Managerial Strategies and Behavior in Networks:

A Model with Evidence from U.S. Public Education*

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Public managers often operate in settings involving public and other institutional actors networked in patterns of interdependence. Considerable attention has been focused on networks, as scholars in a number of countries have sought to understand and analyze the phenomenon (for instance Bogason and Toonen 1998; Bressers, O'Toole, and Richardson 1995; Hufen and Ringeling 1990; Jordan and Schubert 1992; Kickert et al. 1997; Klijn 1996; Marin and Mayntz 1991; Marsh and Rhodes 1992; O'Toole 1997; and Provan and Milward 1995). While much attention has been directed to explaining the emergence of networked public management contexts and to theorizing about how managerial action is likely to be influenced by and to influence such settings, a range of additional issues has yet to be explored.

To date, researchers have not offered careful specification of the relevant models even though such work is a necessary part of developing sound explanations. Linking managerial actions in networks explicitly with assessments of actual program performance is also important.

These issues are dealt with directly in this paper. In particular, we address these core questions: Do public managers' efforts in and on the networks in which they operate affect program performance? And if so, how? In focusing on these

subjects, we use a mathematical model of public management as developed in other recent work (O'Toole and Meier 1999, 2000). We isolate key features of the model for systematic empirical examination in one important policy sector: public education in the United States. We then investigate how the actions of these public managers in interacting with their networked settings contribute to the educational performance of their jurisdictions. We do so via analysis of data from approximately 500 school districts in one large, diverse American state -- Texas -- while controlling for an array of other influences on performance.

Our prime focus in this study is to explore with some care the impact of a strategic choice public managers often face: how much energy and effort should they devote to operating in the network (i.e., outside the core production organization) versus their efforts inside the organization? We are interested in testing the notion that the strategic choice to manage the network makes a measurable difference in program results. We also want to explore evidence on how managers who operate in their networks are able to use their contexts to help make things work better.

Networks, Performance, and Public Management

Public managers often operate in network settings in which their own organizations are interdependent with a congeries of other actors over whom they exercise little formal control. By

network we mean a pattern of two or more units, in which not all the major components are encompassed within a single hierarchical array (O'Toole 1997). Actors in networks often inhabit bureaucratic units, but these units (or parts of units) are in turn connected with other units outside the lines of formal authority. While some programs are explicitly mandated to operate via complex networked institutional arrangements (for systematic evidence, see Hall and O'Toole 2000), other forms of networked action often emerge through voluntary, negotiated, self-organizing actions of participants (Gage and Mandell 1990; Ostrom 1990). In the era of the so-called "hollow state," increasingly large slices of public action are structured through complex multiparty relations, often involving contract ties and intergovernmental links (Milward and Provan 2000). Network nodes can consist of units spanning agencies, governments, and sectors -- including public-private arrays. These developments are not restricted to one country but have been documented widely (examples include Bogason and Toonen 1998; Kickert et al. 1997; O'Toole 1998; Peterson and O'Toole 2001; and Scharpf 1993). Network arrangements can vary on a number of dimensions, but there is little question networks are crucial for the delivery of many important public programs and services (Frederickson 1999).

How public managers undertake their responsibilities in network settings and what impacts such efforts have, therefore,

are obviously central issues. With regard to the former, a strong case can be made that management in networks is different in important respects from management within a hierarchy (Gage and Mandell 1990; Klijn 1996; O'Toole 1997, 2000; Provan and Milward 1995). Recent research on local governments in the United States offers some persuasive evidence in this regard (Agranoff and McGuire 2000).

Does managing in the network make a difference in how well public programs work? Until recently, little systematic research has investigated public-managerial impacts in general, let alone the network variant. (For recent analyses of the governance inputs to performance, see Lynn and Heinrich 2000; Lynn, Heinrich and Hill 2000.) Still, given the indications that effective management in network settings calls for somewhat different actions and approaches from management in a relatively straightforward hierarchy, an investigation of managers' network impacts on performance is apropos.

When public managers operate in network settings, of course, they face many options for action and many strategic choices. Arguably the most important of these is the decision about how much time and energy to work in the network, and in which directions (with which other network actors). After all, managers must also consider that perhaps efforts should be devoted to buffering program activities from the potentially

turbulent and uncertain network impacts. And managers also must devote attention to the internal management of their units. Many other strategic choices confront managers who function in networks, of course, including which issues to raise with others in the network, what positions to take, what style to exhibit, how to balance short-term versus long-term needs, and so forth. But the foundational choices are how much and with whom to undertake network management itself. We concentrate on this topic in the analysis that follows.[1]

The Networked World of U.S. Public Education

We explore the core issue in an important empirical policy context that has rarely been investigated by public management scholars: education.[2] In the United States, the public educational function is conducted by locally managed school districts, typically designed as separate, special-purpose governments, and not formally interdependent with other production units. The special-district design itself was developed precisely to buffer educational efforts from the

[1]We are analyzing some additional strategic choices made by network managers via further empirical research not reported in this study.

[2]Although the education literature rarely includes management explicitly, some of that literature is relevant to the study of public management (see Bessent and Bessent 1980; Duncombe and Yinger 1997; Gross, Mason, and McEachern 1958; Hanushek 1986; Levin 1997; Purkey and Smith 1983; Zeigler, Kehoe and Reisman 1985); and Zigarelli 1996.

potentially confounding actions of other governmental actors (Tyack 1974).

Nonetheless, the technical and political demands placed upon school district superintendents -- the chief administrators of the districts -- encourage them to develop, solidify, and use ties with other important actors in their environments. The most important of these are typically their own school board (the elected body responsible for sketching broad policy for the district), the relevant state-level educational department (a source of primarily formula-based funding that varies in importance from state to state, as well as a unit that issues some regulations that apply to the local districts), state-level legislators (who frame general educational policy), local business leaders (who can play crucial roles in supporting the locally enacted taxing decisions that drive much of school district revenue), and other superintendents (professional colleagues and sources of experience and innovation in the turbulent world of public education). School districts, in short, are organizations that are imbedded in a network.

In contemporary American public education, where funding issues are critical and many ostensibly separate policy problems (e.g., drug abuse, broken families) intrude in highly visible ways in the educational process, schools have become battlegrounds for a range of policy disputes (Chubb and Moe 1990;

Meier and Stewart 1991). Efforts to reform schools and influence educational policy are frequently debated and adopted in realms where the school district is only one voice among many. Accordingly, superintendents may have reason to devote managerial energy and effort to understanding and leveraging their networked environment. This network orientation is more extensive in the U.S. context than in most other countries. An OECD study of 14 national education systems found that more education decisions had to be made in consultation with others (44%) in the U.S. than in any other Western democracy (OECD 1995: 52). U.S. systems were also rated the lowest in terms of local (that is, school district) autonomy.

Superintendents manage their districts — a headquarters office along with sets of schools, which in turn are managed by school "principals" (as the term is used) — within this broader constellation of other actors, who may be potentially important as sources of funds, staff, ideas, guidance, other resources, and turbulence. The extent and kind of network to build, maintain, and use is a matter largely under control of the superintendent.[3]

Network management, then, is an opportunity available to

[3]Some of the networked relationships are mandatory and imposed from the environment. An instance is the authority given to state auditors to check on fiscal matters. In most cases, however, the superintendent can develop new relationships or seek to alter mandated relationships in such a way to benefit the district.

those superintendents who recognize their interdependence and opt to try to manage it actively. To network, in this context, is therefore a key strategic option; and this is the issue we focus on in the empirical portion of this study. The next section sketches a mathematical model of the impact of public management on public program performance and then offers and justifies more simplified renditions for testing.

The Model and Its Refinements

In recent work, we have modeled the impact of public management on program performance (O'Toole and Meier 1999, 2000). We emphasize that programs' institutional arrangements differ greatly, and these variations are likely to be consequential for the role and influence of managers. We are particularly interested in that aspect of variation reflected in a continuum of stable and well-buffered hierarchy (H), at one pole, and flexible, more open network, on the other.

To treat seriously the general tendency for programs and program performance to change incrementally, we build on an autoregressive function. Adjustments to performance can be caused by a wide array of forces, including myriad factors in the environment -- and also the efforts of managers. Indeed, there are reasons to expect public management in networks to matter even more than otherwise (O'Toole 2000). The general model is:

$$[1] \quad O_t = \beta_1(H+M_1)O_{t-1} + \beta_2(X_t/H)(M_3/M_4) + \epsilon_t$$

where

O is some measure of public program output or performance,

H is a measure of hierarchy normalized to range from 0 (pure network) to 1 (pure hierarchy),

M denotes management which can be divided into three parts

M_1 management's contribution to program stability through additions to hierarchy/structure,

M_3 management's efforts to exploit environmental changes and forces,

M_4 management's effort to buffer environmental shocks,[4]

X is a vector of forces in the program's environment,

ϵ is an error term,

the subscripts for O, X, and ϵ denote time periods, and

β_1 and β_2 are estimable parameters.

The several M's reflect the multiple functions or activities of management. The first term of the model can be considered the internal or structural portion; the second term captures the environmental segment. Public management is important in both the structural and the environmental component of the model. Structure also appears in each term, structural stability contributing to program maintenance (represented in the first term) and also creating a barrier to the environmental forces (in

[4]We use the term M_2 to designate the overall managerial effort toward the networked environment, including both M_3 and M_4. That, is, $M_2 = M_3/M_4$.

the second term).

The model is interactive and nonlinear, thus reflecting the complex depictions of public management and its influence, as recounted in the case study literature (O'Toole and Meier 1999, 2000). Management is seldom characterized as simply one more input to performance.

Although equation [1] is built upon the most compelling features of the existing literature, the only way to determine its validity is through systematic empirical testing. The model presents so many issues that testing on all aspects of the argument cannot be conducted in a single research design, let alone with a single data set or in a single context. Our approach to testing here, therefore, is to initiate systematic investigation with simplified forms of the model to probe critical elements.

An early test on the link between network management and public program performance is an ideal place to start. We are particularly interested, therefore, in probing the externally-oriented portion of the model. In particular, we want to isolate the impact of M_2 (where $M_2 = M_3/M_4$), that is, public management aimed at tapping and leveraging the opportunities presented by the actors in the environment of the core unit, while also protecting the program from hostile or disruptive forces. This means the basic research issue to be investigated has to do with

the second or environmental term in the general model, and in particular with the M_2 specified in that term.

Rearranging terms in equation [1] yields the following:

$$[2] \quad O_t = \beta_1(H+M_1)O_{t-1} + \beta_2 X_t M_2(1/H) + \epsilon_t$$

The first term in an autoregressive model such as this would surely be the dominant one in empirical settings: current performance can be expected to be heavily driven by past performance. Our primary interest, nonetheless, is in the second term. We want to know whether exerting managerial skill and effort in the network matters for program output. If it does, the impact of M_2 over more extended time periods can be expected to be considerable, as it feeds into output through each cycle (via the lagged dependent variable) and thus amplifies its impact.

Two options for exploring the second term can be indicated, each simplifying the general model in reasonable ways. One way would be to retain the autoregressive feature as well as the key elements representing network management (M_2) and environmental forces (X), while screening out the other managerial functions as well as the structural variable (H). There is no prima facie reason to expect the other aspects of public management within a given case to covary with the network management function so the

term M_1 can be dropped from a simplified model.[5] The H terms, as well, can be omitted for present purposes. While the structural setting matters, the empirical context we are examining consists of a set of managerial cases highly similar in basic structural features. All are not only in the same policy sector; they are also the same particular type of program setting, institutional design, and managerial level: local public school system superintendents. By selecting a set of cases where public managers confront structurally similar settings, structural variation is minimized and we can examine their strategic choices about how to interact in the network without confounding impacts arising from widely differing structural contexts.

Accordingly, then, a simplified version of the model can be considered:

$$[3] \quad O_t = \beta_1 O_{t-1} + \beta_2 X_t M_2 + \epsilon_t$$

Equation [3] is equation [2] following removal of H and the other managerial form, M_1, as variables. The model in this form is clearly underspecified, but the simplification does allow for testing of important components of the general model.[6] Using

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[5]The actual correlation between network management and interaction with one's school principals (a hierarchical form of management, thus part of M_1), in the data analyzed below, is .18 suggesting that while the two are distinct, they are not contradictory.

[6]Underspecification is clearly less of a problem in the autoregressive form of the model since any omitted variables are likely to affect current outputs via past outputs. Only those

[3], we can test the proposition that network management matters for performance. And we can also explore whether and how networking managers deal with shocks or perturbations from the environment (X) in fashions different from managers who do not network. These are substantial advantages.

One disadvantage that this version carries, nonetheless, is that, given the degree of dominance that the autoregressive term exerts in the model, detecting the impact of M_2, which appears in the much smaller second term, may be difficult. For this reason, an empirical test involving this form of the simplified model can be considered as a rather stringent one.

Another adjustment could also be useful to examine. This version drops the autoregressive term altogether, in the interest of focusing on the environmental impact itself. Thus:

$$[4] \quad O_t = \beta_2 X_t M_2 + \epsilon_t$$

Estimating this form means sacrificing some further explanatory power for the purpose of conducting an empirical test more sensitive to the operation of M_2 and its interaction with a matrix of environmental forces.

Both versions, [3] and [4], are included in the analysis that follows. Despite the fact that these forms of the model

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variables that affect current outputs but not last year's outputs, therefore, are likely to be a problem. The greatest concern should be whether there are omitted factors that covary with elements included in the model.

omit some influences on program performance, they are not themselves so simple. Each includes a *particular* kind of public management contribution, and each specifies a nonlinear relationship between management and the forces in the networked environment. Each, in other words, represents a more complex model than the linear, additive versions more typical in multivariate analysis. A linear version of the simplified model depicted in equation [4] is:

$$[5] \quad O_t = \beta_2 X_t + \beta_3 M_2 + \epsilon_t$$

Here network management would make a difference, but not by interacting with the set of environmental forces. Similarly, a linear version of the autoregressive simplification, equation [3], can be depicted in like fashion:

$$[6] \quad O_t = \beta_1 O_{t-1} + \beta_2 X_t + \beta_3 M_2 + \epsilon_t$$

Estimating [5] or [6] empirically would constitute a test, generally speaking, of whether network management matters; but the simplified forms of our model, [3] and [4], must also be explored to check for the nonlinear relationships that, we have argued, seem to be called for by the extant case-study depictions.

The following hypotheses are the focus of the current investigation:

H1: *Network management matters – in a positive direction – for program performance.* School system output is higher if

superintendents exert management effort in the network surrounding them.

H2: *Network management matters for how management relates to both educational system inputs and environmental perturbations.* In practical terms, network managers deal with environmental shocks in different ways than do those public managers who do not manage in the network. Network management interacts in a nonlinear fashion with the matrix of environmental forces to which school districts are exposed.

H3: *The way that network managers tap their surroundings is to exploit opportunities and buffer impediments to program performance.* That is, the form of the nonlinear function can be expected to show network managers tapping resources in their networked environments to enhance program performance. To the extent that environmental shocks challenge or threaten program performance, network managers can be expected to protect the core performance bureaucracy from these forces.

The next section provides information on the data, context, and procedures used in empirical testing. Findings are then presented and discussed, and some implications are sketched.

Methods

The Units of Analysis

We conducted our empirical test of networking management styles and performance on a subset of Texas school districts. All district superintendents were sent a mail questionnaire to collect information about management styles, goals, and time allocations. A follow-up contact produced a return rate of 55%. Of these 507 responses were useable in our analysis.[7] We pooled five years (1995-99) of data on performance and control variables to produce a total of 2535 cases for analysis. All data other than the survey were taken from the data sets of the Texas Education Agency.

As mentioned earlier, school districts in the United States are generally independent[8] local governments with their own taxing powers; all districts in the sample are organized in this way. They are also subject to both state and federal rules and regulations and receive funds from both sources. The amount of state funding and state control varies from state to state. The

[7]Districts that responded to the survey were no different from nonrespondents in terms of enrollment, enrollment growth, students' race, ethnicity and poverty, or test scores. There were slight differences in a few other factors. Respondents had .48 more students per class, paid their teachers $200 more per year but had annual operating budgets of about $100 per student less.

[8]Independent means that the school district is not subordinate to another unit such as a city. Independent districts have their own elected board, have the ability to tax and set budgets, and acquire bonding authority by a vote of the residents.

state of Texas pays for approximately 50% of the costs of education, but its oversight is generally limited to issues of accountability (testing, attendance, time in class, number of courses, etc.). In contrast to other states, the Texas system is considered relatively decentralized with most authority residing with the local school districts. Each district determines its own curriculum and makes all its own personnel decisions.

Although schools and school districts are the most common public organizations in the United States, they have some distinct characteristics. Schools districts are highly professionalized with elaborate certification processes for various occupations. The organizations themselves tend to be highly decentralized with a great deal of discretion vested at the street level (classroom). The findings here, if they can be generalized, would be applicable to similar types of organizations.

Measuring a Management Networking Style

If managing in a network has a behavioral as well as a structural dimension, then one should be able to measure networking differences -- the behavioral dimension -- even across program settings that are ostensibly similar in structure, including those with core units that are hierarchies.[9] A network

[9]Our formal presentation of theory (see O'Toole and Meier 1999) holds that structures and management are reciprocally related. One function of management is to create, modify, and

management style would be characterized by greater interaction with environmental actors who are not direct line subordinates or superiors. In the present case of school superintendents, we have selected five sets of actors from the organization's environment -- school board members, local business leaders, other school superintendents, state legislators, and the Texas Education Agency. We asked each superintendent to note how often they were in contact with each of these others, on a six point scale ranging from daily to never. Superintendents with a networking management style should interact more frequently with all five other sets of actors than should a superintendent with a traditional hierarchical management style. A composite network management style scale was created via factor analysis (see Table 1). All five items positively loaded on the first factor producing an eigenvalue of 2.07; no other factors were significant.[10] Factor scores from this analysis were then used

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maintain structures. As a result, whether the behavioral dimension that we measure here represents "management" or "structure" is less important. We attempted to sort out these precursors by limiting the analysis to districts with the same superintendent over this five year period, and the result were similar to those presented here.

[10]In our measure of M_2, we include school boards as an element of the networked environment of the superintendent. Since the board-superintendent relationship is designated in principal-agent form, it might be argued that the tie is "internal" to the district, even if not internal to the educational bureaucracy and its day-to-day operations. This interpretation would argue for a recalculated M_2 measure based only on superintendents' interactions with the other four sets of

as a measure of management networking or M_2 with higher scores indicating a greater network orientation.

[Table 1 about here]

Clearly, this measure is simplified. It ignores all aspects of networking aside from frequency and direction -- for instance, skill, reputation, and a number of strategic considerations.[11] Further, it taps a particular kind of networking activity: interactions of managers in clusters of dyadic interactions. Networks can range considerably in the extent to which they are integrated and the degree to which all actors are directly linked to the full range of others. Still, the measure taps the effort managers choose to put into managing externally, in the

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actors identified here. We treat school boards as part of the environment in the analysis that follows since we think that on balance this notion is more appropriate, but we have also performed the entire set of analyses again with M_2 measured only on the other four types of interactions. The results are very similar to those reported here. Omitting boards from the study strengthens the impact of M_2 on performance modestly in the linear versions of the simplified model and weakens slightly the evidence on nonlinearity. The correlation between the two measures of network management is .96. The network management style factor correlates at -.27 with time spent managing the district (in contrast to time spent in contacts outside the organization).

[11]This paper is our first empirical step in operationalizing our model. It is part of a larger research agenda; future work will be devoted to measuring and testing how other aspects of management might affect program and organizational performance.

network.[12] Furthermore, the factor-analytic results suggest that the notion of network management as a strategic choice is a coherent concept that makes empirical sense.[13]

The Dependent Variable

Our measure of program output[14] or performance (O) is the percentage of students in each school district who pass state-required, standardized reading, writing, and mathematics tests each year. While tests such as these clearly do not measure the entire student learning experience, they are frequently used in assessments of the effectiveness of schools and school districts (Jencks and Phillips 1998; Hanushek 1986). At a minimum, schools should be expected to produce students who have basic reading and math skills, and pass rates on these exams serve as good indicators of how schools perform in furnishing students with these skills. The exams themselves are highly salient, and results are front-page news when released. The importance of the exam scores suggests that they should be a relatively good

[12]Clearly, both "sides" can initiate interactions. Anecdotal evidence suggests that skillful superintendents generally do not wait passively to be contacted.

[13]Networking can, of course, occur at other levels of the organization and this measure will underestimate total networking by the organization. Some of the network links are also clearly more important than others, and equal weighting might obscure this. These and other measurement problems are likely to attenuate any relationships found.

[14]In policy analysis terms test scores are an outcome rather than an output.

performance measure for an assessment of management activities.[15]

Environmental Variables

Environments provide both opportunities and constraints (X variables). Although program environments in general and those of school districts in particular are complex, we simplify our analysis by drawing from findings in the research literature on educational policy (for example, Hanushek 1996; Hedges and Greenwald 1996) and focusing on only two sets of environmental variables -- one cluster for the task difficulty (or constraints) facing the unit and the other for program resources (or opportunities). Task difficulty reflects the truism that some students are easier to educate than others. The literature consistently finds that poverty and race are correlated with greater education problems (Jencks and Phillips 1998). Poverty and race are associated both with a lack of educational resources in the home and with other factors (e.g. single-parent households) that can affect student learning. The three specific measures of environmental constraints that we include are the percentage of black students, the percentage of Latino students, and the percentage of poor students (measured as the percentage of students eligible for free school lunch programs). Each of these control variables, as a constraint, should be negatively

[15]Our measure of network effectiveness differs from much of the literature which uses survivability (see Yuchtman and Seashore 1967; Provan and Milward 2001).

related to student performance.

Although the relationship between resources and student performance is controversial in education policy (Hedges and Greenwald 1996; Hanushek 1996), students of organization assume a direct linkage between resources and performance (Simon 1947; Thompson 1967). Recent education research using well-crafted longitudinal data sets and well-designed experiments generally shows that additional resources are associated with higher student performance (Evans, Murray and Schwab 1997; Wenglinsky 1997). Five measures of resources are included -- average teacher salary, average class size, average years of teacher experience, percentage of noncertified teachers, and percentage of funds from state government. Teacher salaries and teacher experience should be positively related to student performance; class size and teacher noncertification should be negatively related to performance (one can think of either small classes as a resource or large classes as a constraint). Funds from the state are included because state government provides a large portion of district resources, especially in low income districts.

School districts differ from other organizations in that they have less control over their inputs and resources. Public schools have to educate everyone who shows up; they have to adjust how they educate students to differing student needs.

Similarly, the school district only raises a portion of its resources via its own taxing powers (and even that portion is limited by public support). It must convince other governments and other actors to provide it money that is needed to hire staff, building facilities, and educate students. Students and resources, therefore, should be considered as part of the school system's environment, as the X variables in our models.

Because our data are pooled (five years), we have also included a set of control variables to deal with the time-series aspect of the data set. Dummy variables for individual years were included in each equation. These dummy variables were always jointly significant reflecting the overall positive trends in the student performance. To deal with the other source of problems related to pools, we assessed the cross-sections of each equation for heteroscedasticity problems. The levels of heteroscedasticity were modest and had little impact on the findings presented here.

Findings

Our strategy of analysis will be to begin with relatively simple models and build up to more complex variants that provide stronger tests of our theory. We will start with tests to determine whether management matters at all in the performance of these school systems (thus testing H1) then move to tests of whether the relationship of management to performance is

nonlinear; and if so, how (H2, H3). A second, more stringent, set of tests will then take place within an autoregressive model of program performance.

Our simplest nonlinear model of management, equation [4], is reproduced below:

$$[4] \quad O_t = \beta_2 X_t M_2 + \epsilon_t$$

As the first step to assessing this relationship, we begin with the linear, additive relationship depicted earlier:

$$[5] \quad O_t = \beta_2 X_t + \beta_3 M_2 + \epsilon_t$$

In this model the question is whether management matters when one controls for the constraints and resources facing the school district (the vector of X variables). The test of this model, handled via standard OLS multiple regression, appears in Table 2. The column designated "Base Model" contains all the X variables, and the next column ("Network+") adds the management measure to this equation. The X variables generally predict as expected with negative relationships for all constraints (percent black, Latino and poor students), noncertified teachers and class size, and positive relationships for the resource variables (with the exception of state aid). When the network management variable is added to this equation, it produces a strong positive coefficient. Programs characterized by greater network management are programs that generate relatively higher outputs. Because the management variable is measured as a factor score

(mean = 0, standard deviation = 1), virtually the entire range of management falls between +3 and -3. This range suggests that network management may contribute as much as 4 percentage points to a district's pass rate, all other things being equal.[16] Although this variable is by no means the most important factor in performance, changes of this magnitude are substantively significant and well worth pursuing. By this test, H1 is supported.

[Table 2 about here]

Nonlinear relationships can be tested in a variety of ways. Our theory suggests that management interacts with the resources and constraints in the environment, that it exploits resources and mitigates constraints. One form of that relationship was shown in equation [4]:

$$[4] \quad O_t = \beta_2(X_t M_2) + \epsilon_t$$

The classic way to test this relationship is to compare the interactive form to the linear form in the following equation:

$$[8] \quad O_t = \beta_2(X_t M_2) + \beta_3(X_t) + \beta_4 M_2 + \epsilon_t$$

The key test would be whether the vector of coefficients β_2 is statistically significant, that is, it adds additional explanatory power to a linear model. The problem with this model is that the interaction terms frequently generate so much

[16]Exactly how network management can influence performance is discussed below.

collinearity that individual coefficients can not be precisely estimated. The actual coefficients are important because we have specific hypotheses about how management affects the environmental variables, that is, it should increase the impact of resources and reduce the impact of constraints.

To test these specific estimates, an alternative approach is necessary. We divide the sample into two parts -- districts with high network management (those with scores above 0) and districts with low network management (scores below 0):

$$[9] \quad O_t = \beta_2(X_t) + \epsilon_t \quad M_2 > 0$$

$$[10] \quad O_t = \beta_2(X_t) + \epsilon_t \quad M_2 < 0$$

The results of these models produced by splitting the sample are shown in Table 3. The constraints can be examined first. Our theory suggests that for high levels of network management, the size, or impact, of each of these should drop in absolute value. Although the coefficients do not change dramatically, in two cases (blacks and Latinos) the hypothesis is confirmed. In one case (low income) it is not. In terms of the four cases of resources (state aid is not significant and can be ignored), three are as predicted. Districts with more network management get more out of teachers' salaries and reductions in class size and are less affected by noncertified teachers. Teacher experience shows an interesting pattern of significance for low-networked districts and insignificance for the high-networked

districts. While this result ostensibly contradicts our hypothesis, it means that high-networked districts are not affected by having less experienced teachers.

[Table 3 about here]

Five of the seven relationships found in Table 3 are consistent with our nonlinear, interactive theory of management. Although this might not seem like strong support for the theory, examining the individual coefficients provides additional corroboration. Most of the relationships differ from each other in only marginal ways. The differences between four sets of the relationships, however, are substantial. Districts characterized by a high network management style get 2.7 times the impact from higher teacher salaries, receive 5.5 times the impact from smaller classes, get only 42% of the negative impact of noncertified teachers, and are not affected at all by inexperienced teachers.[17] Even with the relatively crude test presented here (a simple measure of managing in the network, a deliberately underspecified model), therefore, management does matter; and it matters by interacting with program resources and constraints in predicted directions. H2 (nonlinearity) and H3 (direction of relationships) are supported by these tests.

[17]The resource measures should be thought of as general measures of resources from the environment rather than specifically teacher salaries and class size. Access to resources correlates with both teachers' salaries and class size as well as a variety of other factors.

The pattern of relationships merits some additional comment. Management is about choice and decision making. Quite clearly managers allocate more time and effort to some constraints and resources than to others. As a result, expecting all resources to become more valuable and all constraints to become less negative may not only be expecting too much, it might also conflict with what the manager is trying to do. In other words, the results may be evidence that managers make strategic networking choices beyond the fundamental ones of how often? and with whom? An effective manager might well focus on a small number of strategic factors that can be manipulated to get better results while at the same time accepting some modest negative tradeoffs on less important variables. The relationships in Table 3 are consistent with such an interpretation. The negative findings are relatively small, as are a few of the positive findings. Three of the impacts are substantial -- those regarding teachers' salaries, class size, and noncertified teachers. Getting large positive results on these three variables more than compensates for the modest negative changes on other factors.

Autoregressive Models

Because organizations stress standard operating procedures, specialization, and consistency, they tend to be relatively predictable and stable from year to year. They are, in methods

terms, autoregressive systems (O'Toole and Meier 1999). A stronger and more difficult test of our theory of management involves moving to an autoregressive model where current performance is determined in part by past performance. Again our strategy of analysis will be the same. First, we examine whether management matters at all; and then, we examine whether or not the impact is nonlinear. The autoregressive model analogous to equation [5] -- one treating management as simply another additive input -- is:

$$[6] \quad O_t = \beta_1 O_{t-1} + \beta_2 X_t + \beta_3 M_2 + \epsilon_t$$

The basic linear model without management is shown in the first column of Table 4. The lagged dependent variable dominates the equation. The constraints remain negative, though with diminished impact; similarly the resources remain positive but with smaller impacts. The lagged dependent variable essentially limits the influence of these variables to their impacts on changes from year to year, and this short-term impact by definition must be smaller than a one-shot estimate of impact on a cross-section. Despite the stringent nature of this test, management continues to have a positive impact on performance. For the full range of this variable, management could make a difference of as much as one percentage point *per year* on the pass rate. While this may not appear to be a substantial, with the autoregressive model these impacts continue to affect future

performance for several years into the future (see Pyndick and Rubinfeld 1990; O'Toole and Meier 1999).[18] By this stringent test, therefore, H1 is again supported.

[Table 4 about here]

Assessing the nonlinear impacts in an autoregressive model is somewhat more difficult given that the autoregressive term so dominates the equation. The result is that the remaining coefficients are often less stable so that a standard interaction often has too much collinearity, and dividing the sample could leave too little variance to provide efficient estimates. An alternative approach is to use substantively weighted analytical techniques (SWAT), a form of exploratory data analysis that allows one to focus on interesting subsets of data (Meier and Gill 2000).[19] Applied to the current case, the logic is as follows. If management has a nonlinear/interactive relationship with forces and inputs from the environment, then those units characterized by high levels of network management should operate

[18]The long-run performance of the management variable has a value of approximately .6 which means the maximum total impact is approximately 3.6 percentage points, an estimate very similar to the estimate for nonautoregressive models.

[19]For our purposes, SWAT is preferable to quantile regression. The former retains the comparison to the remaining units in the analysis. And SWAT assumes that differences in the dependent variable are real — that is, that the residual taps real performance differences. Quantile regression assumes that much of the residuals consists of idiosyncratic variation or even error.

with a different set of relationships than the average organization. Hypothetically, this suggests that if one replicated the analysis reported in Table 4 with a sample of units but only had those with high levels of network management, the regression coefficients would change.

To get at this hypothetical situation, SWAT asks what would happen if the population of units were to contain many more with high levels of network management and many fewer with low levels of network management. SWAT creates such an artificial universe by reweighting cases in the existing sample. Comparing the regression from this sample from a hypothetical population to the sample from the existing population should provide some leverage on whether management matters more or in different ways in these sets of situations. In the specific case, we designated those school districts with network management scores above 1.36 (about 10 percent of the total) as having a high level of network management. We used a higher threshold in this situation rather than just the top half because the autoregressive specification is likely to wash out relatively small differences in management activities. School districts with a network management score below 1.36 were weighted at 0.1 compared to weights of 1.0 for those above this threshold. This process artificially creates a sample that has only one-tenth as many districts in the low category and ten times as many (relatively) in the high network

management category. The results of this weighted regression are shown in column 3 of Table 4.

The coefficients in column 3 are not parameter estimates (since they deal with a hypothetical universe) but are informative when contrasted with the OLS regression coefficients because they show how a set of units with a higher degree of network management might use resources differently. The previous results in Table 3 suggest teacher salaries, noncertified teachers, and class size are likely to be the key variables. Most of the SWAT/OLS differences are relatively small, but in two cases, teachers salaries and class size, the differences in coefficients are substantial. In both cases the implication is that programs with more network management get more out of their resources. The SWAT equation stressing high levels of management has a teacher salary coefficient approximately 24% larger,and the class size coefficient is 254% times larger than that for the same variable in the base OLS regression.

The consistency of these two relationships with the same relationships in the nonautoregressive model in Table 3 is reasonable evidence that one style of management is likely to interact with program inputs from the environment to produce outputs above what would be expected in a strictly linear relationship. Again, H2 and H3 are supported even in the estimations of an autoregressive model.

In this analysis we have not demonstrated the process by which managing in the network generates better results. We have several hypotheses. First, management's greater attention to the environment might create buffers from external shocks and thus permit lower level personnel (teachers, principals) to be more effective. Second, a networking style might encourage a more decentralized internal management approach, an approach advocated by much current education reform literature. Third, the networking might expose the superintendent to innovative programs operated by other districts. Fourth, managerial networking might convince external stakeholders to grant more autonomy to the school district and thus allow the district to exploit the expertise it has. In all four cases organizations might be able to use resources more effectively.[20] These and other hypotheses for the linkage between network management and performance are all plausible; future research can be designed to evaluate these hypotheses.

Conclusions

This research presents the first systematic effort to test for the impact of public management on program performance using

[20]Visits to various schools indicate that the process might be that networking behavior is also associated with other behaviors that improve the levels of organizational cohesion. Both good and bad schools frequently have the same programs; the difference is often in the commitment of teachers and administrators to making programs work.

the O'Toole-Meier model. The study focuses on efforts to manage the network of actors that affect one type of program: public education. In districts where superintendents engage in more network interactions, performance improves even if one controls for a variety of factors that affect this performance and even in a autoregressive model. Further, the interactive nature of management is apparent both in relatively simple assessments of management and in relatively complex autoregressive assessments. Network management appears to allow superintendents to translate resources into outputs at a more efficient rate.[21] In short, the hypotheses under examination are supported by this analysis. Since public school systems probably face less complicated and less populated networks than many other public programs, the results of this study strongly suggest the importance of network management more broadly for today's public programs.

Still, the results here are only a first step in an empirical theory of public management. Numerous questions remain to be answered. When do managers decide to buffer environmental influences and when do they decide to exploit them? What conditions lead a manager to devote resources to network management rather than internal management? What is the impact of management -- internal management as well as network

[21]What is more, managers in our sample do so even though they tend to spend less time on the internal management of production itself.

management -- as the degree of hierarchy declines? How is this affected by the need to create networks with other actors? What are the factors that managers opt to manipulate and what factors do they simply seek to minimize? How well does the present theory of management work in situations where core production organizations are structured differently?

These and other questions remain to be addressed. Still, the results of this study offer encouragement for those who are convinced that public management matters, that network management itself can be important for performance, and that complex models of public management are worthy of serious attention.

Table 1. Measuring Network-Management Style

Factor Loadings	
Indicator	Loading
Frequency of Contact with	
School Board Members	.60
Business Leaders	.73
Other Superintendents	.67
State Legislators	.68
Texas Education Agency	.51

Eigenvalue = 2.07

Table 2. Management and Organizational Performance:

Additive Linear Estimation

Dependent Variable = Student Exam Pass Rates		
Independent Variables	Base Model	Network+
Network Management	--	.7035 (4.60)
Resources		
Teacher's Salaries (k)	.4875 (4.49)	.4665 (4.31)
Class Size	-.3199 (4.83)	-.3117 (4.72)
Teacher Experience	.2048 (2.10)	.1943 (1.90)
Non Certified Teachers	-.1874 (5.28)	-.1873 (5.30)
Percent State Aid	-.0127ns (1.53)	-.0173 (2.09)
Constraints		
Percent Black Students	-.2153 (13.35)	-.2167 (13.49)
Percent Latino Students	-.1099 (10.43)	-.1091 (10.39)
Percent Low Income Students	-.1671 (11.12)	-.1670 (11.16)
R-squared	.58	.59
Standard Error	7.65	7.62
F	294.96	276.07
N of Cases	2534	2534

Dummy variables for individual years not reported
ns= not significant

Table 3. Management and Organizational Performance:

Nonlinear Impacts

Dependent Variable = Student Exam Pass Rates	Level of Management Networking	
Independent Variables	High	Low
Resources		
Teacher's Salaries (k)	.7727 (4.55)	.2835 (1.98)
Class Size	-.6620 (5.90)	-.1211ns (1.47)
Teacher Experience	-.1256 (.85)	.4556 (3.51)
Non Certified Teachers	-.1100 (2.20)	-.2638 (5.30)
Percent State Aid	-.0189ns (1.39)	-.0073ns (0.69)
Constraints		
Percent Black Students	-.1846 (7.20)	-.2291 (13.49)
Percent Latino Students	-.1003 (6.18)	-.1147 (10.39)
Percent Low Income Students	-.1966 (8.53)	-.1537 (11.16)
R-squared	.57	.61
Standard Error	7.60	7.61
F	124.23	176.83
N of Cases	1154	1380

Dummy variables for individual years not reported

ns= not significant

Table 4. Management and Organizational Performance

Autoregressive and Nonlinear Models

Dependent Variable = Student Exam Pass Rates			
Independent Variables	Base Model	Network+	SWAT
Network Management	--	.1719 (1.65)	--
Performance (t-1)	.7172 (63.65)	.7162 (63.48)	.7042 (63.49)
Resources			
Teacher's Salaries (k)	.3679 (6.75)	.3704 (6.80)	.4520 (8.63)
Class Size	-.0752 (1.69)	-.0750 (1.69)	-.1913 (4.08)
Teacher Experience	-.1448 (2.38)	-.1526 (2.50)	-.1285 (2.10)
Non Certified Teachers	-.0947 (3.95)	-.0947 (3.95)	-.1159 (5.30)
Percent State Aid	.0074ns (1.39)	.0064ns (1.21)	.0049 (0.89)
Constraints			
Percent Black Students	-.0586 (5.19)	-.0593 (5.25)	-.0521 (4.48)
Percent Latino Students	-.0412 (5.76)	-.0413 (5.79)	-.0475 (6.53)
Percent Low Income Students	-.0165ns (1.62)	-.0165 (1.69)	-.0135 (1.27)
R-squared	.81	.81	.82
Standard Error	5.18	5.18	2.11
F	1187.17	1069.46	1296.65
N of Cases	2534		2534

ns = not significant, note classical statistical significance

does not apply to SWAT models.

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