 91 percent white) in order to deseg-
regate classrooms in the metropolitan Richmond area. This ruling,
if upheld by the Supreme Court, tends to eliminate the distinction
between "de jure" and "de facto" segregation. No metropolitan
area in the country can escape the implications of this ruling
(New York Times, January 13, 1972, pp. 32, 40, 41).

The task of eliminating "de jure" school segregation has
fallen by default on the courts. But the courts are overburdened
and must proceed on a case by case basis. Congressional and
executive action would seem a more logical way to proceed.

In the Civil Rights Act of 1964, Congress outlawed discrim-
ination in public accomodations. The Act states that no federal
funds can be used to support a program embodying racial discrimin-
ation. Because of this provision many southern school districts
decided to meet federal desegregation edicts to avoid a cutoff
of federal funds. The Act also gave the Attorney General new
powers to speed school desegregation. However, the Act forbids
the cutoff of funds if segregation is caused by neighborhood
racial patterns (New York Times, July 3, 1964, p. 1; July 5, 1964,
p. El; August 4, 1964, p. 12; February 15, 1970, p. E2). Thus
Congress maintained the distinction between de jure and de facto
segregation.

Congress usually has contented itself with incorporating desegregation guidelines in educational authorization and appropriations bills. The effect of this has been to give the Department of Health, Education, and Welfare the power to withhold funds as a way of promoting desegregation in southern school districts (New York Times, February 20, 1970, p. 1).

However, in the late 1960s lower federal courts began ruling that some de facto segregation was really fostered and accepted by local officials and thus was unconstitutional. Court orders were issued to a number of school districts in the North to desegregate. Busing then became a national rather than a sectional issue (New Yorker, March 11, 1972, pp. 27-29).

When the judicial decisions on desegregation of schools began to affect major cities outside the South, liberal Congressmen began to change their votes. An analysis in the Congressional Quarterly shows how the shift came about in the House of Representatives between 1968 and 1972. In seven key votes on language about busing in education bills, the pro-busing stance of 1968, 1969, and early 1970 gave way to anti-busing language (San Francisco Sunday Examiner & Chronicle, December 26, 1971, p. 8A). The last vote of the seven surveyed came in November, 1971, when the House of Representatives voted overwhelmingly in opposition to the busing of school children to achieve racial desegregation. Liberal Democrats teamed with Republicans and southern Democrats to prohibit use of federal funds to pay for buses and drivers to carry out desegregation plans and to forbid officials of the executive branch from encouraging communities to use local or state funds for busing (New York Times, November 5, 1971, p. 1).

In February, 1970, Senator Ribicoff of Connecticut called upon his fellow Northern liberals to drop their "monumental hypocrisy" on the segregation issue and to consider that their school systems are almost as unbalanced racially as those in the South. He cited a January, 1970, report by the Department of Health, Education, and Welfare that showed that in the South, 70 percent of black students attended schools 95 to 100 percent black while in the North the figure was 50 percent (New York Times, February 10, 1970, p. 1).

In 1971 Ribicoff submitted a proposal designed to require large cities and their suburbs in all parts of the country to desegregate their schools within twelve years. The Senate rejected his proposal. During the debate Ribicoff attacked Senator Javits of New York for being "unwilling to accept desegregation for his state though he is willing to shove it down the throats of the Senators from Mississippi." Ribicoff continued the attack, "I don't think you have the guts to face your liberal constituents who have moved to the suburbs to avoid sending their children to school with blacks." Ribicoff cited government statistics showing that while 38.1 percent of the black students in the South now attend majority white schools, only 27.6 percent of the black students in the North attend such schools (New York Times, April 21, 1971, p. 1; April 22, 1971, p. 26).

The actions of the executive branch of government in the school busing problem are more complex and thus are harder to summarize than the judicial and Congressional branches. Many agencies and individuals are involved. Arbitrarily, this brief

account will start with the Nixon administration. The statistics
previously cited show that segregation remained widespread in
public schools when he was elected President in 1968.

In a story entitled, "Busing and the President: The Evolution
of a Policy," the New York Times traces President Nixon's involve-
ment with this problem from 1968 to his March 17, 1972, broadcast
on busing (New York Times, March 19, 1972, p. 1). The story
relates that the Johnson administration had set the fall of
1970 as the final deadline for the end of the dual school system.
(Note that this deadline did not apply to de facto segregation.)
The Green v. County School Board decision (391 U.S. 430) was to
be incorporated in the guidelines that the Department of Health,
Education, and Welfare had been using to compel school districts
to desegregate or lose federal aid. Preoccupied with other issues,
Nixon let his Department of Health, Education and Welfare proceed
along these lines. Aroused Southerners protested and after much
discussion, revised guidelines were issued. The federal push
against segregated schools eased. However, lower federal courts
kept applying the decisions of the Supreme Court. In March, 1970,
Nixon issued a statement on busing in which he reaffirmed his
opposition to de jure segregation, his commitment to neighborhood
schools, and his opposition to busing. However, the Supreme
Court decision in the Swann v. Charlotte-Mecklenburg Board of
Education case with its authorization of busing created a new
situation (402 U.S. 1). The Department of Health, Education
and Welfare produced a plan to desegregate the public schools in
Austin, Texas, that called for extensive busing. But on August 3, 1971,

Nixon disavowed his administration's plans to desegregate the Austin public school system. He reasserted his strong opposition to busing as a means of achieving racial balance. He directed Attorney General Mitchell and Secretary of Health, Education, and Welfare Richardson to "work with individual school districts to hold busing to the minimum required by law" (New York Times, August 4, 1971, p. 1). He authorized his press secretary to warn all government employees who flouted those instructions to think about finding other employment.

But again court decisions changed the situation. A variety of lower courts began to break down the distinction between de jure and de facto segregation and to order busing in northern and western cities. Key persons in the administration held a series of meetings to determine what course the President should take. In February, 1972, Nixon ordered a study to determine whether it would be better for the administration to ask Congress for specific legislation or to seek a constitutional amendment to negate the trend of recent federal court decisions requiring extensive busing to achieve desegregation (New York Times, February 11, 1972, p. 1). The upshot of these long, intense deliberations came in Nixon's proposal to Congress in which he asked for, among other things, an immediate halt to all new busing orders by federal courts (San Francisco Chronicle, March 17, 1972, p. 43). Acting Attorney General Kleindienst later testified that Nixon's anti-busing legislation would permit the reopening of every school desegregation case in the country (New York Times, April 13, 1972, p. 1). The Justice Department intervened in Denver, Detroit, Richmond,

and Nashville school desegregation cases seeking a stay in any new busing orders (New York Times, April 27, 1972, p. 1).

In June, 1972, a major education bill passed by Congress and signed by the President contained provisions that would in effect place a moratorium on all new, court-ordered busing for the purpose of achieving racial balance until well into 1973. President Nixon had requested Congress to enact such a moratorium. The bill also contained provisions to discourage communities from using federal funds for busing (New York Times, June 9, 1972, p. 1, San Francisco Chronicle, June 24, 1972, p. 1).

In summary, the Supreme Court in a series of rulings has done the most to desegregate schools. Congress did not take leadership. Although a majority of the members of Congress supported the elimination of de jure segregation in the South, their views changed when judicial decisions threatened de facto segregation in the North and West. President Nixon has established his control over the Department of Health, Education, and Welfare's actions in school desegregation cases, and is pushing legislation to curb the effects of court decisions. Desegregation in metropolitan areas remains the crucial area. Even in the South most of the desegregation has occurred in small cities and rural areas (New York Times, April 21, 1971, p. 29).

NOTES

1. In Denver, Colorado, where students are bused to achieve racial
balance, dynamite was used to blow up one-third of the city's
school buses. Forty-six vehicles were destroyed in this act of
sabotage (140). "The Battle Over Busing" was featured on the cover
of *Time* magazine. The article reported the fire bombing of
ten school buses that were to be used to carry out court-ordered
busing in Pontiac, Michigan (169). In Lamar, South Carolina,
state police used tear gas and clubs to beat back a mob of 200
white men and women armed with ax handles and baseball bats who
attacked three school buses bringing black children to a formerly
all-white school (141).

2. A comprehensive view of the many difficult problems faced
by operations researchers when they prepare plans to desegregate
a large metropolitan school district and of the quantitative
methods used to resolve those problems may be found in a series
of eight research memorandums and two working papers prepared
by staff of the Stanford Research Institute. Their summary report
contains a description of the published material available (129).
This material gives one an appreciation of the data needed, the
level of sophistication on analysis required, and the complexity
of the technical problems involved in developing plans to achieve
racial balance in a school district with 125 schools, 4 large

racial groups (White, Spanish, Negro, Oriental) and a projected
1971 enrollment of some 83,000 students.

3. Berkeley was the first city of substantial size to completely
desegregate its school system through two-way busing. Some details
of this plan are discussed in the next section.

4. Any school district, no matter what its racial composition,
may be characterized by the homogeneous model if divided into a
sufficiently large number of tracts. The trade-off between the
use of the simpler homogeneous model and the increase in the num-
ber of tracts that may be needed to make the homogeneous model
applicable depends upon the particular situation in a school dis-
trict. Therefore, an operations researcher should make a careful
analysis of the demographic composition in the district under
study before drawing tract boundaries and building a linear
programming model.

5. A study done by Stanford Research Institute for the San Fran-
cisco Unified School District demonstrates the wide variety of
information that operations research studies can generate for use
in administrative decision making (68, 86, 128, 129, 131, 135,
164, 165). A further example of what analytical techniques can
do is illustrated by the Lambda Corporation's study of alternative
ways to desegregate 29 school districts in 18 states. The study
shows that segregation could be largely eliminated with relatively
little additional busing beyond what the districts are now doing
(150, 181).

6. Numerous studies have investigated the effects of a wide range
of variables on achievement test scores. These variables include:

school characteristics (e.g. full-time librarian, free lunch
program, music teacher, speech improvement classes, drama club,
social class level of school, racial composition of school,
types of science laboratories, curriculum, library volumes per
student, pupil/teacher ratio, school size, guidance facilities);
student, family, and home characteristics (e.g., real father at
home, real mother at home, five or more brothers and sisters,
parents' daily discussion of school, student's academic aspir-
ations, student's attitude toward staying in school, student's
feeling of power over his environment, self-image of student,
items in the home such as encyclopedias and daily newspapers,
parents' education, parents' educational desires for student, years
in segregated schools, having white friends); characteristics
of classmates (e.g., proportion planning to go to college, percent
whites in classroom, social class composition of classmates);
teacher characteristics (e.g., percent who majored in academic
subjects, percent who prefer white students, average highest
degree earned, average salary, average years of experience, percent
who want to teach here, percent of teachers reporting racial
tension in the school); and so forth. All this activity may
reflect one method of social science research; namely, if we
correlate everything with everything, surely something interesting
will turn up.

7. The Coleman Report resulted from a request by Congress in the
Civil Rights Act of 1964 that the U.S. Office of Education study
and report on the lack of availability of equal educational
opportunities for individuals by reason of race, color, religion,

or national origin in public schools in the United States. The study undertaken was the second largest social science research project in history involving as it did testing some 570,000 students and collecting data on 60,000 teachers and 4,000 schools. The large research staff that undertook the study was headed by Professor James S. Coleman of Johns Hopkins University (91, p. 5).

8. The Coleman Report generated much discussion and controversy (e.g. 1, 12, 13, 16, 17, 91, 136, 161). The Harvard Educational Review devoted its Winter 1968 issue to a series of articles about the Report. In replies to critics and in subsequent articles Coleman amplified his views (32, 33, 34, 35, 36, 37, 38, 39).

9. Cohen, Pettigrew, and Riley in their re-analysis of data contained in the Coleman Report conclude that the Report over-stressed the impact of school social class (30).

10. The opposition to putting low income housing in the suburbs comes from many sources. President Nixon said he would not use federal leverage to force local communities to accept low and moderate income housing against their wishes (145, 176). Other powerful opposition forces include Democratic Congressmen from Northern states (152), the U.S. Department of Housing and Urban Development (180), the New York State Assembly (108), and the Chicago Housing Authority (180).

11. In 1970 CORE formally abandoned its support of school deseg-regation in favor of a separatist plan in which blacks would control the schools in their communities (143). One of the resolutions adopted by the 1972 National Black Political Convention condemned

the notion that black children are unable to learn unless they are in
the same setting as white children (148).

12. However, a recent survey among 54,000 college-bound black
students found that about two-thirds of such youths believe racial
integration to be not only good but also necessary (111).

13. Recent court decisions may permit state legislatures to equalize
the tax burden for the support of schools. For example, in 1971
the California Supreme Court in Serrano v. Priest ruled that a
public school financing system that relies heavily on local
property taxes and causes substantial disparities among individual
school districts in amount of revenue available per student invid-
iously discriminates against the poor and violates the equal
protection clause of the Fourteenth Amendment (158). At present,
wealthy school districts are able to raise large amounts of money
with a low school tax rate. There have been similar decisions in
other states. These decisions have been appealed to the Supreme
Court (151)..

14. Glazer, in his challenging analysis of busing and the attendant
problem of what equal protection of the law means in a multi-racial
and multi-ethnic society, concludes by suggesting a policy of
benign neglect. "The judges should now stand back, and allow the
forces of political democracy in a pluralist society to do their
proper work" (64, p. 52).

15. In interviews for a story about the desegregation of schools
in Coy, Alabama, a reporter for the Wall Street Journal asked local
residents the question, "When does a ride to school on a bus become
busing?" The answer given by one white mother was, "As long as

we don't have niggers on there, it's not busing. Busing is making

the white children get on with the niggers" (178).

16. In the past few years the meetings of the Institute of

Management Sciences and the Operations Research Society of America

have devoted an increasing number of sessions to important areas

of the public sector such as health care, education, transpor-

tation, air pollution, law enforcement, and water resource manage-

ment. The theme of the 19th International Meeting of the Institute

of Management Sciences held in March, 1972, was "Management,

Science, Ecology, and the Quality of Life." More articles dealing

with urban problems are appearing in the journals of the two societies.

The August, 1970, issue of Management Science was entitled "Urban

Issues" and the May-June, 1972, issue of Operations Research was

entitled "Urban Problems." However, there appears to be a gap

between the aspirations of operations researchers to study impor-

tant problems in the public sector and to significantly affect

public policy decision-making and the actual performance of opera-

tions researchers in the public sector. All too often the papers

presented at the meetings or published in the journals deal with minor

parts of policy questions. In many areas of the public sector

the use of operations research models and techniques that have

worked well in industrial settings seem to capture and quantify

relatively unimportant parts of social problems. A big challenge

operations researchers face is to develop models and procedures to

deal with public sector problems at the policy level.

17. I wish to thank Professor Howard M. Taylor for telling me of

his experience as a witness and for furnishing a copy of the news-

paper account of his appearance in court.

18. In arguments about the busing of students to achieve racial balance in schools, opponents of busing often pose the question, "Do you want to spend money for education or for busing?" The thrust of their argument is, of course, that if busing is undertaken money will be diverted from education to transportation, to the detriment of education. In this argument the opponents make several assumptions that may not be correct: (1) The cost of busing to achieve racial balance is substantial. (2) Desegregation per se is not an important goal. (In effect, this means that the 1954 Supreme Court finding in Brown v. Board of Education of Topeka that the segregated education of black children "generates a feeling of inferiority as to their status in the community that may affect their hearts and minds in a way unlikely ever to be undone" is either incorrect or of little consequence.) (3) Whatever beneficial effect desegregation may have on educational performance, it is not worth the cost of busing. (4) Educators know what makes for quality education, and further, if there is no busing, the school board will use the money that busing would cost to support programs that achieve quality education.

19. Cohen makes a similar arguement. He also points out that attention has been focused on schools rather than on employment and housing because schools and their governance are far more visible and accessible (29).