

# **Evaluating Capital Management: A New Approach**

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## **ABSTRACT**

The objective of this paper is to develop a methodology for evaluating capital management performance. We have employed a new methodology, fuzzy rule-based systems (FRBS) that allows evaluators to break down complex systems into manageable components. FRBS can also use a variety of data types by converting data into ordinal input measures that are not overly sensitive to small measurement errors. In developing an overall performance measure, the evaluator under a FRBS creates explicit rules for combining inputs that can reflect the complex contextual judgments commonly made by evaluators. Using survey data on 35 large American cities from the Government Performance Project, we develop a FRBS for city capital management.

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## INTRODUCTION

Capital budgeting and capital management are crucial components of any government financial management system. Yet capital budget decisions are often made in relative obscurity, in part, because the capital budgeting process is typically separated from the operating budget process. Despite the lack of visibility of these decisions, the stakes for the long-run financial health of local governments are high. In the last two decades, the federal government has drastically reduced its financial support for capital projects, especially for environmental infrastructure, such as water and sewage treatment plants.<sup>1</sup> In an era of increased local contribution for basic infrastructure, sound capital management becomes all the more important.

Given its importance for the fiscal health of a local government, capital management should be an important bond rating criterion. However, rating agency descriptions of the rating process mention capital management only in passing, typically in the context of financial management or debt management.<sup>2</sup> Moreover, analyses of the determinants of bond ratings have not considered capital management practices in their list of variables.<sup>3</sup>

The objective of this paper is to develop a method for evaluating and comparing the capital management practices of local governments. This paper is one of the first attempts to develop a composite measure of capital management. Using survey results from 35 large cities from the Government Performance Project, we will categorize and evaluate capital management practices. We employ a relatively new evaluation method, Fuzzy Rule-Based Systems (FRBS), to develop performance measures of capital management, because it is less sensitive to measurement error, and permits systematic use of expert judgement. The paper is divided into three major sections. In the next section, we will describe key components of a strong capital

management system, and will briefly summarize the content and results of the GPP survey. The second part of the paper provides an introduction to FRBS. The capital management results for the 35 largest American cities (in terms of revenue) are reported in the third section.

## **COMPONENTS OF A CAPITAL MANAGEMENT SYSTEM**

Before it is possible to evaluate city capital management practices, key components of a strong capital management system must be identified. Ideally, these components would have emerged from careful evaluations of the impact of specific capital management practices on desired outcomes, such as the condition of the capital stock. Unfortunately, well-crafted evaluations of capital management practices in state and local governments are limited. Instead, most studies of capital management are either prescriptive lists of good policies, typically based on best practice case studies, or descriptive accounts of current practices in state or local governments.<sup>4</sup>

In developing our evaluation scheme, we synthesize both types of studies into an assessment of desirable practices for managing capital assets. Our choice of management factors was influenced by the information available in the Government Performance Project survey of large cities.<sup>5</sup> However, any capital management rating system will ultimately be subjective, in that, choices are made about what represent valuable versus unimportant components of a capital management system. Thus, the results of our evaluation should be viewed not as a definitive assessment of capital management in large American cities, but rather an example of how such evaluations might be performed. For convenience, we divide capital management into four broad categories: long-run planning, capital budgeting and programming, project management, and maintenance. Figure 1 illustrates the framework used for our evaluation.

[Figure 1 about here]

### *Long-Run Planning*

The origins of capital planning in this country were linked to the development of physical master plans in the 1920s.<sup>6</sup> While capital management has generally moved from the domain of city planners to budget and finance departments, the long-run planning component of capital management remains important. Ideally long-run community economic forecasting and planning should be prerequisites for capital planning, and good comprehensive plans will have a capital component.<sup>7</sup> The principal capital planning document in most cities, the capital improvement plan (CIP), should be linked to any community master plan. Besides forecasts of future infrastructure requirements, capital planning needs to be based on an assessment of the condition of public infrastructure in the community and long-run forecasts of revenues, expenditures, and debt burdens.<sup>8</sup> Fiscal forecasts define the fiscal constraints, including affordable debt burdens, faced by any proposed capital program.

Approximately three-quarters of the 35 cities claim that their capital plan is tied to a community master plan. However, since most cities did not furnish a master plan, we were unable to determine the extent to which cities in our sample linked the CIP and the master plan. But it is clear that only a small proportion of the cities have strong long-range fiscal planning or capital facilities condition assessment systems. Very few CIPs include projections of revenues, expenditures, debt ratios, and tax rates. And while many cities have “pavement management systems” to store and manage road condition information, relatively few have similar systems for their other capital facilities.

### *Capital Budgeting and Programming*

We have divided capital budgeting into four components: the CIP document itself, the capital budgeting process, project selection, and the relationship between the capital and operating budgets. Most state and local governments produce some form of CIP, which includes a list of planned projects over a four-to-six-year time period.<sup>9</sup> Assuming that the CIP is going to

play a central role in project selection, it should provide justification for projects consistent with formal selection criteria identified by the city. If a government is going to make the capital budgeting process accessible to the public, then the CIP should include clear explanations of the projects and their justification, and the capital budgeting process, and also should include some form of glossary or user's guide. Of the 35 cities in our sample, only 13 had CIPs that we characterized as user friendly.

The capital budgeting process generally involves the preparation of capital requests by individual agencies, and the submission of these requests to a central office.<sup>10</sup> Capital requests should include thorough supporting documentation including estimated benefits of the project, and projected lifecycle costs. Ideally, the capital planning process would include some type of formal coordination across departments, and project selection would be based on formal criteria matching community priorities.<sup>11</sup> While there is limited evidence linking a more open capital processes with more efficient decisions, involvement of citizens in the capital planning process has the potential of reducing pork barrel distribution of capital projects.<sup>12</sup> With regard to the capital budgeting process, most cities appoint a capital manager to manage the CIP process, but formal coordination across agencies through a capital planning team, for example, is less common. Relatively few cities have either a formal set of criteria for ranking capital projects, or a formal process that involves citizens in project selection.<sup>13</sup>

Another aspect of the capital planning process that deserves attention is whether there is a formal link between the capital and operating budgets. Most governments preparing a capital improvement plan have a separate capital budgeting process. While this separation has been justified because of the long range planning required for capital, separate capital budgets can exacerbate the neglect of regular maintenance, unless a special effort is made to link capital and operating budgets.<sup>14</sup> Based on the survey, it appears that a growing number of cities are requiring formal estimates by agencies of the operating budget impact of their capital projects.

However, the accuracy of these estimates, and their link to actual operating budget requests is less clear.<sup>15</sup>

### *Project Management*

Project management is an important element of good capital management because the consequences of making a mistake can include significant project delays and cost overruns. The project management part is a short-term function that assures that projects are “delivered” on time and within the budget. The key to good project management is careful tracking of progress against the schedule and budget, and frequent reporting to top management.<sup>16</sup> Good project management software and formal methods exist that should allow governments to monitor project status. Ultimately, good project management involves attention to detail to catch and correct problems early in the construction or procurement process. Given the availability of off-the-shelf project management software, it is surprising that only approximately one-half of cities in our sample have a formal centralized system, and produce regular reports on project status. In many cities, monitoring projects is still left primarily in the hands of individual agencies, which makes enforcement of uniform standards and reporting requirements difficult.<sup>17</sup>

### *Maintenance*

The maintenance function can be divided into maintenance planning and maintenance funding. Maintenance planning involves systematically estimating the condition of the capital stock and determining what funding would be required to bring existing infrastructure up to an acceptable condition. Maintenance planning should be tied directly to the assessment of the condition of the capital stock with the asset management system serving as the link. An asset management system (AMS) combines information about the condition of capital assets with typical depreciation schedules, and information on replacement costs. AMS can be used to develop estimates of both the full cost of bringing infrastructure up to good condition and the mix of repair versus replacement of capital assets that should take place. While the potential

exists for using an AMS to develop detailed maintenance plans, committing adequate funds for maintenance requires fiscal discipline on the part of political leaders. Unfortunately, the temptation to defer maintenance, particularly during economic recessions, often takes precedence over an adequate level of maintenance.<sup>18</sup>

Maintenance remains the Achilles' heel of most city capital management systems. Despite the growth in asset management systems, especially for roads, relatively few of the 35 cities have attempted to estimate the full cost of bringing their capital assets up to good condition. Such estimates are important, because they provide a benchmark that a city can use to develop a maintenance plan for working off the backlog of deferred maintenance.<sup>19</sup> Even among some of the cities with good maintenance needs estimates, the political follow-through to provide adequate maintenance funding on an annual basis is lacking. Nowhere is this more evident than in Los Angeles. The city actually has detailed estimates of the condition of its roads, including the cost to catch up on its deferred maintenance. Unfortunately, by its admission, the city's level of maintenance funding for roads has been grossly inadequate.

### **FUZZY LOGIC: A TOOL FOR EVALUATING CAPITAL MANAGEMENT SYSTEMS**

Overall performance assessments of a complex phenomenon, such as capital management, require a formal measurement technique if they are going to be replicated and evaluated. The increasing emphasis on evaluating performance of organizational, social and political units has led to the development of a variety of methodologies and techniques.<sup>20</sup> Developing performance evaluations generally involves three stages: 1) determining the criteria to be used in the performance evaluation; 2) developing measures of these criteria; and 3) aggregating these input measures into an overall measure of performance. Performance evaluation of management should allow for the use of a variety of types of variables including

imprecise and subjective data, and the process of aggregating these diverse measures should accurately reflect the complex conditional judgments of individuals with expertise in the field.

The simplest approach to developing capital performance measures is to assign scores to each individual item in the survey, and simply add them up (possibly using different weights) to get a total score. It is difficult to add scores for items expressed in different units, without first turning all inputs into ordinal measures with the same scale. Unfortunately, using ordinal data with these additive methods produces performance measures that are sensitive to relatively small measurement errors. In addition, most aggregation methods use a fixed procedure that cannot adjust to the context of the evaluation. Many practitioners and theorists believe that performance evaluation should remain a context and environment dependent problem, thus any fixed set of rules will miss important contingent relationships between variables.<sup>21</sup>

This section of the paper describes the application of a method, Fuzzy Rule-Based Systems (FRBS) in the evaluation of evaluating capital management. The term “fuzzy” refers to the development of robust measures of inputs that are less sensitive to measurement error. “Rule-based systems” describes a method for combining individual inputs into performance measures, which can reflect the contextual judgment of the evaluators. The technique has been successfully applied in various contexts of performance evaluation.<sup>22</sup> We will provide an introduction to the FRBS method and illustrate its application in developing performance measures for capital management. It is beyond the scope of this paper to provide a detailed description of FRBS,<sup>23</sup> but we will highlight its main features hereby using the capital management evaluation of the first city in our sample, Anchorage, Alaska. FRBS is the culmination of three modeling tools that reflect the key stages in the development of performance measures: 1) decomposition of the evaluation object into important components; 2) input fuzzification to construct robust ordinal measures of these components; and 3) rules

bases, which are a set of formal rules used to combine inputs into performance measures. This section provides a description of how FRBS works.

### *Decomposition*

It is helpful to decompose the overall evaluation problem into smaller groups of evaluations that lead to an overall rating. First, the key components of capital management—long run planning, project management, capital budgeting, and maintenance—are used to form the first level of decomposition (see Figure 1). These components are further decomposed into sub elements of evaluations. For example, the evaluation of capital budgeting is based on evaluations of the planning document, the planning process, project selection, and the relationship between the capital and operating budgets. Using the decomposition model, the evaluation is performed bottom up. Each of the four elements of capital budgeting is first evaluated, and then combined into an overall measure of capital budgeting performance. Similarly, intermediate evaluations are produced for long-run planning, project management, and maintenance. Table 1 provides descriptive statistics for the coded results from the GPP survey used in constructing the FRBS for capital management.

<Table 1 about here>

### *Input Fuzzification*

Even though performance criteria can be articulated, some assessments require the evaluation of responses to survey questions that include qualitative descriptions of policies and procedures. Detailed guidelines for scoring responses help evaluators identify key aspects of the evaluation and increase reliability and objectivity in the process. However, guidelines do not completely eliminate subjectivity and imprecision in the process. Thus, it is important that evaluation methods not be overly sensitive to imprecise measures.

For example, guidelines for evaluating the capital planning process were developed by the authors such that a city could obtain a score between zero and five. One point each was

assigned if a city had a capital budget manager and a capital planning board. A city was given one point if the public is significantly involved in the process, and up to two points was given for the level of coordination of projects across agencies. While these items capture relatively discrete attributes of the process, there is still room for measurement error, particularly if the city did not accurately reflect its planning process in the survey. In addition, this scoring scheme represents a gross simplification of what can be a complex process.

FRBS begins by turning all inputs into ordinal measures. While the number of ordinal categories is determined by the evaluator, generally three categories—poor, fair, and good—are adequate. Under classic set theory, a city would be put into only one of these categories. Thus, a small mistake in classifying a city could cause it to go from the poor category to the fair category, for example. Given the imprecision in the evaluation process, it is appropriate to assume that the transition between these ordinal categories is gradual. One tool for modeling imprecision in the assignment of scores is fuzzy set theory,<sup>24</sup> which is a generalization of classical set theory. A fuzzy set is defined by a membership function that ranges between 0 and 1, which assigns the degree of membership to each element in the set. The degree of membership represents the extent to which an element, in this case a city, can be placed in the set. Under fuzzy set theory, an element can belong to more than one set with different degrees of membership.

Developing fuzzy sets involves constructing sets for each ordinal category, which capture the range of performance associated with this category. For example, we decided that the set for a good capital planning process would begin with any score above the average for all cities (3.4 points), fair performance of varying degrees would range between 1 and 5 points, and that the poor performance set would begin for all cities with performance below the average (3.4 points).<sup>25</sup> Any city with a score of 5 (1) would be considered fully good (poor), and would have membership in this set of 1, and membership of 0 in the other two sets.

[Figure 2 about here]

Fuzzy sets for the four components of capital budgeting are illustrated in Figure 2, with capital planning in the lower right-hand panel. By design the sets overlap to reflect that a city can be a member of more than one set. The final step in this process is to assign membership levels between 0 and 1 in each set to a city. Anchorage has a score for the planning process of 3 out of 5. To find the membership levels using Figure 2 go to the panel for “planning process” (lower right), draw a vertical line above 3 (on the X axis), and find the points of intersection with the poor (0.17) and fair (0.83) categories. Anchorage’s planning process lies in the range between poor and fair performance, but it should also be considered more fair than poor.

### *Rule Bases*

The next step in the methodology is to combine the evaluations of the individual components into an overall evaluation. This is achieved in a FRBS by developing a set of rules about what represents good, fair or poor performance. The rules should reflect the judgment of evaluators about the relative importance of the various components in the context of performance on other components. For example, in evaluating capital budgeting, how useful is a well-prepared planning document in light of a poor project selection process? Is the quality of the document only relevant in the presence of adequate processes for project selection and capital planning? A rule base is a comprehensive collection of rules that express experts’ judgments in a form where contextual contingencies can be easily represented. For example, a rule base can include, as a rule, a statement that capital budgeting is considered poor if the planning and project selection processes are poor, regardless of the quality of the planning document. The biggest challenge in designing a rule base is extracting from experts a complete set of rules that include all possible evaluation scenarios. One way to simplify this task is to have them develop rules for only a few performance levels, such as poor (p), fair (f), and good (g).<sup>26</sup>

To illustrate, the four components of capital budgeting can be combined using a rule base into an overall performance measure for capital budgeting. In order to extract a complete rule base, a matrix representation is used. With three levels of performance and four components of capital budgeting, there are a total of  $3^4 = 81$  possible combinations that can be represented in a matrix (see Figure 3.) Each cell in the matrix corresponds to a rule for capital budgeting. For example, the shaded cell in the upper right-hand corner represents the rule, “if the project selection process is good, the relationship between capital and operating budgets is poor, the quality of planning document is good and the planning process is poor, then overall capital budgeting is judged to be poor (p).”

[Figure 3 about here]

Each panel in Table 2 contains the fuzzy set membership levels for the four components of capital budgeting for Anchorage. The fuzzified input given in Table 2 indicates that “project selection” falls only in the fair category of performance for Anchorage. This means that the applicable rules are in the middle broad column of the matrix in Figure 3. Also the “link to operating budget” falls in only one category of performance, good. This further reduces the applicable rules to the last broad row of the matrix. Therefore, based on these two components, the applicable rules for the city of Anchorage are contained in the lower middle box of the rule base matrix. An evaluated component that falls in a single category of performance is the exception rather than the rule. Typically, each component falls in two adjacent categories. Table 2 indicates that the “planning document” quality and the “planning process” each fall in two categories, fair and good (for document); and poor and fair (for process). This further reduces the applicable rules for the city of Anchorage to four cells in the matrix. These four cells are highlighted in Figure 3.<sup>27</sup>

[Table 2 about here]

To further illustrate the application of rules consider the detailed conditional statements for the four identified rules. Remember, the rules generally emerge from discussions with experts on what combination of these four factors constitutes a particular capital budgeting performance level. In all four rules the statement includes fair project selection and good link between capital and operating budgets. The rules vary only in the combinations of performance categories for the document and the planning process. The first three rules assign a fair performance rating for capital budgeting, and the fourth rule assigns a good rating for capital budgeting. Each rule is a conditional statement describing the condition under which the rule applies, and the resulting judgment of capital budgeting performance.

**Rule 1:** IF project selection is fair (f) AND link to operating budget is good (g) AND document is fair (f) AND the planning process is poor (p) THEN capital budgeting is fair (f).

**Rule 2:** IF project selection is fair (f) AND link to operating budget is good (g) AND document is fair (f) AND the planning process is fair (f) THEN capital budgeting is fair (f).

**Rule 3:** IF project selection is fair (f) AND link to operating budget is good (g) AND document is good (g) AND the planning process is poor (p) THEN capital budgeting is fair (f).

**Rule 4:** IF project selection is fair (f) AND link to operating budget is good (g) AND document is good (g) AND the planning process is fair (f) THEN capital budgeting is good (g).

Looking at the four panels of Table 2, which apply to these four rules, the membership levels are repeated in each panel for the components of capital budgeting. For each rule the applicable categories are circled. For example, in Rule 1, if project selection is fair, link to operating budget is good, planning document is fair, and planning process is poor, then capital budgeting is given a fair score. Membership levels in these four categories are 1, 1, 0.8, and 0.19, respectively for Anchorage.

The question is what membership level in the fair output category for capital budgeting should be assigned to Anchorage under Rule 1? Under the “extension principle” in fuzzy set theory, the minimum membership level for all inputs is assigned to the output category. Intuitively, the level of membership defines a cutoff for the degree of belonging to a performance category. To be conservative in selecting a membership level, we want a level that applies for all the inputs, thus the minimum defines the common level all inputs share.<sup>28</sup> When Rule 1 is applied the judgment of fair capital budgeting is assigned a membership level of 0.17. An illustration of applying Rule 1 through Rule 4 to the city of Anchorage and assigning a membership to the rule conclusion is shown in Table 2.

The first three rules assign membership in the fair category, and the fourth rule assigns membership in the good category (membership level of 0.2). Since no rule assigns membership in the poor category, it is given a membership level of zero. When more than one rule assigns membership to the same category, a decision has to be made on which of these membership levels to apply to the final category. Another element of the extension principle in fuzzy set theory is that when more than one rule applies to an output category, the rule with the highest membership dominates. This rule is used to assure that a city is not penalized for having more than one rule apply to the same output set. For example Rule 1 through Rule 3 lead to the conclusion of fair capital budgeting performance, but Rule 2 has the highest membership (0.8)

for Anchorage and hence the judgements of fair capital budgeting of Rule 1 and Rule 3 (both with memberships of 0.17) are eliminated.

The end result of applying the relevant rules is a judgement on capital budgeting using the three categories each with an assigned membership. For Anchorage, capital budgeting is said to be poor with 0.0 membership, fair with 0.8 membership and good with 0.2 membership (Table 3, fourth column). This result is known as the fuzzy output of the rule base, in this case, capital budgeting.

[Table 3 about here]

The process continues using the hierarchy described in Figure 1. For each of the scored components (white boxes in Figure 1), the raw score is converted into a fuzzified input, much like the method described for the planning process component. The remaining rule bases (shaded boxes in Figure 1) are then evaluated.<sup>29</sup> The relevant rules are identified and applied in a manner similar to that described for the capital budgeting rule base. The result is an evaluation expressed as a fuzzy output that contains the three categories of performance, poor, fair and good each with an assigned membership level. For the city of Anchorage the resulting outcome of the four components that form the overall capital management evaluation is given in Table 3.

The last level of the hierarchy is the evaluation of overall capital management using the four components-long-run planning, project management, capital budgeting, and maintenance-as inputs. Figure 4 presents the rules matrix for these components, which are classified into 3 categories-poor, fair, and good. The information in Table 3 can now be used in conjunction with Figure 4 to determine an overall evaluation in the form of a fuzzy output. For the city of Anchorage the overall evaluation of capital management was derived to be poor with a membership of 0.19, fair with a membership of 0.80 and good with a membership of 0.20 (last column of Table 3).<sup>30</sup> In practical terms, Anchorage has fair capital management performance, with some elements that are fair to poor (long-run planning and maintenance), and fair to good

(capital budgeting). One of the advantages of FRBS is that it is possible to quantify this variation in performance.

[Figure 4 about here]

The computation required in applying a multilevel FRBS, such as the one described for capital management evaluation of 35 cities, is quite extensive. It involves the fuzzification of hundreds of scores and the application of over a thousand rules. Software developed by several of the authors automates this process.<sup>31</sup> Typically the process of defining rules and fuzzy sets is iterative. Rules are reevaluated after the results have been estimated if they fail to match the expectation of evaluators. The rules matrix makes these judgments explicit, and any rules changes are applied to all cities. The software makes doing sensitivity analysis to changes in rules or fuzzy sets relatively easy.

#### *Defuzzification of Output*

In many applications of FRBS the fuzzy outputs illustrated in Table 3 (last column) are sufficient representation of the measured outcomes. However, in the context of ranking capital management performance for large cities, it is important to convert the fuzzy outputs into a single value that can be ordered. This process is called defuzzification. Some of the robustness built into the system, and the information it conveys is lost in the process of defuzzification. Methods for defuzzification, and comparisons among them have received much attention in the literature.<sup>32</sup> Choosing the right defuzzification method requires a certain level of experimentation within particular applications. Essentially, defuzzification involves fitting a distribution to the fuzzy set results, and then selecting a summary measure for this distribution. The most commonly used technique, known as the center of gravity (COG) method, uses an average as the summary measure. The COG method produces a defuzzified score for the city of Anchorage of 10.08.

## FUZZY RULE-BASED SYSTEMS RESULTS

Using the FRBS described above for Anchorage, Alaska, both fuzzy and defuzzified results can be obtained for the 35 cities included in the GPP Capital Management survey. No evaluation system, including FRBS, is immune to basic data errors or omissions. While the GPP survey provides a unique opportunity to evaluate capital management in large cities, the quality of the evaluation is contingent on the accuracy of the information in the survey, and the judgments made by the authors in coding the survey. Ideally, actual capital spending in the city would be tracked against the CIP to see if this document reflects actual capital decisions or is just an agency wish list. Unfortunately, such detailed audits were not feasible for the GPP project. The results presented below should be viewed only as a first step in the process of evaluating capital management in these large cities.

[Table 4 about here]

Each city in Table 4 receives fuzzy measures for poor, fair and good performance on overall capital management as well as a defuzzified score for each of the four components of capital management. We have ordered the results in Table 4 in ascending order by the city's rank on the overall measure of capital management. For total capital management, Table 5 presents the city's membership in each category, as well as the defuzzified score. Most cities receive scores that indicate they have characteristics of two levels of performance. For example New York City's capital management is judged to be primarily fair at a 0.83 level but also good to a lesser 0.17 level. New York's planning and project management are both fair to good but the capital budgeting and maintenance are primarily fair. A few cities fall fully in a single category, Phoenix's capital management falls entirely in the good category (1.0) while Nashville and Buffalo's managements are placed entirely in the poor category. Other cities have characteristics of all three levels. Indianapolis, for example, is judged to be poor to some extent

(0.19), largely fair (0.81), and good to a degree (0.17). Indianapolis receives poor marks in planning and maintenance but has a good rating in project management.

[Table 5 about here]

Significant variation exists across cities in their capital management performance. The cities ranked primarily in the good category, Phoenix, Minneapolis, Austin, Kansas City, Virginia Beach and San Jose demonstrate strong performance on the capital management criteria almost across the board. One exception is maintenance where only Phoenix and San Jose are ranked primarily in the good category. Another group of cities—New York City, Baltimore, Seattle, Denver, Honolulu, Anchorage and Indianapolis—are ranked primarily in the fair category. For close to half of the 35 cities, the membership is equally divided between the poor and fair categories. However, even within this group, there is significant variation in city performance on particular criteria (Table 4). Seven cities have their highest membership in the poor category. For most of these cities, their low rank is driven primarily by very low scores for long-run planning and maintenance, and fair to poor scores in capital budgeting. Receiving an average score on project management is not sufficient to outweigh poor performance on the other criteria.

A simpler alternative to constructing a FRBS for city capital management would involve merely adding the total points received in each category on the coding sheet. Table 5 contains a comparison of each city's defuzzified score and the total points from the survey response. The cities are ranked by their defuzzified score. In most cases the relative rankings are very similar. Cities with more points tend to obtain higher defuzzified scores. However some of the differences illustrate the advantages of a fuzzy rule-based system.

Los Angeles' 25 total points match those of Jacksonville, yet its defuzzified score is much lower. In Los Angeles' case, the points tended to be concentrated in two areas, long range planning and project management. Project management in LA actually received the highest

possible rating and long-range planning is above average. Since the rules established in the evaluation process emphasize the importance of maintenance and capital budgeting, high scores cannot be obtained with poor results in these two categories. An effort could be made to weight the total points so that summing or averaging all points would take into account the same expert judgement. However, weighted averages cannot take into account situations that FRBS handles easily. For example, in the areas of capital budgeting and maintenance, Los Angeles' points result from planning rather than implementation. One-half the budgeting points are obtained for the planning document while none of the points are associated with any attempt to have a link between the capital planning and the actual operating budget. Regardless of how weights are assigned, planning documents should have limited value without some effort to ensure that plans are implemented. Similarly, on the maintenance side all the points are associated with needs assessment and none with actual maintenance funding. The rules established by the authors for this evaluation credits quality needs assessment when appropriate funding takes place but discount it when funding is inadequate. This ability to judge value in the context of other parameters cannot exist with predetermined weights assigned to various components.

## **CONCLUSIONS**

Capital management is a critical component of financial management and strategic planning at the state and local government level. The long-term nature of capital investments has encouraged the use of capital budgeting and planning processes that are generally separate from the operating budget, and have a longer range perspective. Past research on capital budgeting has documented that most cities and states prepare some type of capital improvement plan, which is used to develop the capital budget. However, much less attention has been paid to the content of the plan, the planning and project selection processes, the project management system,

and maintenance planning and funding. We are not aware of any attempt to develop an overall assessment of capital management in state or city governments.

The objective of this paper has been to develop a framework and methodology for evaluating capital management performance. Using survey data on 35 large American cities, we have categorized each city on several capital management criteria. In general, we find that almost all cities produce capital improvement plans of at least four years' duration, many attempt to tie these plans to community master plans, and most cities have some type of formal project management system. A growing number of cities are attempting to link operating and capital budgets in some formal way, and are developing asset management systems particularly for roads. Project selection remains primarily a political ranking exercise that does not use formal criteria or involve citizens in a meaningful way. Maintenance planning and particularly funding remain the Achilles' heel of most capital management systems. Relatively few cities have estimates of the cost of fully funding maintenance in transportation and public buildings, and even some cities that do have good planning systems significantly under-fund maintenance.

In developing an overall measure of capital management, we have employed a methodology, fuzzy rule-based systems (FRBS), that offers a number of advantages to performance evaluators. First it allows evaluators to break down complex systems into manageable components that can first be evaluated separately. This evaluation can be performed without undue concern about how to combine different types of data, since all inputs into a fuzzy system are converted into measures of poor, fair and good. The next advantage of FRBS is derived through the use of fuzzy sets, which represent the inherent imprecision in the input data, and make sure that small changes in inputs do not result in disconnected jumps in the output. The final advantage of FRBS comes as the individual components are combined into a performance measure. The evaluator can create rules that assign value based on the total context of the evaluation and hence reflect the circumstantial judgements humans regularly make.

The evaluation of capital management practices in the 35 largest cities reveals some large differences across cities. At the top of the scale, Phoenix, Minneapolis, Austin, Virginia Beach, and Kansas City demonstrate consistently strong performance in all four elements of capital management. These cities are often among the leaders in the quality of their CIP document, in the use of citizens in their capital planning process, in the thoroughness of their project management systems, and in the development of asset management systems. On the other end of the scale, the cities of Nashville and Buffalo rank low on almost all criteria, and generally show little commitment to improving capital management. Cities such as Washington, DC and Philadelphia are presently ranked fairly low in capital management, but indicate in the survey they are making substantial improvements in their systems. For the many cities that fall in the middle, they have some parts of their capital management systems that are fair to good, and some parts that belong in the poor to fair categories. One of the strengths of a fuzzy rule-based system is the evaluations done for individual components of management, which will help managers focus improvement efforts.

As demand for performance assessment of complex phenomena such as capital management increase, FRBS offers the potential for robust and flexible methods for combining a diverse array of performance measures using the judgement of experts. Through the use of rules matrices, FRBS encourages evaluators to focus on refining their judgments about what represents good management, and not waste resources trying to make precise a process which must by nature be imprecise.

## FOOTNOTES

1. Richard Nathan and John Lago, "Intergovernmental Relations in the Reagan Era," *Public Budgeting & Finance* 16 (Autumn 1988): 15-29; William Duncombe and Jocelyn Johnston, "American Intergovernmental Fiscal Relations: Revisions and Reforms," in *The White House and the Blue House*, ed. Yong Hyo Cho and George Frederickson (New York: University Press of America, 1997), 271-310.
2. Moody's Investors Service, "The Determinants of Credit Quality," *Municipal Credit Research* (November 1999): 1-16; Standard & Poor's, *Public Finance Criteria*, (New York: Standard & Poor's, 2000); Fitch IBCA, "Local Government General Obligation Rating Guidelines," *Tax Supported Special Report* (May 23, 2000): 1-11. One exception is a recent publication by Fitch, "Impact of Management Practices on Municipal Credit," *Special Report* (May 4, 2000): 1.
3. See Anthony Loviscek and Frederick Crowley, "Municipal Bond Ratings and Municipal Debt Management," in *Handbook of Debt Management*, ed. G. Miller (New York: Marcel Dekker, 1996), 475-514.
4. See Annie Millar, "Selecting Capital Investment Projects for Local Governments," *Public Budgeting & Finance* (Autumn 1988): 63-77; John Forrester, "Municipal Capital Budgeting: An Examination," *Public Budgeting & Finance* (Summer 1993): 85-103; J. Lisle Bozeman, "The Capital Budget: History and Future Directions," *Public Budgeting & Finance* (Autumn 1984): 18-30; and U.S. General Accounting Office (GAO), *Leading Practices in Capital Decision-Making*, GAO/AIMD-99-32 (Washington, DC, December 1998).
5. More information on the Government Performance Project is available on the project's web site, [www.maxwell.syr.edu/gpp](http://www.maxwell.syr.edu/gpp). The capital management evaluation is based on both a survey sent to financial managers in the 35 largest cities (based on total revenue) during 1999, and other available financial documents sent by the cities, such as capital improvement plans. A coding sheet was developed to translate this information into ordinal variables. One of the authors of the paper did the coding of the surveys.
6. Bozeman, 1984.
7. John Mikesell, *Fiscal Administration*, 5<sup>th</sup> ed. (New York: Harcourt Brace, 1999).
8. J. Richard Aronson and Eli Schwartz, "Capital Budgeting," in *Management Policies in Local Government Finance*, ed. J.R Aronson and E. Schwartz (Washington, DC: ICMA, 1996), 433-455.
9. See Arie Halachmi and Alex Sekwat, "Strategic Capital Budgeting and Planning: Prospects at the County Level," *Public Budgeting and Financial Management* (Winter 1997): 578-596; C. Bradley Doss, "The Use of Capital Budgeting Procedures in U.S. Cities," *Public Budgeting & Finance* (Autumn 1987): 57-69; Forrester, "Municipal Capital Budgeting: An Examination," 1983.
10. Bozeman, 1984.

11. See GAO, *Leading Practices in Capital Decision-making*, 26, and Millar, "Selecting Capital Investment Projects for Local Governments." Millar provided a list of possible criteria that a community could use, including physical condition, fiscal impact, cost effectiveness of repair versus replacement, health and safety effects, and environmental effects.
12. Citizen participation can range from the use of public hearings to formal capital planning committees with active citizen participation in project selection. See Susan MacManus, "Democratizing the Capital Budget Planning and Project Selection Process at the Local Level: Assets and Liabilities," *Public Budgeting and Financial Management* (Fall 1996): 406-27.
13. Exceptions are Minneapolis and Phoenix, which have capital review boards with citizen members.
14. Michael Pagano, "Notes on Capital Budgeting," *Public Budgeting & Finance* (Autumn 1984): 31-40.
15. Seattle is unique in how they have established this link. They have a formal fiscal note process for capital projects over \$500,000, which requires that agencies estimate project life, and ongoing operating and maintenance costs.
16. GAO, *Leading Practices in Capital Decision-Making*, 58.
17. Los Angeles has recently passed a particularly elaborate new project management process, which includes a Citizen's Oversight Committee, top management involvement, and project managers for the day-to-day management of each project.
18. Michael Pagano, "Notes on Capital Budgeting."
19. Minneapolis, New York, Phoenix and San Francisco have developed formal estimates for both buildings and roads. New York City actually estimates the "state of good repair" in dollar terms as part of its asset management system, and has tied this system to its regular assessment of capital condition.
20. Peter Rossi and Howard Freeman, *Evaluation: A Systematic Approach* (Newbury Park, CA: Sage, 1993).
21. Huey-Tsyh Chen, *Theory-Driven Evaluations* (Newbury Park, CA: Sage, 1990).
22. Salwa Ammar, and Ronald Wright, "Fuzzy logic: A Case Study in Performance Measurement," in *Uncertainty Analysis in Engineering and the Sciences*, ed. B. M. Ayyub and M. M. Gupta (Boston: Kluwer Academic Publishers, 1997), 233-245. Salwa Ammar, Ronald Wright, and Sally Seldon, "Ranking State Financial Management: A Multilevel Fuzzy Rule-based System," *Decision Sciences* (Spring 2000): 449-481.
23. See William Treadwell, "Fuzzy Set Theory Movement in Social Sciences," *Public Administration Review*, 55 (January/February, 1995): 91-98; J. Durkin, *Expert Systems: Design and Development* (New York: Macmillan Publishing, 1994); and Ammar and Wright, "Fuzzy Logic: A Case Study in Performance Measurement."

24. D. Dubois and H. Prade, *Possibility Theory*. (New York, NY: Plenum Press, 1988).
25. The point of transition is not always the average score. In some cases the average score was considered sub par and the point of transition was placed higher than the average score. In other cases the average score was considered above standard and the point of transition was placed below the average score.
26. In conjunction with using fuzzy set theory this simplification is not limiting and maintains sufficient gradation for robust evaluation. The rules bases for this paper were developed by the authors based on our judgment about the relative importance of various capital management practices.
27. Since each component can belong to two adjacent categories, a four component rule base will typically generate as many as 16 applicable rules for any given evaluation. This multiple rule application adds robustness to the evaluation process and makes the use of only three evaluation categories appropriate.
28. D. Dubois and H. Prade, *Possibility Theory* (New York: Plenum Press, 1988).
29. The rule bases for long-run planning and maintenance are available from the authors upon request.
30. Anyone trying to duplicate the results in Figure 7 from Table 5 and Figure 6 may find that they cannot recreate the score for the fair category. This is because one additional step is taken to assure that results are consistent. Any adjacent rules in Figure 6 that are identical on all criteria except one should be collapsed into one rule. The visual basic software created by Ammar and Wright for this application has a search algorithm that identifies and combines all rules that are identical except one category. Also, note that fuzzy measures indicate the extent to which elements belong to a set, not a probability. Hence, there is no expectation that all fuzzy measures for a single element add to one.
31. Raw data are entered using a spreadsheet. Fuzzification of the raw scores, creation and application of the rules, and generation of reports with fuzzy results and rankings are all completed using algorithms defined using Visual Basic Application in Microsoft Excel.
32. L. Zadeh, "A New Direction in Fuzzy Logic: Toward a Computational Theory of Perceptions," *Proceedings of 18<sup>th</sup> International Conference of the North American Fuzzy Information Processing Society* (New York, NY, 1999): 1-4; W. Pedrycz, *Fuzzy Control and Fuzzy Systems* (London, UK: Research Studies Press, 1993); R. Yager and D. Filev, "On the Issue of Defuzzification and Selection Based on a Fuzzy Set," *Fuzzy Sets and Systems* (1993): 255-271.

**TABLE 1**  
**Summary of Capital Management Data**

Category	Range of Scores for Survey Response	35-City		
		25 Percent Quartile	Median	75 Percent Quartile
<b>Project Management</b>	0 to 6	3.0	4.0	5.0
<b>Long-Run Planning</b>				
Conditions assessment	0 to 6	3.0	3.0	5.0
Economic needs fiscal planning	0 to 5	3.0	3.0	4.0
<b>Capital Budgeting</b>				
Planning document	0 to 6	3.0	4.0	5.0
Operating budget link	0 to 6	2.0	4.0	5.5
Project selection	0 to 6	2.0	2.0	3.0
Capital planning process	0 to 5	3.0	3.0	4.0
<b>Maintenance</b>				
Planning	0 to 6	1.0	2.0	4.0
Funding	0 to 6	2.0	2.0	3.0

**TABLE 2**  
**Applying Rule 1- Rule 4 in Capital Budgeting Rule-Base**

Rule 1 (IF)	Project Selection	Link to Operating Budget	Planning Document	Planning Process	(THEN) Capital Budgeting
	Fair	Good	Fair	Poor	<b>Fair</b>
Anchorage Fuzzified Input					<b>0.17</b>
Poor	0.0	0.0	0.0	0.17	
Fair	1.0	0.0	0.80	0.83	
Good	0.0	1.0	0.20	0.0	
Anchorage Fuzzified Input					<b>0.17</b> <i>minimum</i>
Poor	0.0	0.0	0.0	0.17	
Fair	1.0	0.0	0.80	0.83	
Good	0.0	1.0	0.20	0.0	
Anchorage Fuzzified Input					<b>0.8<sup>a</sup></b>
Poor	0.0	0.0	0.0	0.17	
Fair	1.0	0.0	0.80	0.83	
Good	0.0	1.0	0.20	0.0	
Anchorage Fuzzified Input					<b>0.17</b> <i>minimum</i>
Poor	0.0	0.0	0.0	0.17	
Fair	1.0	0.0	0.80	0.83	
Good	0.0	1.0	0.20	0.0	
Anchorage Fuzzified Input					<b>0.2</b> <i>minimum</i>
Poor	0.0	0.0	0.0	0.17	
Fair	1.0	0.0	0.80	0.83	
Good	0.0	1.0	0.20	0.0	

<sup>a</sup>Maximum membership of fair conclusions.

**TABLE 3**  
**City of Anchorage Fuzzified Scores for Components**  
**of Capital Management**

	<b>Component</b>		
	<b>Poor</b>	<b>Fair</b>	<b>Good</b>
Long-run planning	0.19	0.81	0.0
Project management	0.0	1.0	0.0
Capital budgeting	0.0	0.8	0.2
Maintenance	0.43	0.57	0.2
Overall capital management	0.19	0.80	0.2

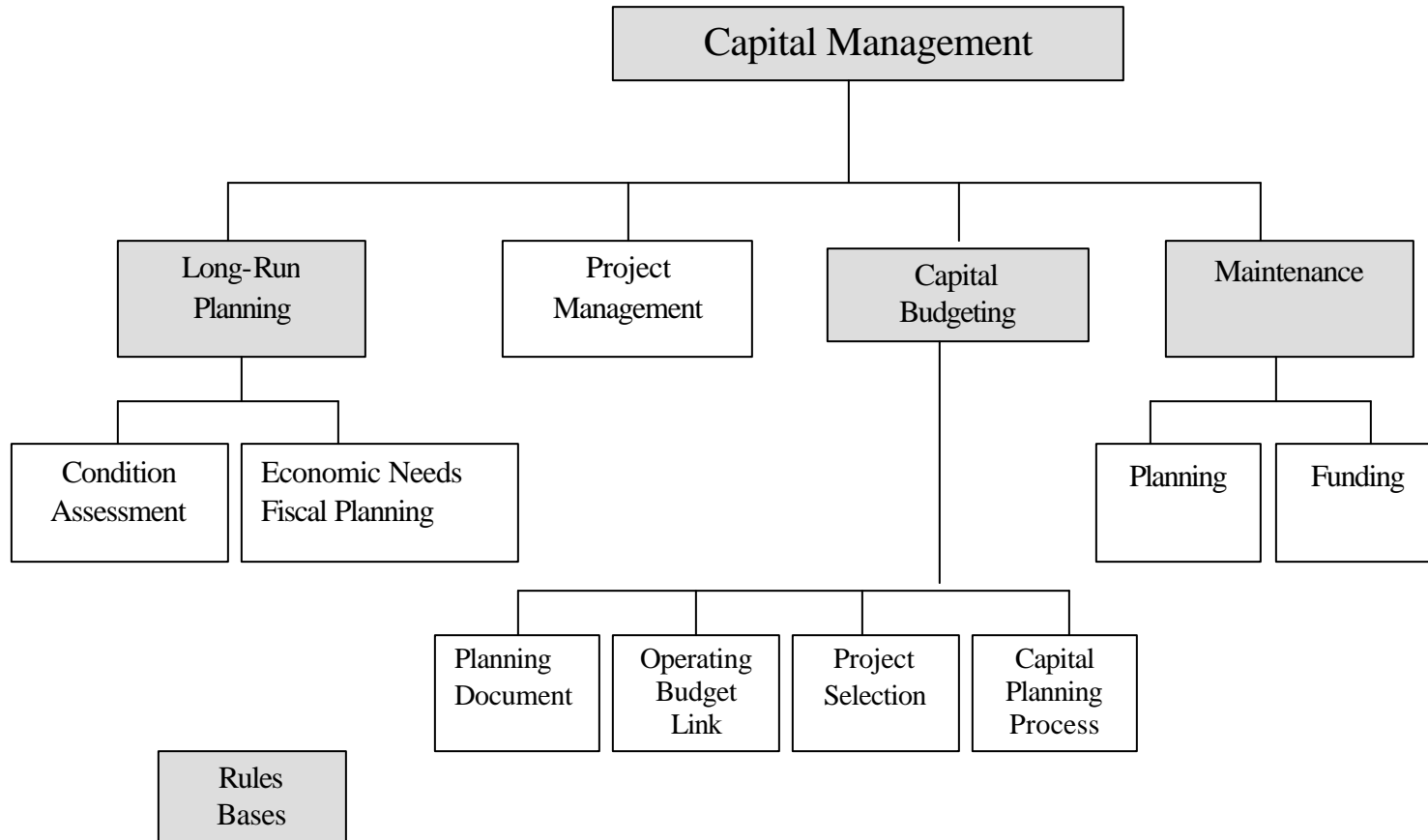
**TABLE 4**  
**Fuzzy Rule-Based System Scores for the Components of Capital Management**

City	Long-Run Planning				Project Management				Capital Budgeting				Maintenance			
	Membership Grades			Defuzzied Score	Membership Grades			Raw Score	Membership Grades			Defuzzied Score	Membership Grades			Defuzzied Score
	poor	fair	good		poor	fair	good		poor	fair	good		poor	fair	good	
Phoenix	0.00	0.00	1.00	20.00	0.00	0.00	1.00	6	0.00	0.33	0.67	15.75	0.00	0.00	1.00	20.00
Minneapolis	0.00	0.00	1.00	20.00	0.00	1.00	0.00	4	0.00	0.33	0.67	15.75	0.00	0.80	0.20	11.53
Austin	0.00	0.43	0.57	14.72	0.00	0.50	0.50	5	0.00	0.40	0.60	15.06	0.00	0.80	0.20	11.53
Kansas City, MO	0.05	0.43	0.57	14.30	0.25	0.75	0.00	3	0.00	0.00	1.00	20.00	0.00	1.00	0.00	10.00
Virginia Beach	0.00	0.43	0.57	14.72	0.00	1.00	0.00	4	0.00	0.00	1.00	20.00	0.00	0.80	0.20	11.53
San Jose	0.00	0.87	0.13	10.99	0.00	0.00	1.00	6	0.17	0.50	0.50	12.66	0.00	0.40	0.60	15.06
New York City	0.00	0.43	0.57	14.72	0.00	0.50	0.50	5	0.00	0.83	0.17	11.27	0.00	1.00	0.00	10.00
Baltimore	0.00	0.87	0.13	10.99	0.00	0.00	1.00	6	0.00	0.83	0.17	11.27	0.71	0.29	0.00	3.73
Seattle	0.05	0.87	0.13	10.63	0.00	1.00	0.00	4	0.00	0.33	0.67	15.75	0.00	1.00	0.00	10.00
Denver	0.05	0.43	0.57	14.30	0.00	0.00	1.00	6	0.00	0.83	0.17	11.27	0.43	0.57	0.00	6.56
Honolulu	0.05	0.87	0.13	10.63	0.00	0.50	0.50	5	0.00	0.83	0.17	11.27	0.43	0.57	0.20	8.22
Anchorage	0.19	0.81	0.00	8.56	0.00	1.00	0.00	4	0.00	0.80	0.20	11.53	0.43	0.57	0.20	8.22
Indianapolis	0.19	0.81	0.00	8.56	0.00	0.00	1.00	6	0.00	0.83	0.17	11.27	0.43	0.57	0.20	8.22
San Antonio	0.00	0.43	0.57	14.72	0.00	1.00	0.00	4	0.50	0.50	0.17	7.34	0.43	0.57	0.00	6.56
Chicago	0.43	0.57	0.00	6.50	0.00	0.50	0.50	5	0.40	0.60	0.33	9.50	0.43	0.57	0.00	6.56
Cleveland	0.19	0.81	0.00	8.56	0.00	0.50	0.50	5	0.50	0.50	0.00	5.91	0.43	0.57	0.00	6.56
Jacksonville	0.19	0.81	0.00	8.56	0.00	1.00	0.00	4	0.63	0.38	0.00	4.68	0.43	0.57	0.00	6.56
Long Beach	0.05	0.87	0.13	10.63	0.00	0.50	0.50	5	0.44	0.56	0.00	6.42	0.43	0.57	0.00	6.56
San Diego	0.19	0.81	0.00	8.56	0.00	1.00	0.00	4	0.50	0.50	0.17	7.34	0.43	0.57	0.00	6.56
Memphis	0.46	0.54	0.00	6.28	0.00	0.00	1.00	6	0.00	0.83	0.17	11.27	0.71	0.29	0.00	3.73
Atlanta	0.46	0.54	0.00	6.28	0.50	0.50	0.00	2	0.50	0.50	0.00	5.91	0.43	0.57	0.00	6.56
Detroit	0.19	0.81	0.00	8.56	0.50	0.50	0.00	2	0.44	0.56	0.00	6.42	0.71	0.29	0.00	3.73
Milwaukee	0.00	0.05	0.95	19.29	0.50	0.50	0.00	2	0.50	0.50	0.42	9.39	1.00	0.00	0.00	0.00
New Orleans	0.19	0.81	0.00	8.56	0.25	0.75	0.00	3	0.50	0.50	0.17	7.34	0.71	0.29	0.00	3.73
Richmond	0.19	0.81	0.00	8.56	0.50	0.50	0.00	2	0.17	0.83	0.00	8.73	1.00	0.00	0.00	0.00
San Francisco	0.05	0.43	0.57	14.30	1.00	0.00	0.00	0	0.50	0.50	0.00	5.91	0.00	1.00	0.00	10.00
Dallas	0.52	0.48	0.00	5.68	0.25	0.75	0.00	3	0.63	0.38	0.00	4.68	0.43	0.57	0.00	6.56
Philadelphia	0.52	0.48	0.00	5.68	0.00	0.50	0.50	5	0.50	0.50	0.00	5.91	0.71	0.29	0.00	3.73
Columbus, OH	0.19	0.81	0.00	8.56	0.00	1.00	0.00	4	0.63	0.38	0.00	4.68	0.71	0.29	0.00	3.73
Boston	1.00	0.00	0.00	0.00	0.00	1.00	0.00	4	0.50	0.50	0.00	5.91	0.71	0.29	0.00	3.73
Houston	1.00	0.00	0.00	0.00	0.25	0.75	0.00	3	0.42	0.58	0.00	6.67	0.71	0.29	0.00	3.73
Washington, D.C.	0.73	0.27	0.00	3.56	0.50	0.50	0.00	2	0.40	0.60	0.00	6.81	1.00	0.00	0.00	0.00
Los Angeles	0.19	0.81	0.00	8.56	0.00	0.00	1.00	6	0.80	0.20	0.00	2.73	0.80	0.20	0.00	2.73
Nashville	1.00	0.00	0.00	0.00	0.25	0.75	0.00	3	1.00	0.00	0.00	0.00	0.43	0.57	0.00	6.56
Buffalo	1.00	0.00	0.00	0.00	0.50	0.50	0.00	2	1.00	0.00	0.00	0.00	0.71	0.29	0.00	3.73

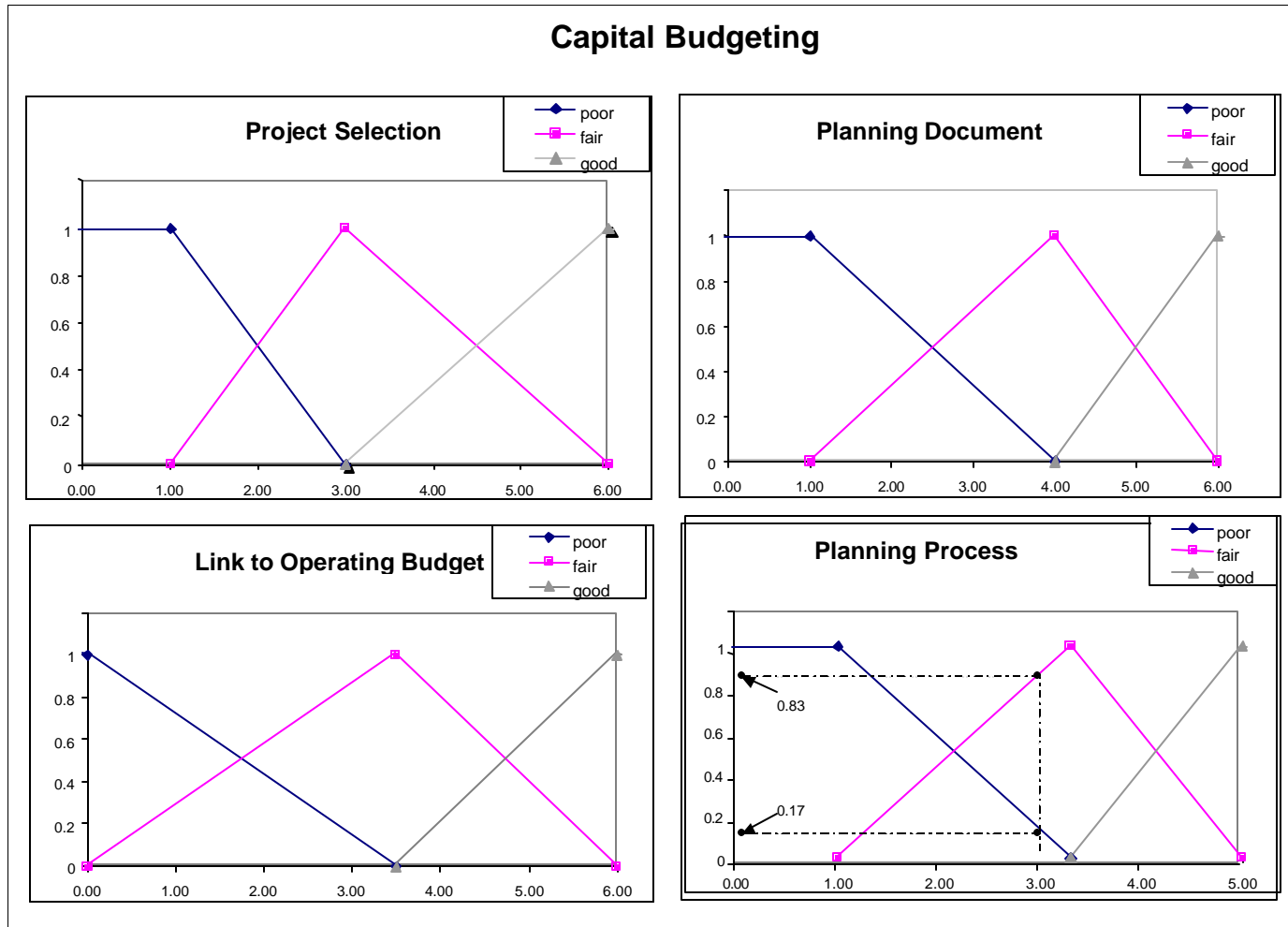
**TABLE 5**  
**Fuzzy Rule-Based System Scores for Capital Management,**  
**Comparison with a Simple Sum of Total Points**

City	Membership Grades			Defuzzied Score	Fuzzy Rank	Sum Score	Sum Rank
	Poor	Fair	Good				
Phoenix	0.00	0.00	1.00	20.00	1.0	48	1.0
Minneapolis	0.00	0.33	0.67	15.75	2.0	43	2.0
Austin	0.00	0.43	0.57	14.72	4.0	41	3.5
Kansas City, MO	0.00	0.43	0.57	14.72	4.0	40	5.5
Virginia Beach	0.00	0.43	0.57	14.72	4.0	41	3.5
San Jose	0.00	0.50	0.50	14.09	6.0	39	7.5
New York city	0.00	0.83	0.17	11.27	7.0	39	7.5
Baltimore	0.00	0.87	0.13	10.99	8.5	33	9.5
Seattle	0.00	0.87	0.13	10.99	8.5	40	5.5
Denver	0.05	0.83	0.17	10.91	10.5	32	11.5
Honolulu	0.05	0.83	0.17	10.91	10.5	32	11.5
Anchorage	0.19	0.80	0.20	10.08	12.0	33	9.5
Indianapolis	0.19	0.81	0.17	9.83	13.0	31	14.0
San Antonio	0.43	0.57	0.17	7.94	14.0	31	14.0
Chicago	0.43	0.57	0.00	6.56	17.0	31	14.0
Cleveland	0.43	0.57	0.00	6.56	17.0	26	22.0
Jacksonville	0.43	0.57	0.00	6.56	17.0	25	23.5
Long Beach	0.43	0.57	0.00	6.56	17.0	28	18.0
San Diego	0.43	0.57	0.00	6.56	17.0	28	18.0
Memphis	0.46	0.54	0.00	6.28	20.0	28	18.0
Atlanta	0.50	0.50	0.00	5.91	23.5	21	32.5
Detroit	0.50	0.50	0.00	5.91	23.5	22	30.5
Milwaukee	0.50	0.50	0.00	5.91	23.5	28	18.0
New Orleans	0.50	0.50	0.00	5.91	23.5	24	26.0
Richmond	0.50	0.50	0.00	5.91	23.5	27	21.0
San Francisco	0.50	0.50	0.00	5.91	23.5	28	18.0
Dallas	0.52	0.48	0.00	5.68	27.5	23	28.5
Philadelphia	0.52	0.48	0.00	5.68	27.5	24	26.0
Columbus, OH	0.63	0.38	0.00	4.68	29.0	24	26.0
Boston	0.71	0.29	0.00	3.73	30.5	23	28.5
Houston	0.71	0.29	0.00	3.73	30.5	22	30.5
Washington, D.C.	0.73	0.27	0.00	3.56	32.0	21	32.5
Los Angeles	0.80	0.20	0.00	2.73	33.0	25	23.5
Nashville	1.00	0.00	0.00	0.00	34.5	20	34.0
Buffalo	1.00	0.00	0.00	0.00	34.5	16	35.0

**FIGURE 1**  
**Components of Capital Management**



**FIGURE 2**  
**Fuzzy Sets for Components of Capital Budgeting**



**FIGURE 3**  
**Capital Budgeting Rule Matrix**

		<b>project selection</b>											
		poor			fair			good					
<b>Operating</b>	<b>Poor</b>	<b>document</b>			<b>document</b>			<b>document</b>					
		<b>process</b>	poor	fair	good	<b>process</b>	poor	fair	good	<b>process</b>	poor	fair	good
		poor	p	p	p	poor	p	p	p	poor	p	p	p
	fair	p	p	p	fair	p	p	f	fair	p	f	f	
	good	p	p	p	good	p	f	f	good	p	f	f	
	<b>Fair</b>	<b>document</b>			<b>document</b>			<b>document</b>					
		<b>process</b>	poor	fair	good	<b>process</b>	poor	fair	good	<b>process</b>	poor	fair	good
		poor	p	p	p	poor	p	f	f	poor	p	f	f
	fair	p	p	f	fair	f	f	f	fair	f	f	f	
good	p	f	f	good	f	f	f	good	f	f	g		
<b>Good</b>	<b>document</b>			<b>document</b>			<b>document</b>						
	<b>process</b>	poor	fair	good	<b>process</b>	poor	fair	good	<b>process</b>	poor	fair	good	
	poor	p	p	p	poor	f	f	f	poor	f	f	f	
fair	p	f	f	fair	f	f	g	fair	f	g	g		
good	p	f	f	good	f	g	g	good	g	g	g		

Middle Column

Good  
Last Row

**FIGURE 4**  
**Capital Management Rule Matrix**

		<b>capital budgeting</b>											
		poor				fair				good			
maintenance	Poor	<b>planning</b>				<b>planning</b>				<b>planning</b>			
		<b>project</b>	poor	fair	good	<b>project</b>	poor	fair	good	<b>project</b>	poor	fair	good
		poor	p	p	p	poor	p	p	p	poor	p	p	f
	fair	p	p	p	fair	p	f	f	fair	p	f	f	
	good	p	p	f	good	p	f	f	good	f	f	f	
	Fair	<b>planning</b>				<b>planning</b>				<b>planning</b>			
		<b>project</b>	poor	fair	good	<b>project</b>	poor	fair	good	<b>project</b>	poor	fair	good
		poor	p	p	p	poor	f	f	f	poor	f	f	f
	fair	p	f	f	fair	f	f	f	fair	f	f	g	
good	p	f	f	good	f	f	f	good	f	f	g		
Good	<b>planning</b>				<b>planning</b>				<b>planning</b>				
	<b>project</b>	poor	fair	good	<b>project</b>	poor	fair	good	<b>project</b>	poor	fair	good	
	poor	p	p	p	poor	f	f	f	poor	f	f	f	
fair	p	f	f	fair	f	f	g	fair	f	g	g		
good	f	f	f	good	f	f	g	good	f	g	g		

