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**Recognizing the Competing Values in Science and Technology Organizations:
Implications for Evaluation
Gretchen B. Jordan, L. Devon Streit¹**

ABSTRACT

This paper proposes a framework for assessing the effectiveness of Science and Technology (S&T) organizations that recognizes the Competing Values theory of effectiveness developed by Rohrbaugh, Cameron and Quinn. The paper shows that use of this framework provides a method for assessing S&T organizational effectiveness that is credible, valid, accounts for differing resources and external circumstances, and recognizes the particular working and management environments of S&T programs. The Competing Values theory incorporates four traditional models of organizational effectiveness and thus is able to integrate and organize most dimensions or values that stakeholders hold dear. The means of managing an organization to achieve the sometimes competing perspectives of effectiveness (high morale, creativity, productivity, and efficiency) are defined specifically for S&T organizations, based on what scientists and the literature suggest are necessary for innovation and conducting excellent research. The implications of the proposed framework are outlined for evaluation planning and utilization, for defining "leading" performance indicators, and for modifying data collection methods.

INTRODUCTION

Since 1996, the U.S. Department of Energy's (DOE) Office of Basic Energy Sciences has sponsored a study to better understand the elements of research environments that contribute to scientists' and engineers' ability to perform excellent research and to develop new techniques to assess the Science and Technology (S&T) organization's effectiveness in providing these elements. This DOE study would also like to clarify what is the "best practice" in managing research and how to meaningfully compare the effectiveness of different organizations, given the different types of research they conduct and their differing circumstances.

In order to accomplish these goals, the authors found it necessary to propose a new way to describe and assess the effectiveness of S&T organizations, building on a concept called the Competing Values Framework developed by Rohrbaugh, Cameron and Quinn (1983, 1988, 1999). The authors first describe current motivations for assessing organizational effectiveness and existing models for doing so. Then they present the proposed framework that includes the Competing Values perspective on organizational culture and effectiveness within

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the context of the organization: its resources, products and purpose, and external environment. After describing the model of organizational effectiveness developed by Rohrbaugh, Cameron and Quinn, the authors adapt this model for S&T organizations. Attributes of the S&T organizational culture are defined, using as guidance work with more than 1500 scientists and engineers and an extensive literature review on what influences innovation, productivity, and "best practice." Finally, implications that the proposed framework has for evaluation planning, utilization, and data collection and for defining a balanced set of leading indicators are outlined.

MOTIVATION FOR THE RESEARCH

Desire to Improve and Report

There is increased interest in assessment of the effectiveness of S&T organizations both because people want to know how to improve these organizations and because they need to report current effectiveness to senior managers and investors. For some, this is a matter of improving a situation that is already excellent or a result of the Quality movement (Endres, 1997; McLaughlin, 1995; Miller, 1995). Within the large U.S. public research laboratories, however, there is concern that the environment for research has been deteriorating. This worry has been voiced both by scientists within these organizations, as well as by the leaders whose responsibility it is to steward the nation's research infrastructure (U.S. House of Representatives, 1994).

Public concern that governments improve performance, clarify responsibilities and control, and realize cost savings has also increased the need to demonstrate the effectiveness of research organizations. This need is not unique to the United States. An Organization For Economic Cooperation and Development (OECD) study (1997) states that these concerns are noticeable in all OECD performance management frameworks, although to different degrees.

The call for more performance management has science managers concerned. Many feel the push toward measuring milestones that can be quantified on an annual basis creates an undesirable bias toward doing short term, less risky research. A recent study by the National Academies of Sciences Committee on Science, Engineering, and Public Policy (1999) concluded that while milestones are appropriate for applied research, agencies conducting basic research must set their expectations based on research quality, attainment of leadership in their field, and the development of human resources, and that these are three good indicators that the organization will provide long-term, valuable returns on the public or private research investment. Branscomb, in his 1999 article "The False Dichotomy: Scientific Creativity and Utility," suggests that a new conceptual model for public science is needed so that managers of public science can articulate the goals of public investment in research and measure its progress in a way that meet Congressional needs. Branscomb suggests that the new model should address both the motives for spending public money on research and the environment in which to perform the work.

The Desire to Look at Differences in Goals, Organizational Design, and Circumstances

Branscomb's call for a new model for discussing public science is echoed by many who seek ways to assess S&T organizations that recognize differences in goals, management environments, their circumstances, and expected outcomes. A 1993 report by the Federal Government of Canada suggests that methods for assessing the socioeconomic impacts of

government S&T will differ depending on the type of S&T (basic, applied and technology development), the purpose of the S&T being assessed, and whether or not the impact has already occurred. Organizational design also influences organizational outcomes. For example, Hull (1988) argues that efficient research performance is partly a function of the match between organizational design and the type of work performed. His research showed that organic, non-hierarchical systems are best for dynamic contexts, small organizations, and complex products.

Furthermore, there often appears to be a need to balance competing demands in managing S&T organizations. Udwardia (1990) suggests that “technological organizations need to engender environments that provide a delicate balance between giving the creative mind freedom to conduct its work while maintaining external constraints like goal setting and time-tables which are essential for the conduct of profitable business.” In other cases, a change in focus and culture is needed. The U.S. General Accounting Office (1996) suggests that one of the leadership practices that will reinforce results-oriented management is to redirect organizational culture from the traditional focus on inputs and activities to a new focus on defining missions and achieving results. Finally, there are differences in the resource bases of organizations and in their current and future circumstances that may influence organizational decisions, design and performance. A 1996 National Science and Technology Council Report suggested that “science agencies must devise assessment strategies ... designed to ... respond to surprises, pursue detours, and revise program agendas in response to new scientific information and technical opportunities essential to the future well-being of our people.”

CURRENT FRAMEWORKS FOR ASSESSING THE EFFECTIVENESS OF S&T ORGANIZATIONS

Several authors have proposed frameworks for assessing S&T organizations that respond to the many requirements articulated above. In describing his approach, Szakonyi (1994) states that while “improving the effectiveness of R&D is the most important issue in R&D management ... there are still no methods that are widely accepted for measuring R&D effectiveness.” He suggests that there are major flaws in the last 30 years of effort, including lack of objectivity, credibility, and frame of reference. The audit model proposed by Chiesa, Coughlan, and Voss (1996) measures performance in seven areas of innovation and allows organizations not only to identify their strengths and weaknesses but also to determine methods of improving innovation processes and capacity. Kanter (1988) argues that recognizing the conditions that stimulate innovation first require understanding the factors involved in the innovation development process. Hurley (1997) concludes that even if an organization hired the right scientists, the highest level of discovery would occur only if they were put into a discovery-oriented environment. Crow and Bozeman (1998) suggest that their Environmental Context Taxonomy identifies laboratories of similar character and behavior, which then allows for a more accurate assessment of laboratory performance based on specific needs and goals of each S&T laboratory. These models as well as Udwardia's (1990) Multiple Perspective Model and the Industrial Research Institute's Technology Value Pyramid are discussed briefly below before the authors propose a framework that builds on these and encompass four perspectives on effectiveness.

In Szakonyi's model (1994), how well an organization performs each of ten activities, such as selecting S&T, planning and managing projects, maintaining quality S&T processes, motivating technical people, coordinating S&T and marketing, is rated on a logical, objective six-point scale that ranges from “issue is not recognized” to “continuous improvement is

underway.” Benchmarking against the “average” department allows organizations to determine how well they are performing and guides their improvement.

Chiesa et al. (1996) look at five dimensions of performance: resource availability and allocation, understanding competitor's strategies, understanding the technological environment, structural and cultural context, and strategic management to deal with entrepreneurial behavior. Central to their audit model are the interacting core processes of concept generation, product development, product innovation, and technology acquisition. These are fed by enabling processes of leadership, resources, and systems and tools.

Kanter's model (1988) looks at individual researchers, organizational structure, and the social and legal environment and suggests that it is most likely that innovations will develop in environments with “flexibility, quick action and intensive care, coalition formation, and connectedness.” Some conditions are more important than others at different points in the innovation/development process.

Hurley's model (1997) suggests that an organization maximizes scientific discovery dependent upon individual characteristics such as scientific knowledge, personality characteristics, and organizational characteristics that include both resources and dynamics. Resources that foster discovery include money, equipment, libraries, competent technicians, and rewards. Organizational dynamics address psychological factors such as organizational stability, intellectual freedom, and a climate of enthusiasm, dedication, and encouragement.

Udwadia (1990) highlights creativity as the most critical element for the effective management of innovation. He presents his Multiple Perspective Model which includes three perspectives: the individual characteristics associated with creativity, the needed technical resources (material as well as human), and the organizational practices and managerial actions that aid or stifle creativity.

The Industrial Research Institute has developed the Technology Value Pyramid (TVP), a group of 50 metrics used to assess and predict S&T performance. As described by Tipping, Zeffren, and Fusfeld (1995), two of the five managerial factors that describe the innovation capability of the firm are the “Practice of R&D Processes to Support Innovation” which includes management practices, idea generation, and communication and the “Asset Value of Technology” which includes technology know how, people and proprietary assets.

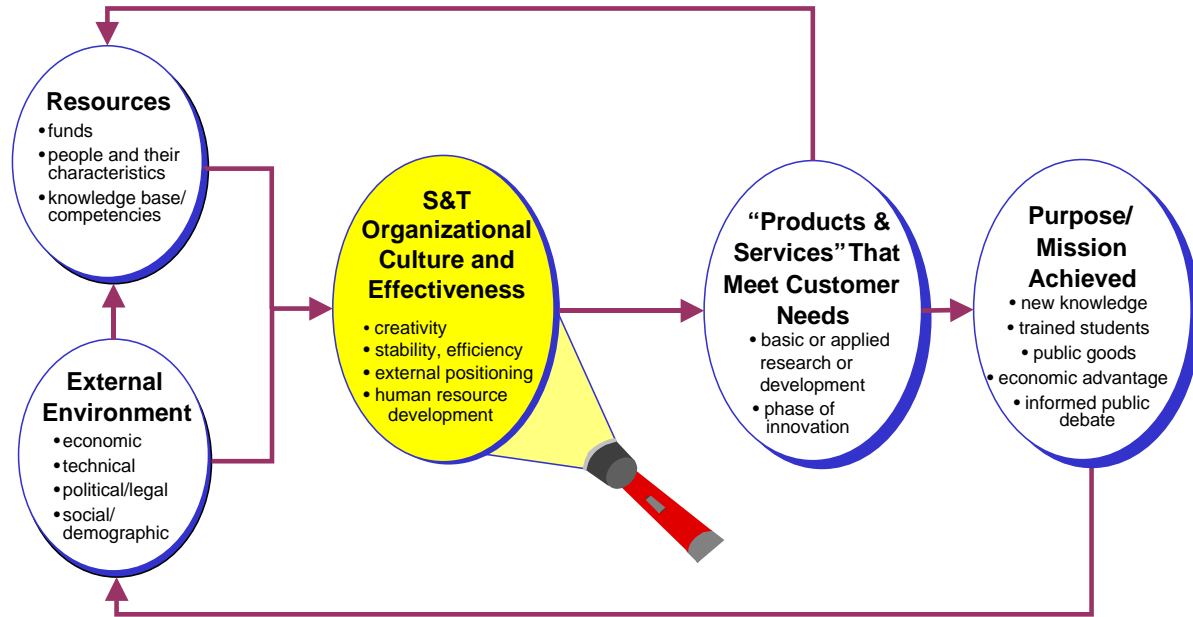
Crow and Bozeman (1998) propose their Environmental Context Taxonomy classification system because the traditional way of classifying laboratories along the lines of university, industrial, and government overlooks the diversity in technical abilities, organization, economics, politics, and flexibility that S&T laboratories exhibit. They suggest that the level of government and economic influence that affects a laboratory has repercussions on the performance and capability of the organization, and is associated with research type and focus, resource quality, and laboratory structure.

A NEW FRAMEWORK FOR ASSESSING EFFECTIVENESS OF S&T ORGANIZATIONS

All of the models described above link innovation, creativity or excellent S&T to organizational structure, culture, characteristics, or activities and processes. The models of Szakonyi (1994), Kanter (1988), Chiesa, et al. (1996), Udwadia (1990), and Crow and Bozeman (1998) also include relationships with one or more aspects of the external environment. All the models, except for Szakoyi's (1994), explicitly include organizational resources. In Figure 1, the authors present a comprehensive framework that builds on the elements in these models to

provide a complete and logical picture of the S&T organization, its “products,” and its internal and external circumstances.

Figure 1. A Framework for Assessing Effectiveness of S&T Organizations



The important aspects of the proposed comprehensive framework are

- Organizational culture and effectiveness,
- The primary purpose or mission of the organization,
- The type of research or “product” of the organization,
- The level and quality of resources available to those doing the science, and
- The external environment (technology, political/regulatory, social/demographic, and economic).

The authors’ primary focus is the study of organizational culture and effectiveness (spotlighted in Figure 1) which they believe must be assessed within the larger context in which the organization operates. This context includes:

- **The primary purpose/mission of the organization**, here defined using categories developed by Laredo and Mustar (2000): new knowledge, trained students, public goods, economic advantage, and informed public debate.
- **The type of “products and services” of the S&T organization**, in this case the stage or type of research conducted. This component is meant to capture the results of the S&T activities as well as its uses. Although some would define the types of S&T more carefully to distinguish use-directed basic research from curiosity-driven research, for example, most define the types of S&T as basic, applied, and development. Kanter (1988) suggests it is

important to distinguish the phases of innovation (idea generation, coalition building, idea realization, and transfer.)

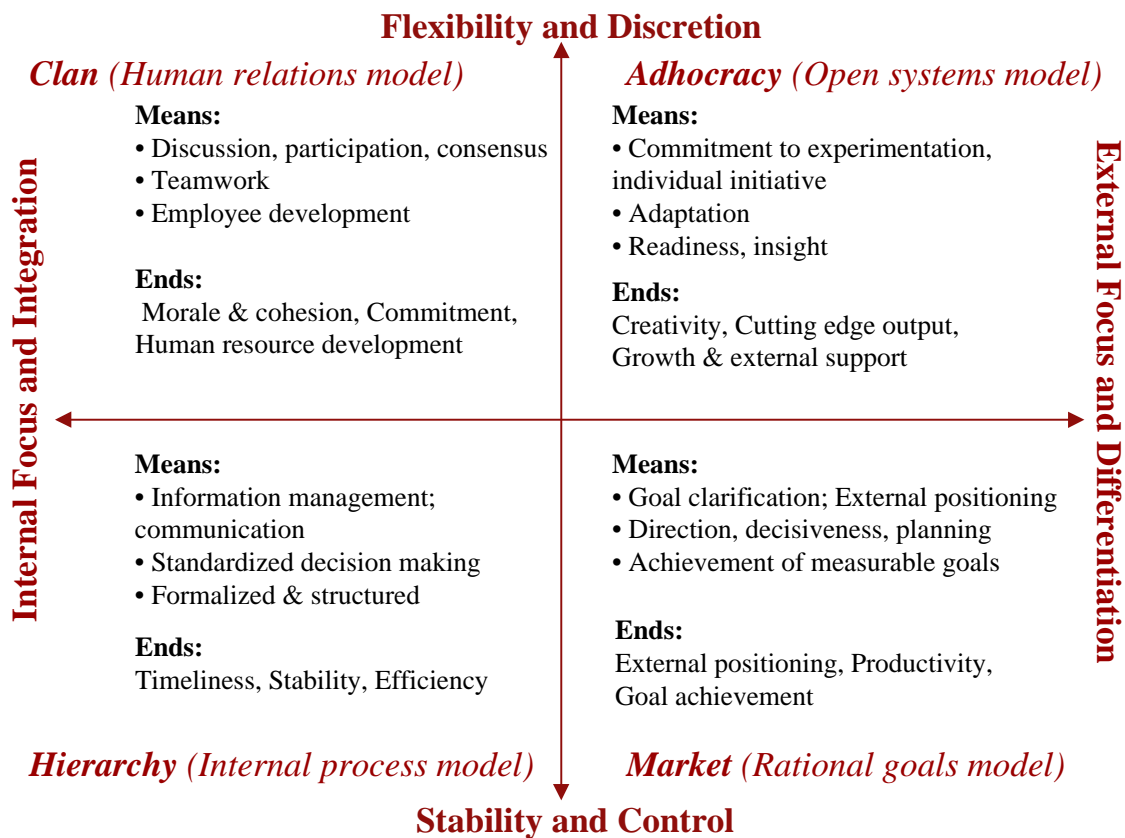
- **The external environment's influences** on the organization are typically broken into four categories: technical, economic, social and cultural, and political/regulatory. Each of these may be of varying influence and that influence may be stable or dynamic, and favorable or unfavorable.
- **The resources** currently available to an S&T organization include funding, staff and their characteristics, facilities and equipment, its knowledge base and core competencies. The characteristics of these resources define, in part, what an organization is capable of doing.

Within this framework, an effective organization is one whose culture, structure and management is optimal to turn its resources into outputs and accomplish the purpose of the organization's effort, given the external environment in which it operates. The framework embraces a broad definition of effectiveness that includes creativity, productivity, efficiency, and employee morale and development. This is based on the Competing Values theory and is described in more detail in the next section.

THE COMPETING VALUES THEORY OF ORGANIZATIONAL EFFECTIVENESS

The DOE research environment study has chosen the Competing Values theory of Rohrbaugh, Cameron, and Quinn (1983, 1988, 1999) to describe the organizational culture and effectiveness of research organizations. The term "culture" is used broadly here to encompass all of the values, structure, focus, and behaviors of the organization. The authors strongly agree with the Cameron and Quinn (1999) argument that follows. Since organizational culture is a complex, interrelated, comprehensive, and ambiguous set of factors, it is impossible to include every relevant factor in diagnosing and assessing organizational culture. Therefore it is important to use an underlying framework, or theoretical foundation, that can narrow and focus the search for key cultural dimensions. The most appropriate framework should be based on empirical evidence, should capture accurately the reality being described (*i.e.*, be valid), and should be able to integrate and organize most of the dimensions that stakeholders value. It should also be congruent with well-known and well-accepted categorical schemes that organize the way people think, their values and assumptions about what makes a good organization, and the ways they process information. Cameron and Quinn (1999) have found that the Competing Values theory meets all of these requirements.

Figure 2. The Rohrbaugh, Cameron, and Quinn Competing Values Theory of Organizational Effectiveness



The Competing Values theory suggests three “value dimensions” that underlie conceptualizations of organizational effectiveness and therefore it can be used to organize the traditional and often conflicting models of effectiveness. The three value dimensions identified by Rohrbaugh, Quinn, and Cameron (1983, 1988, 1999) are *organizational structure*, *organizational focus* and the *means-ends continuum*. The dimension of *organizational structure* distinguishes between those values and activities that emphasize the organization’s flexibility and adaptability and those that stress control and stability. The dimension of *organizational focus* contrasts an emphasis on “internal and integrating issues,” such as the well being and employee development, with “external and differentiating issues,” such as the development and growth of the organization itself or its relations with entities outside itself. The *means-ends continuum* reflects emphasis on the objectives of the organization, such as productivity or human resource development, and the means by which it achieves these objectives, such as goal setting or enhancing morale. As illustrated in Figure 2, Rohrbaugh, Cameron, and Quinn (1983, 1988, 1999) use these value dimensions as axes with which to organize four of the most common theoretical models of organizational effectiveness: the *human relations model*, the *open systems model*, the *rational goal model*, and the *internal processes model*.

Each of the four models stresses the importance of different ends or criteria for creating an effective organization. The four criteria clusters define the core values on which judgements about organizations are made. For some, creativity and what it takes to foster creativity, is most

important. For others, productivity, efficiency or morale and the means to achieve these ends may be most important. As Cameron and Quinn (1999) describe this,

What is notable about these four core values is that they represent opposite or competing assumptions. Each continuum highlights a core value that is opposite from the value on the other end of the continuum – that is, flexibility versus stability, internal versus external. The dimensions, therefore, produce quadrants that are also contradictory or competing on the diagonal. The upper left quadrant identifies values that emphasize an internal, organic focus, whereas the lower right quadrant identifies values that emphasize an external, control focus. Similarly, the upper right quadrant identifies values that emphasize an external, organic focus, whereas the lower left quadrant emphasizes internal, control values. The competing or opposite values in each quadrant give rise to the name for the model, the Competing Values Framework.

The concept of competing values is implicit in much of the current organizational development and management literature. Collins and Porras (1997), in their book “Built to Last,” describe the successful habits of visionary companies, which they define as premier institutions in their industries, widely admired by their peers and having a long track record of making a significant impact. One of the twelve myths that were shattered during their research is the “Tyranny of the OR.”

[Visionary companies] reject having to make a choice between stability or progress; cult-like cultures OR individual autonomy; home-grown managers or fundamental change managers; conservative practices OR Big Hairy Audacious Goals; making money OR living according to values and purpose. Instead they embrace the ‘Genius of the AND’ - the paradoxical view that allows them to pursue both A AND B at the same time.

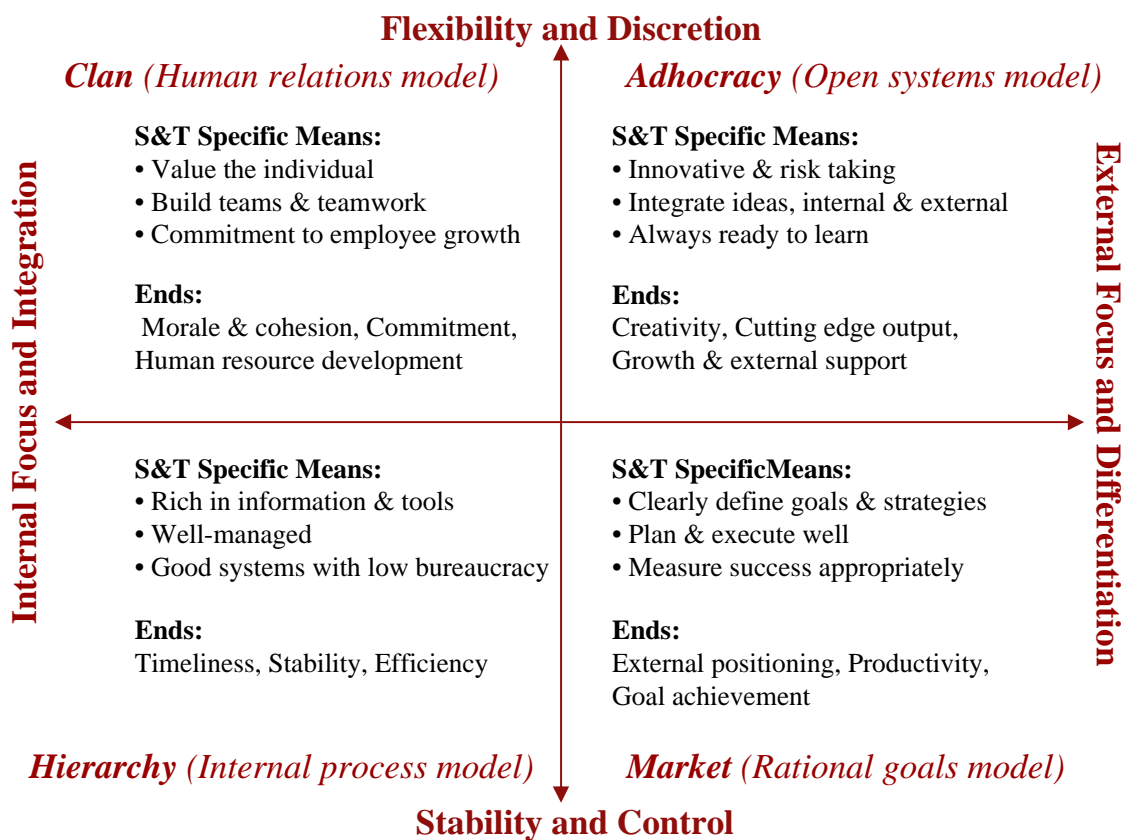
DEFINING THE COMPETING VALUES THEORY FOR S&T ORGANIZATIONS

Altschuld and Zheng (1995) first proposed using the Competing Values theory to assess research organizations. They examined major assessment approaches and identified key issues in evaluating effectiveness for educational and social science research organizations whose outputs were intellectual rather than tangible products. They argued that research organizations need a framework because otherwise value judgments will be implicit rather than explicit. Since the Competing Values theory captures four different models of organizational effectiveness, it provides guidance for recognizing value biases. Using it as a framework may be more appropriate for research than any single model of effectiveness. For example, the goal-attainment approach is not by itself appropriate because research organizations have intangible goals. This lack of tangible goals and quantitatively measurable outcomes means that frameworks considering only efficiency and output measures reveal only part of the picture of effectiveness. The strategic constituency approach, while it is applicable because social references are important for publicly funded research organizations, creates opportunities for political manipulation which suggests it would not be wise to use it as the single model for S&T effectiveness.

Taking the lead from Altschuld and Zheng (1995), this DOE study set out to identify the attributes of a S&T organization's culture from the perspectives of the four models represented

in the Competing Values theory. This was accomplished through an extensive literature review and more than a dozen focus groups and questionnaires from more than 1500 scientists in DOE and industrial research laboratories. The study defined and organized the attributes that S&T managers and evaluators found essential to spur innovation and achievement of the desired performance. The twelve attributes that have been defined as the “means” that S&T organizations achieve the four criteria of effectiveness are shown in Figure 3. Just as Cameron and Quinn (1999) do not claim to have the only framework for assessing organizational effectiveness, this study does not claim to have determined the one right way of grouping and categorizing the attributes that are necessary in the S&T organizational environment. Rather, this scheme is proposed as one way to organize thinking about the effectiveness of S&T organizations. It is based firmly in the S&T management literature and structured to take advantage of what is known about the competing values of organizational effectiveness.

Figure 3. The Competing Values Theory Adapted for S&T Organizations



The twelve attributes in the DOE study are further defined below, along with examples of supporting references from the literature. The authors whose work is noted below are: Bennis and Biederman (1997); Bland and Ruffin (1992); Brown and Eisenhardt (1995); Chiesa, Coughlan and Voss (1996); Ellis (1997); Endres (1997); Hauser and Zettelmeyer (1997); Hull (1988); Hurley (1997); Judge, Fryxell and Dooley (1997); Kanter (1988); Kumar, Persaud and Kumar (1996); Martin and Skea (1992); Menke (1997); Miller (1992, 1995); Montana (1992); National Research Council (1996); Pelz and Andrews (1976); Purdon (1996); Ransley and

Rogers (1994); Roberts (1988); Rosenberg (1994); Szakonyi (1994); Tipping, Zeffren and Fusfeld (1995); Udwardia (1990); Van de Ven and Chu (1989).

Attributes Influencing Morale, Commitment, Human Resource Development

Valuing Individuals includes demonstrating respect for people, rewarding and recognizing merit, and offering competitive salaries and benefits. Kanter mentions that feeling valued and secure helps people be creative. Martin and Skea and Tipping et al. conclude that performance is dependent upon morale. Bland and Ruffin, Ellis, Kanter and Van de Ven and Chu think that appropriate rewards are consistently related to productivity or innovation, and Judge et al. suggest that intrinsic rewards are more important than monetary rewards.

Building Teams and Teamwork includes valuing cooperation and teamwork, emphasizing trust and integrity, and providing support to S&T projects. Chiesa et al., Hurley, Judge et al., Kumar et al., Martin and Skea, Montana, and Udwardia mention teamwork as a prerequisite for effectiveness. Kumar et al. says that cohesion in the project team and support from other teams affect project success. Udwardia argues that creativity is enhanced when trust and respect are promoted. The mix of skills within a team is also important. Hurley concludes that technical productivity and excellence require well-trained and highly developed technicians.

Commitment to Employee Growth includes hiring and retaining quality scientific and technical staff and providing opportunities for career development, as well as educational and professional development. Bland and Ruffin, Hurley, Judge et al., Martin and Skea, the NRC study team, and Udwardia all cite quality of staff as important. In particular Bennis and Biederman and Judge et al. suggest that recruitment should be careful to fit individuals within the group. Commitment to training and career paths is also important. One of ten best practices summarized by Ransley and Rogers is having career development in place and tied to strategy. Endres and Kanter mention employee development as important to innovation, with Kanter specifically mentioning jobs that are broadly defined.

Attributes Influencing Creativity, Cutting-Edge Output, Growth and External Support

Innovative and Risk Taking environments include a sense of challenge and enthusiasm, encouragement to pursue new ideas, and autonomy in scientific management. Bland and Ruffin and Udwardia note that intellectual challenges and positive group climate stimulates productivity and creativity. Creativity and effectiveness is also enhanced, according to Hurley, Kanter, Udwardia, and Van de Ven and Chu, in organizations that push change and risk taking. Hurley, Judge et al., Kanter, Pelz and Andrews, Udwardia, and Van de Ven and Chu, believe that productivity and excellence are dependent on researchers having autonomy and the freedom to make decisions about their research.

Integrates Ideas, Internally & Externally requires organizations to be effective at the internal cross-fertilization of ideas, external collaborations and interactions, and at developing integrated, relevant project portfolios. Chiesa et al., Endres, Hurley, Roberts, Montana and several others indicate that project success hinges on the ability of researchers to exchange and discuss ideas with colleagues in their organization as well as outside their organization. Hauser

and Zetzmeyer, Menke, Ransley and Rogers, Roberts, Tipping et al., and Udwadia expand idea integration to include an organization's ability to develop a portfolio that combines risks, needs, and goals with the ideas of decision-makers, program managers, researchers, and marketers.

Always Ready to Learn captures an organization's commitment to critical thinking, their ability to identify new projects and opportunities, and willingness to protect a researcher's time to think and explore. Pelz and Andrews, Tipping et al., and Udwadia emphasize that effective organizations create environments where researchers feel free to learn, interact, disagree, and produce. According to Chiesa et al., Hauser and Zetzmeyer, Kanter, Purdon, Ransley and Rogers, and Roberts, successful organizations must have the ability to consistently identify customer needs, emerging trends, and external opportunities. Kanter, Martin and Skea, Purdon, Udwadia, and Van de Ven and Chu reinforce the importance of having adequate time to conduct research, explore new approaches, and maintain mastery in their field.

Attributes Influencing Timeliness, Stability, Efficiency

Rich in Information and Tools includes good internal communication, strong research competencies and knowledge base, and good facilities and equipment. Bland and Ruffin, Chiesa et al., Hull, Kanter, Purdon, Rosenberg, and Udwadia mention that consistent and direct communication between researchers, managers, and departments facilitates the production, circulation, and development of new ideas and technologies. Developing and taking advantage of expertise, diversity, and areas of core competency help organizations to maintain success, innovation, and "best practices" according to Bland and Ruffin, Endres, Kumar et al., Menke, Purdon, and Ransley and Rogers. Research project and program success is enhanced by the quality of a laboratory's tools, equipment, and facilities, according to Chiesa et al., Hurley, Kumar et al., Martin and Skea, the NRC study team, and Udwadia.

Well-Managed refers to laboratory management that is decisive and informed, adds value to the research, and allocates resources well. Bland and Ruffin, Brown and Eisenhardt, Kumar et al., Menke, Udwadia, and Van de Ven and Chu emphasize the importance of having managers with the technical knowledge, ability, and authority to make hard decisions about projects, employees, and resources. Bland and Ruffin, Hurley, Montana, Roberts, Szakonyi, and Udwadia mention the importance of committed managers with leadership and people skills. Kanter, Kumar et al., Roberts, and Van de Ven and Chu state that the ability to allocate resources with forethought and strategy is an important management quality.

Good Internal Systems include laboratory services and laboratory systems and processes, such as financial accounting and purchasing, and minimal overhead rates and indirect burden. Hurley and Udwadia list the importance of library, computing, database, and communication services to research productivity. Chiesa et al., Ellis, Menke, Roberts, Szakonyi, and Van de Ven and Chu expand this concept by introducing the importance of effective S&T processes and procedures ranging from project initiation and termination to human resources and hiring. Bland and Ruffin, Brown and Eisenhardt, Ellis, Judge et al., Kumar et al., Montana, and Tipping et al. stress the importance of overall efficiency of organizational functions, low bureaucracy, low cost, and decentralization.

Attributes Influencing External Positioning, Productivity, Goal Achievement

Clearly Defines Goals & Strategies includes an organization's ability to define a research vision and strategies for achieving it, maintain its commitment to fundamental research, and maintain strong relationships with its sponsors. Bland and Ruffin, Menke, Montana, Ransley and Rogers, and Tipping et al. stress the importance of developing clear long- and short-term goals, a unifying and guiding organizational vision, and a well-communicated strategy for fulfilling goals and vision. Chiesa et al., Hauser and Zettlemeyer, Kumar et al., Menke, Miller, Montana, Purdon, Ransley and Rogers, and Roberts note that the organization's goals and strategies must be developed in response to sponsor need and input. To be successful, organizations must communicate with their sponsors and ensure that all projects address customer and end-user requirements and feedback.

Plans and Executes Well includes how an organization plans for and executes projects, whether they have sufficient, stable project funding, and if they invest in future capabilities. Brown and Eisenhardt, Chiesa et al., Kumar et al., Menke, Pelz and Andrews, Roberts, Szakonyi, Tipping et al., and Udvardia list aspects of planning that enhance organizational performance that include having a formalized plan for activity integration, a clear definition of potential applications, and a strategy for choosing the right projects and focusing on realistic and relevant goals. Chiesa et al. and Judge et al. stress the importance of having sufficient funding that is stable and flexible, completing projects, and pursuing innovation. Essential to the success of long-term planning is the organization's investment in future capabilities. Chiesa et al., Hull, Menke, Rosenberg, and Tipping et al. state that future success depends on an organization's existing S&T processes as well as its ability to monitor and adapt to emerging technologies, industry change, and market fluctuation.

Measures Success Appropriately includes the criteria and methods the organization uses to evaluate both project and laboratory success, and the organization's reputation for excellence. Kanter, Miller, Montana, Ransley and Rogers, and Tipping et al. found that research projects are the most innovative and successful when they have milestones to reach, when they meet both research and business objectives, and when they are periodically and objectively reviewed. The NRC study team found that a reputation for excellence stemmed from a focus on continuous improvement, commitment to quality, and quality of research. Kanter and Martin and Skea note that an organization's reputation for excellence was a factor in driving future innovation and excellence.

IMPLICATIONS FOR EVALUATION

This new framework for assessing the effectiveness of S&T organizations recognizes that there are competing values implicit in the different perspectives of effectiveness, and that effectiveness must be assessed within the context of the organization's circumstances. These circumstances may be stable or changing and include the organization's resources, the stage or type of research, and its external technical, economic, social and legal/political influences. As discussed in more detail below, use of the proposed framework could improve evaluation planning, provide a balanced set of leading indicators for research performance, be useful for

investigating differences for different types of research and environmental contexts, and guide the modification of existing data collection methods.

Evaluation planning and utilization

The better the evaluation planning, the more likely the evaluation is to provide information that users perceive as valuable and useful. Good evaluation planning starts with a clear definition of the purpose of the evaluation and its audience and a thorough picture of the components of the “program” or organization being evaluated. Whether the purpose of the evaluation is to provide managers with information on how to improve, or to provide senior managers and sponsors of the S&T with evidence that the S&T is well managed and meeting its objectives, an evaluation is more likely to be utilized and credible if it is based on a framework that includes various stakeholder perspectives.

The proposed framework provides guidance with respect to recognizing value biases and making them explicit. It provides a means for matching an organization's basic characteristics with evaluation strategies and facilitates the choice of effectiveness criteria such that assessment will be respected and accepted both internally and externally. The relationships between organizational structure and organizational effectiveness are recognized and can be investigated. Since the proposed framework also looks at the organization within its particular context, evaluations using this framework can examine relationships between organizational effectiveness and other measures of performance such as outputs and impact, or the stage or type of research.

A Balanced Set of Leading Indicators

Use of the proposed framework could also provide a balanced set of leading indicators for improvement and reporting. Leading indicators provide managers with early warning of opportunities for improvement as well as challenges that may detract from performing excellent S&T. The effectiveness of the S&T organization is a leading indicator for future S&T outcomes and provides a balance to the current emphasis on measuring those outcomes. Moreover, use of the Competing Values theory suggests that a balanced set of indicators for organizational effectiveness would include (1) creativity, (2) morale, (3) external positioning and productivity, and (4) efficiency of internal support structure and systems. For example, measures of creativity would include the extent of internal and external collaboration and the use of cross-functional teams. Other important leading indicators might be the alignment of organizational structure and culture with type of research and purpose as well as with resources and influences of the external environment.

The importance of using a balanced set of indicators should not be underestimated. Measurement always perturbs the system but will perturb it less if the set of measures or indicators are comprehensive enough to cover all aspects of the system and, where indicators push or pull in undesirable directions, offsetting indicators are included in the set.

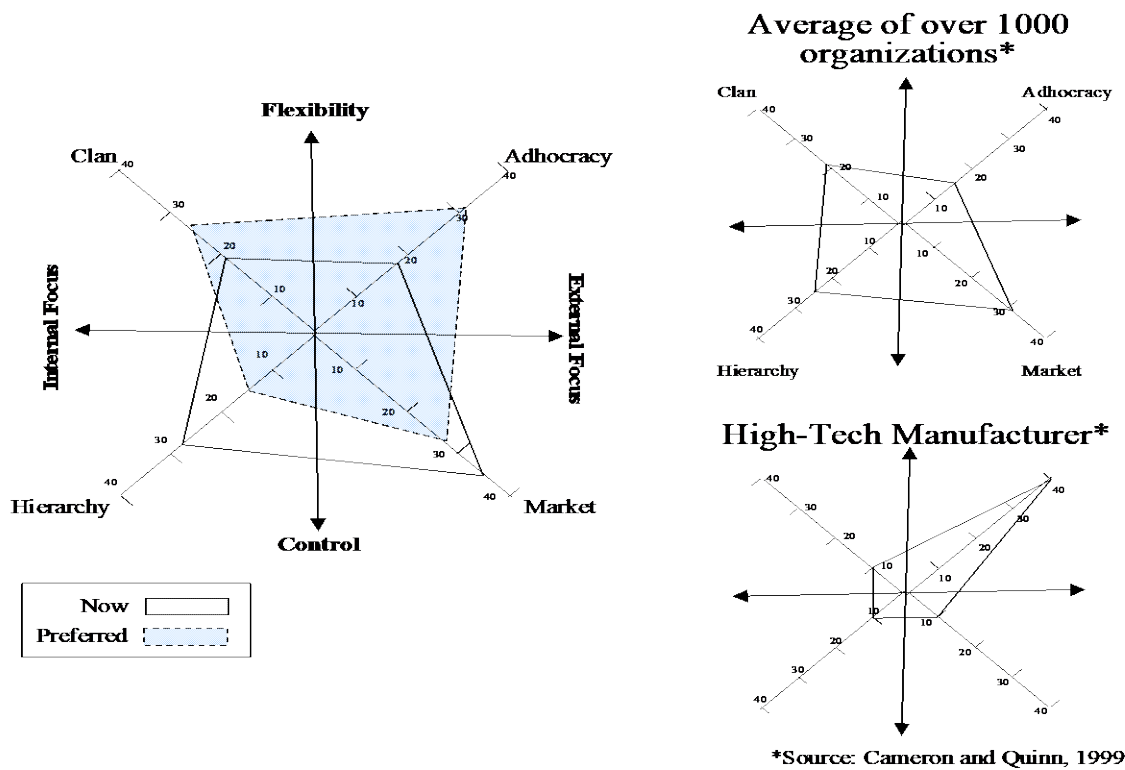
Investigating differences for different types of research and environmental context

Use of the proposed framework is helpful for clarifying differences in organizational structure and focus, depending on the type or purpose of S&T or changing external circumstances. One of the tensions in the Competing Values theory is between control and

flexibility. As Branscomb (1999), Udwardia (1990), and many others point out, more fundamental research requires a more flexible, non-hierarchical organization. The other tension is between internal focus and integration and external focus and differentiation. The trends toward increasing globalization and collaboration would indicate that organizations need to strike a balance between internal and external focus that is more on the side of external focus than it has been in the past.

Examples from experience with Cameron and Quinn's (1999) Organizational Culture Assessment Index (OCAI) demonstrate the potential usefulness of the framework in this area. A questionnaire is supplemented by qualitative methods to produce an overall organizational culture profile that assesses six dimensions of how an organization works and what it values. The OCAI identifies what the current organizational culture is like, as well as what the organization's preferred culture should be. For each of the six dimensions people suggest the weight that the organization gives or should give to values that represent each of the four quadrants of the Competing Values theory. An average for each quadrant is calculated from the six dimensions for both current and preferred and is plotted as shown in Figure 4.

Figure 4. Examples of Organizational Culture Assessments



*Source: Cameron and Quinn, 1999

The OCAI helps the organization diagnose its dominant orientation based on the four core culture types. The organization on the left in Figure 4 sees its culture as dominated by hierarchical structure and rules, as well as an orientation toward setting and achieving market or market-like goals. It would prefer to be more agile and flexible and more concerned about developing human resources. This might be in response to a dynamic and changing external environment that requires more cross-functional teaming, a different skill mix, and assurance to

staff that they will be valued in the new environment. The figures on the right of Figure 4 are averages based on Cameron and Quinn's (1999) experience with more than 1000 organizations. As expected, the dominant culture profile of a high technology manufacturing organization is weighted toward flexibility and external focus, where effectiveness is viewed as creativity, cutting edge output, and external growth and support.

Modifying Data Collection Instruments

Another implication for evaluation is in the area of modifying data collection methods. Currently self-assessment, employee and customer evaluations, and reviews by peers, advisory committees and experts outside the laboratory, are the primary means used by U.S. federal laboratories to assess their workplaces and organizational effectiveness. Criteria for assessment differ and there is no common framework. Existing self-assessment and evaluation instruments fail to cover all of the perspectives of effectiveness in the Competing Values theory and thus are seen as incomplete or biased by those whose perspectives are not represented. In employee attitude surveys used by DOE laboratories, for example, the attributes identified in the literature and by DOE scientists as necessary for creativity and innovation, such as the freedom to pursue new ideas and the cross fertilization of ideas, are not usually investigated. Peer and expert review, while well regarded by scientists, typically provide information at the project level rather than the organizational level. Thus organizational assessments are rarely comprehensive or credible and are not comparable from one organization to the next.

It appears feasible and valuable to add a few standard questions to existing assessment instruments, including peer review, using anchored word scales to describe aspects of the S&T environment and the four views of effectiveness. This standard information could be compared across organizations, perhaps even aggregated from project level data and summarized. The relationships between this standard information and characteristics of the organization and its circumstances could then be investigated. Given increasing capabilities in "data mining," this approach could increase the usefulness of current data collection methods.

AREAS FOR FURTHER RESEARCH

Initial use of the framework in the DOE study indicates that, as Cameron and Quinn (1999) have found, the Competing Values theory is intuitively appealing to people and is useful in describing the tensions in managing S&T organizations. For example, managers of public research see that the proposed framework explains the tension between typical government hierarchical rules and the flexible environment needed for S&T. More research is suggested in several areas. First it is necessary to get more stakeholder input and refine the definition of the proposed framework through application to various types of S&T organizations in differing circumstances. More research is also needed to understand what is "good" or "best practice" for various circumstances, as well as how the framework and assessments can be used by managers to direct change and even to allocate resources. A related area for research, given the current interest in performance measurement and performance based management, is the relationship between the competing values in the S&T organizational culture and concepts such as the Balanced Scorecard and "Built to Last" strategies. The aim of these research questions would be to demonstrate that use of the proposed framework provides credible, valid, and useful information to the managers of S&T organizations.

SUMMARY AND CONCLUSION

There are two major requirements that motivate the interest in better methods for assessing the effectiveness of S&T organizations. First there is a desire to know how to improve S&T organizations and demonstrate effectiveness. Second there is the need to describe and recognize differences in effectiveness and management environments that are related to the type of research conducted, the resources available to the organization, and the influence of external circumstances. The framework for assessing S&T organizational effectiveness proposed by the authors builds on current models to include multiple perspectives of effectiveness, using the notions of Rohrbaugh, Cameron and Quinn's (1983, 1988, 1999) Competing Values theory. The proposed framework suggests that organizational effectiveness be assessed within the context of the organization's resources, external environment, and the type and purpose of the research.

The linkages described in the literature between specific attributes of S&T organizations that lead to effectiveness and outcomes begin to demonstrate that a framework can be defined that many would agree organizes and provides focus and credibility for assessing S&T organizational effectiveness. More research is necessary, but it appears possible that use of this framework could improve evaluation planning and utilization by bringing in the perspectives of multiple stakeholders. It could provide a balanced set of leading indicators for performance management efforts and facilitate investigating differences across S&T organizations. Valuable information could be gained by the addition of a few questions on organizational culture and circumstances to existing self-assessment, customer and employee surveys, and peer and expert review. If standardized, these questions would provide comparative data that would establish "best practices" depending on type of research and circumstances. Data mining would provide managers and policy makers with valuable information not currently available.

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