Innovation-supportive culture: The impact of organizational values on process innovation

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Received 30 June 2004; received in revised form 25 October 2005; accepted 20 August 2006
Available online 13 November 2006

Abstract

For managers, innovation is vital, but paradoxical, requiring flexibility and empowerment, as well as control and efficiency. Increasingly, studies stress organizational culture as a key to managing innovation. Yet innovation-supportive culture remains an intricate and amorphous phenomenon. In response, we explore how organizational values – a foundational building block of culture – impact a particular process innovation, the implementation of advanced manufacturing technology (AMT). To unpack this scarcely studied construct, we examine three-dimensions of organizational values: value profiles, value congruence and value–practice interactions.

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Keywords: Empirical research methods; Flexible manufacturing systems; Innovation

1. Introduction

Innovation offers a critical source of sustainable competitive advantage. Indeed, Christensen (1999) describes the management of innovation – in its many forms – as an overriding responsibility of today’s managers. Product innovation, for instance, entails developing new goods and services. Managing such innovation may help firms meet or even drive changing market demands. Likewise, process innovation involves creating or improving methods of production, service or administrative operations. Effective process innovation may enhance organizational efficiency and responsiveness (Damanpour and Gopalakrishnan, 2001).

Despite its promised potential, however, innovation poses tremendous challenges. For example, innovation efforts may be highly disruptive, altering relationships across functional and occupational boundaries or requiring changes to the organizational structure and climate (Baer and Frese, 2003; Black et al., 2004; Detert et al., 2000; McDermott and Stock, 1999). Paradoxes of innovation may pose even more fundamental and less understood challenges (Lewis et al., 2002). As Dougherty (1996) explains, successful innovation requires managing flexibility-control tensions. Flexibility enables creativity, empowerment and change vital for the
exploration that fuels innovation. Control, on the other hand, provides discipline, focusing innovation initiatives, for instance, on achieving long-term goals, leveraging core competencies, and meeting budgets. As such, innovation paradoxes may foster mixed messages and role ambiguity that adversely affect performance.

Studies increasingly tout organizational culture as a key to managing innovation. Jassawalla and Sashittal (2002) define an innovation-supportive culture as a firm’s “social and cognitive environment, the shared view of reality, and the collective belief and value systems reflected in a consistent pattern of behaviors among participants” (2002: 43). They propose that culture may provide an overarching frame of reference, helping align employee behavior with organizational objectives of innovation and meet paradoxical demands for control and flexibility. Yet researchers stress that innovation-supportive culture remains an intricate and amorphous phenomenon (e.g., Frohman, 1998; Higgins and McAllaster, 2002). In their review, Detert et al. (2000) argue that the complexity of accumulating theories of culture is matched by a dearth of corresponding empirical research. They conclude by calling for studies that investigate specific components of innovation-supportive culture and their impact.

In response, this study explores organizational values, a foundational building block of innovation-supportive culture that has received scant attention in empirical research. To unpack this phenomenon, we examine three-dimensions of organizational values. First, we examine the role of value profiles, clusters of interwoven values representing paradoxical orientations of flexibility or control (Quinn and Rohrbaugh, 1983). Second, value congruence refers to the extent to which there is an agreement or consensus about organizational values amongst organizational members (Chatman, 1989; Kalliath et al., 1999). Value congruence draws attention to the importance of common goals and consistent expectations for firm performance (Deal and Kennedy, 1982; Peters and Waterman, 1982). Lastly, value–practice interactions address consistency between organizational values and practices, drawing attention to the potential for mixed messages (e.g., Argyris and Schöon, 1974) in an innovation-supportive culture. In sum, this study seeks to contribute an expanded understanding of how values may affect innovation.

To enable focus, we explore a particular context of process innovation: the implementation of advanced manufacturing technology (AMT). AMT represents “a range of programmable machinery that execute, monitor and connect the production process, including computer-aided manufacturing, flexible manufacturing systems, and computer numerically controlled machines” (Lewis and Boyer, 2002: 111). Given its computerization, AMT often marks a dramatic change from mechanized technologies and manual operations. Process innovation occurs throughout implementation and beyond—from initial AMT adoption, through system design and programming, to use and continuing improvement within the manufacturing plant.

This process innovation offers potential insights for two primary reasons. First, like many cases of innovation, AMT holds great, but often-untapped potential. Since the 1970s, AMT has been praised for its ability to enhance plant performance by improving production quality, efficiency and responsiveness (Hayes et al., 1988). Yet reports find that only 25–50% of implementations live up to expectations (Cleland et al., 1995), with researchers often blaming a lack of supportive culture (e.g., Bates et al., 1995; Lewis, 1998). Second, AMT research stresses the flexibility-control tensions reflected in wider innovation literature (Adler, 1993). Successful implementation requires flexibility for operators to explore, debug and customize the technology in use. Yet control remains critical. Clear management objectives, for instance, help guide implementation and continuous improvement to ensure that the AMT adds value (Kern and Schumann, 1992).

Manufacturing plants serve as the unit of analysis. The plant level reduces the impact of technological heterogeneity and matches the locus of innovation, as implementation – from initial adoption through debugging and ongoing use – occurs within a plant or final home of the AMT (Dean et al., 1992). Furthermore, when studying culture, staying close to the phenomena is vital (Hofstede et al., 1990). The distance between values espoused at corporate headquarters and those perceived on a factory floor exacerbates the potential for value incongruence and confounding variables that reduce meaningfulness of findings.

2. Literature review and hypotheses

Although conceptualizations vary, organizational culture is defined broadly as a collection of values, beliefs and norms shared by its members and reflected in organizational practices and goals (Hofstede et al., 1990). Applying this definition, Jassawalla and Sashittal (2002) further describe innovation-supportive cultures
as fostering expectations and guidelines for member creativity, experimentation and risk taking.

Values are a primary building-block for culture (Quinn and Rohrbaugh, 1983). Studies suggest that an innovation-supportive culture derives from values, which inform an underlying belief structure and reinforce daily practice (e.g., Frohman, 1998; Higgins and McAllaster, 2002). According to Detert et al. (2000), values serve as the backbone of cultures that foster process innovation, thereby enabling or hindering performance improvements. Zammuto and O’Connor (1992) theorize that values play a subtle, yet powerful role. During AMT implementation, values may affect critical decisions and emerging norms (e.g., how should AMT be integrated within the production process; to what degree should operators experiment with the new AMT).

Research suggests that three-dimensions of values may influence innovation: value profiles, value congruence and value–practice interactions. This following section details each dimension, developing related hypotheses focused on the AMT implementation context.

2.1. Value profiles

Quinn and Rohrbaugh (1983) stress the impact of different value profiles. They define profiles as cohesive sets of organizational values that orient its members, guide their expectations, decisions and actions. While a flexibility value profile stresses creativity, change and empowerment, a control value profile encourages efficiency, productivity and stability.

Given their paradoxical demands, however, successful firms rarely hold a single profile, and may even thrive with a paradoxical mix of values (Quinn and Kimberly, 1984). Innovation research often highlights the importance of value profiles that support both flexibility and control (Dougherty, 1996). Lewis et al. (2002) explain that product development requires an emphasis on employees’ applying creative problem solving, and on managers’ setting clear objectives and deadlines. Frequently, cases of successful AMT implementation depict cultures built on seemingly conflicting, yet complementary values (Lewis, 1998). Likewise, in their survey study, McDermott and Stock (1999) find that plants espousing high values for flexibility and control are most satisfied with AMT implementation.

Zammuto and O’Connor (1992) theorize that flexibility values enable innovation-supportive culture by fostering experimentation. Flexibility values, they claim, underlie a decentralized structure and supportive climate that enables operators to debug and tailor AMT to their work. By espousing empowerment, managers help operators develop new skills, fostering trust and reducing potential resistance (Lewis and Boyer, 2002). According to Cleland et al. (1995), flexibility values enable higher performance by encouraging employee commitment and problem solving necessary to adjust production processes to AMT.

Yet studies also suggest that control values support AMT implementation. Tyre and Orlikowski (1993) propose that control values encourage stable routines, which help operators surface and solve problems during process innovation. Similarly, Lewis (1998) claims that discipline is vital to leveraging AMT’s potential. By stressing explicit goals for responsiveness and productivity, for instance, control values may enable computerized coordination. Customer demands (identified by sales representatives) and systems efficiencies (analyzed by engineers) may be programmed within AMT machinery (managed by operators).

In sum, we propose that paradoxical value profiles support innovation: the higher the flexibility and control values, the greater the improvement in plant performance following AMT implementation. Although related survey studies are scarce, McDermott and Stock (1999) examine the impact of the value profiles perceived by plant managers. Managers are those most likely to promote the espoused (i.e., formal or overt) values of the organization (Argyris and Schön, 1974; Kotter and Heskett, 1992). Hence, a managerial focus is a useful starting point.

**Hypothesis 1a.** Flexibility values (value profile perceived by managers) will be positively related to plant performance.

**Hypothesis 1b.** Control values (value profile perceived by managers) will be positively related to plant performance.

2.2. Value congruence

Value profiles provide a basis for organizational culture, but perceptions of an organization’s values may vary across hierarchical levels, functional departments and geographic locations (Quinn and Rohrbaugh, 1983). As mentioned earlier, value congruence refers to the extent to which organizational members perceive similar organizational values (O’Reilly and Chatman, 1986). Congruence enables a more cohesive culture, setting consistent and common expectations for behavior. Shared values enhance goal alignment and,
in turn, may positively impact performance (Denison, 1989; Gordon and DiTomaso, 1992). Moreover, it has been shown that organizations may benefit from employees who are dedicated to common goals (e.g., Deal and Kennedy, 1982; Peters and Waterman, 1982).

In the context of AMT, congruence between managers and operators is particularly vital. Managers are the decision makers, determining AMT goals, guiding its initial design, and monitoring its effectiveness (Lewis, 1998). Operators, on the other hand, are AMT users. Operators may adjust the machinery to improve its speed and accuracy (Kelley, 1990). In addition, AMT’s informational capabilities enable greater problem solving on the factory floor, rendering process innovation an ongoing, operator activity (Zammuto and O’Connor, 1992).

Given managers and operators’ interdependent roles, value congruence may be critical to support a common vision of AMT and its potential to improve plant performance. Building from the previous hypotheses, we propose that values should not only be shared, but also should reflect the paradoxical nature of innovation. In sum, the positive effects of congruence may be greater when managers and operators share higher levels of flexibility and control values.

**Hypothesis 2.** Plant performance (a) will be positively related to the congruence between flexibility values as perceived by managers and operators; and (b) will be positively related to the level of flexibility values as perceived by managers and operators.

**Hypothesis 3.** Plant performance (a) will be positively related to the congruence between control values perceived by managers and operators; and (b) will be positively related to the level of control values as perceived by managers and operators.

### 2.3. Value–practice interactions

In an innovation-supportive culture, organizational practices complement values (Frohman, 1998; Higgins and McAllaster, 2002). Practices moderate the impact of values by reinforcing or contradicting their message. As Detert et al. (2000) explain, practices interact with values, ideally forging a consistent understanding of “what matters most” in daily life. In contrast, when practices contradict values, mixed messages arise. According to Argyris and Schön (1974), mixed messages denote conflicts between espoused values (i.e., as perceived by managers) and values in practice (i.e., as applied by employees). They offer the common example of managers claiming to value empowerment, while employees feel closely monitored and act accordingly. The result is a sense of growing distrust between the groups.

AMT studies suggest countless work, human resource, coordination and strategic practices that may interact with flexibility or control value profiles (e.g., Cleland et al., 1995; Dean et al., 1992; Lewis, 1998; Zammuto and O’Connor, 1992; Zhao and Co, 1997). As a comprehensive review and test is beyond this paper’s scope, we pair each value profile with a single practice. Our goal here is to aid future research on innovation-supportive culture by offering theoretical rationale for value–practice interactions and examples. The specific practices also were chosen to illustrate that flexibility and control are not simple opposites—e.g., control is not the absence of flexibility or visa versa. Rather they denote a more intricate paradox.

Applying insights from Poole and Van de Ven (1989), we chose practices that illustrate how the flexibility-control tension may operate on multiple levels. Flexibility may emerge from the bottom-up, as creativity and change are driven often by those on the front line—or in the case of AMT, by those on the factory floor. In contrast, control typically descends from the top, as managerial direction provides formal goals, guidelines and constraints. In this light, we pair flexibility values with operator discretion and control values with formalized AMT objectives.

Operator discretion reinforces flexibility values and their emphasis on empowerment. AMT literature takes a very focused view of discretion, examining operators’ ability to decide how they use AMT—e.g., by setting the pace of their work, choosing the order in which they complete tasks, and varying their work methods (e.g., Jackson et al., 1993; Kelley, 1990). The interaction of flexibility values and operator discretion may facilitate the ongoing AMT adjustments and factory floor problem solving needed to enhance performance.

Similarly, AMT objectives may complement control values. Successful implementation requires that managers – AMT decision makers and planners – clearly communicate the purpose of this process innovation and its strategic role (Zhao and Co, 1997). In addition, Small and Yasin (1997) claim that well-defined, long-term objectives signal management’s commitment to AMT and their expectations for improved plant performance.

**Hypothesis 4a.** Operator discretion (as perceived by operators) will moderate the relationship between flexibility values (as perceived by managers) and plant
performance. Specifically, the positive impact of higher flexibility values on plant performance will be greater when operator discretion is high.

Hypothesis 4b. AMT objectives (as perceived by operators) will moderate the relationship between control values (as perceived by managers) and plant performance. Specifically, the positive impact of higher control values on plant performance will be greater when AMT objectives are more explicit.

3. Methods

Studies of AMT implementation, as well as of other process innovations, pose challenging research trade-offs (Dean et al., 1992; Lewis, 1998). Rare, large sample studies enable comparisons, but introduce numerous confounding variables (e.g., variations in type of new technology, degree of innovation, timing of implementation, etc.). In contrast, case studies are prevalent, particularly when examining innovation-supportive culture. Yet cases enable depth at the expense of generalizability. Responding to these tradeoffs, we sought a relatively large, yet focused sample of manufacturing plants that had recently implemented the same AMT.

To identify potential respondents, we worked with one of the world’s largest AMT manufacturers. Their North American distributor sells computerized die/mold machinery (e.g., machining centers, graphite milling machines) to nearly 100 plants per year, and provided us access to their entire customer network. Engineers from the distributor served as a pilot for the survey, helping ensure that items (all adapted from previous studies and shown to be valid and reliable) were appropriate and clearly worded for this particular sample.

Focusing on computerized die/mold machinery served two purposes. First, this is an excellent example of AMT. Successful implementation can dramatically enhance production quality and productivity, while enabling greater customization. The second reason for examining this AMT is the diversity of its users. Die/mold manufacturers vary widely in terms of their size and sales, their primary industries, and their investments in AMT. The initial sampling pool included all 271 plants that had purchased computerized die/mold machinery from the distributor within the past 3 years. The distributor provided considerable a priori data, such as customer name and address, primary contact, and AMT purchased (six closely related machines).

The initial pool was well targeted toward our objectives, but limited in size. To increase our response rate, we paid close attention to data collection techniques. First, we sent the survey packet to the primary contact at each customer plant, typically the plant manager. The packet included a cover letter from the distributor, introducing the survey and requesting responses; a survey and return envelope for the manager overseeing the implementation (usually completed by the primary contact); and a separate survey and return envelope for an AMT operator. The cover letter asked the manager to provide the operator survey to the operator working most closely with the new AMT [the distributor’s engineers stressed that a new AMT rarely had more than one to three primary operators, offering limited choice for managers in choosing an operator]. One week later, all contacts received a follow-up letter. A second follow-up letter and survey packet were sent 1 month later to plants that had not yet responded. The final sample consisted of 110 plants (each with completed, usable surveys from both a manager and an operator, for a response rate of 40.6%). Table 1 offers a profile of the resulting sample, illustrating its diversity.

3.1. Value profiles

Following McDermott and Stock (1999), we measured value profiles using Likert-scale items consistent with the competing values framework (Quinn and Rohrbaugh, 1983). Variables were calculated separately for managers and operators. Flexibility values were measured by averaging responses to five items, which gauge the degree to which the manager or operator perceived organizational values of empowerment, growth, change, creativity and flexibility (e.g., To what extent does your plant value empowerment? 1: low emphasis to 7: high emphasis).

Control values were measured by averaging responses to four similar items that assess to what extent the manager or operator perceived organizational values of stability, efficiency, predictability and control (e.g., To what extent does your plant value stability? 1: low emphasis to 7: high emphasis).

3.2. Value congruence

Traditional measures of congruence, such as score differences, have been criticized for conceptual ambiguity and discarded information (Edwards, 1993). For this study, polynomial regression analyses provided a more sophisticated means of examining...
congruence through the use of three-dimensional surface graphs (Edwards and Parry, 1993). Our use of this approach is detailed in Section 4.

3.3. Practices

To examine potentially complementary practices, we asked operators—those using the new technology on a daily basis—a series of survey questions. Operator discretion was measured using Likert-scale items adapted from Jackson et al. (1993). We calculated this variable by averaging operators’ responses to six items, indicating the extent to which they felt empowered to determine the timing, method and pace of their work on the AMT machinery. Items assessed operators’ agreement with descriptions of their AMT work (e.g., The machine operators can vary how they do their work. 1: strongly disagree to 7: strongly agree). AMT objectives were calculated by averaging responses to three items, indicating the extent to which the objectives of purchasing the new technology were well-defined, long-term and supported by top management. Adapted from Zhao and Co (1997), these Likert-scale items gauged to what extent operators agreed with descriptions (e.g., the objectives of the new machine were well-defined. 1: strongly disagree to 7: strongly agree).

3.4. Plant performance

We measured plant performance by averaging managers’ responses to five, Likert-scale items. These items gauged the extent to which performance has changed since implementation: “Please indicate how much your plant’s performance has changed over the past 2 years in the area of (product quality, scrap minimization, on-time delivery, equipment utilization, or manufacturing lead-time)” (1: significant decline to 4: no change to 7: significant improvement). Such subjective measures potentially introduce manager bias, but are common practice in manufacturing and AMT research for two reasons (see Boyer et al., 1997). First, studies find that respondents are less willing to provide objective performance data. Second, more objective measures may limit the accuracy and comparability of responses (Dess and Robinson, 1984; Porter, 1979). For example, other AMT studies use these same indicators, stating that a host of contextual factors impede the usefulness of objective data (e.g., different metrics for quality, efficiency, productivity) (Dean and Snell, 1991; Zhao and Co, 1997). Ketokivi and Schroeder’s (2004) extensive multitrait–multimethod analysis concludes that such perceptual performance measures satisfy reliability and validity requirements.

3.5. Control variables

A major challenge of culture research is the potentially confounding effects of numerous, interwoven factors, requiring thoughtful inclusion of control variables. As our focus is on the plant level, we included three variables that could represent important, contextual differences and contingencies that might influence plant performance following AMT implementation: plant size, AMT investment, and AMT training. Plant size denotes
the total number of full-time employees. AMT investment was measured by asking survey respondents how much their plant had invested in implementing the new machinery, including training, related software purchases and development, test runs, etc., but not including the actual cost of the machinery. Finally, AMT training was measured using a single item, indicating the degree of training received on the new AMT prior to the implementation (plant employees received extensive training on the new machine prior to implementation. 1: strongly disagree to 7: strongly agree).

4. Results

Correlations and descriptive statistics variables are reported in Table 2. Cronbach’s alphas, shown along diagonal, indicate that the measures are reliable (alphas from .68 to .81).

Using regression analyses, we first tested the impact of flexibility and control value profiles on plant performance (see Table 3). Plant size, AMT investment, and AMT training acted as controls in the base model.

When entered separately, flexibility and control values were significantly and positively correlated to performance. Yet when both variables were entered into the full model only flexibility values remained significant, offering partial support for Hypotheses 1a and 1b.

Post hoc analysis suggests that flexibility values completely mediated the control values–plant performance relationship. The mediation path was as follows: control values to flexibility values, flexibility values to plant performance. Following Baron and Kenny (1986), we estimated three equations: (1) regress flexibility values on control values ($p < .01$; see Table 2), (2) regress plant performance on control values ($p < .01$; see Table 3), and (3) regress plant performance on flexibility and control values (only flexibility values significant, $p < .01$; see Table 3). Hence, all conditions for complete mediation were satisfied.

Next, we tested value congruence. Edwards and Parry (1993) and Kalliath et al. (1999) detail serious flaws of the traditional congruence methods: score difference and square of score difference. Both methods discard vital information by reducing two data points

### Table 2
Descriptive statistics and correlations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>S.D.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plant size</td>
<td>1.34</td>
<td>.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. AMT investment</td>
<td>2.58</td>
<td>1.03</td>
<td>-.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. AMT training</td>
<td>3.68</td>
<td>1.86</td>
<td>.14</td>
<td>n.a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Flexibility values – mngs</td>
<td>5.34</td>
<td>.92</td>
<td>.02</td>
<td>.02</td>
<td>.17</td>
<td>.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Flexibility values – oprs</td>
<td>5.02</td>
<td>1.09</td>
<td>-.07</td>
<td>-.16</td>
<td>.14</td>
<td>.25</td>
<td>.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6. Control values – mngs</td>
<td>5.52</td>
<td>.92</td>
<td>.06</td>
<td>.20</td>
<td>-.13</td>
<td>.50</td>
<td>.77</td>
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<td>7. Control values – oprs</td>
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<td>1.02</td>
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<td>-.01</td>
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<td>.74</td>
<td>.31</td>
<td>.78</td>
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<tr>
<td>8. AMT objectives</td>
<td>6.01</td>
<td>1.00</td>
<td>.04</td>
<td>-.13</td>
<td>-.06</td>
<td>.06</td>
<td>.31</td>
<td>.10</td>
<td>.33</td>
<td>.72</td>
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<td>9. Operators discretion</td>
<td>5.21</td>
<td>1.22</td>
<td>-.08</td>
<td>-.19</td>
<td>-.02</td>
<td>.17</td>
<td>.04</td>
<td>-.05</td>
<td>.04</td>
<td>.12</td>
<td>.81</td>
<td></td>
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<tr>
<td>10. Plant performance</td>
<td>5.13</td>
<td>.73</td>
<td>.02</td>
<td>.06</td>
<td>.21</td>
<td>.37</td>
<td>.12</td>
<td>.26</td>
<td>.09</td>
<td>.20</td>
<td>.09</td>
<td>.76</td>
</tr>
</tbody>
</table>

Cronbach’s alpha provided along the diagonal, shown in bold (n.a. signifies that alpha is not appropriate for scale comprised of less than three items).

** $p < .01$.
* $p < .05$.
† $p < .10$.

### Table 3
Regression analyses: flexibility and control value profiles (Hypotheses 1a and 1b)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Base model</th>
<th>Flexibility model</th>
<th>Control model</th>
<th>Full model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>.07</td>
<td>.19</td>
<td>.15</td>
<td>.20</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>.04</td>
<td>.16</td>
<td>.12</td>
<td>.17</td>
</tr>
<tr>
<td>$F$</td>
<td>2.42†</td>
<td>6.17**</td>
<td>4.57**</td>
<td>5.34**</td>
</tr>
<tr>
<td>Plant size</td>
<td>.12</td>
<td>.17†</td>
<td>.15</td>
<td>.17</td>
</tr>
<tr>
<td>AMT investment</td>
<td>.10</td>
<td>.10</td>
<td>.09</td>
<td>.10</td>
</tr>
<tr>
<td>AMT training</td>
<td>.19†</td>
<td>.13</td>
<td>.22**</td>
<td>.15†</td>
</tr>
<tr>
<td>Flexibility values – mngs</td>
<td>.37**</td>
<td></td>
<td></td>
<td>.29**</td>
</tr>
<tr>
<td>Control values – mngs</td>
<td></td>
<td></td>
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<td>.29**</td>
</tr>
</tbody>
</table>

Dependent variable is plant performance †$p < .10$; ‡$p < .05$; ‡‡$p < .01$. 
into one, and do not predict outcomes at various levels of congruence. In response, researchers increasingly employ polynomial regression analysis (see Edwards and Parry, 1993).

Polynomial regression analysis involves polynomial regression equations and response surface methodology. Analysis first requires regressing the dependent variable on the individual main terms to determine main effects and overall model significance. Higher order terms—the quadratic and interaction terms—are introduced only if main effects and the model are significant. The significant beta coefficients of the full model then are used to compute scores for the linear and curvilinear slopes of two lines. The line of perfect fit signifies complete congruence (e.g., managers’ perceptions of flexibility values = operators’ perceptions of flexibility values), whereas, the line of misfit represents incongruence. These scores are then used to plot the three-dimensional graph needed to interpret findings of polynomial regression. This process enabled us to test the overall impact of value congruence on plant performance, and how that impact varies at different levels of values (e.g., at high versus low flexibility values).

Applying this method to test Hypothesis 2, we regressed plant performance on flexibility values perceived by managers (FM), flexibility values perceived by operators (FO), the interaction between FM and FO, the square of FM, and the square of FO. Z represents the dependent variable (plant performance), while e represents the error term. The polynomial regression equation is:

\[ Z = b_0 + b_1(FM) + b_2(FO) + b_3(FO)^2 + b_4(FM) \]
\[ \times (FO) + b_5(FM)^2 + e \]

Following guidelines specified by Edwards and Parry (1993), we regressed plant performance on the main effects of flexibility values of managers and operators (model 1). We then included the cross-product of flexibility values of managers and of operators and the square of flexibility values of managers and of operators (model 2). Results shown in Table 4 indicate that value congruence explained significant variance (\( R^2 = .18, p < .05 \)).

Our findings can be interpreted using the three-dimensional graph shown in Fig. 1. The dotted line represents the line of misfit. At the left-hand extreme,
coordinates of this line for flexibility values of managers and operators are (7, 1). As one moves along the line of misfit toward the line of perfect fit (solid line), congruence between managers and operators’ flexibility values rises. In other words, congruence increases along the line of misfit, until it reaches a point of intersection with the line of perfect fit. Beyond the line of perfect fit, congruence decreases.

As predicted, plant performance is highest along the line of perfect fit. Plant performance rises as congruence between flexibility values of managers and operators increases, indicated by the upward slope of the line of misfit (dotted line) as it moves toward the line of perfect fit (left-hand side of solid line). Furthermore, plant performance declines as congruence between managers and operators’ values decreases. This trend is indicated by the downward slope of the line of misfit as it moves away from the line of perfect fit. These findings support Hypothesis 2a.

Hypothesis 2b, however, is not supported. There is no significant variation in performance along the line of perfect fit, indicating that congruence at varying levels does not impact performance. In other words, high flexibility values of both managers and operators do not necessarily translate into better performance than congruent, but low flexibility values.

Similarly, the polynomial equation for control values is represented as follows:

\[ Z = b_0 + b_1(CM) + b_2(CO) + b_3P(CO)^2 + b_4(CM) \]

\[ \times (CO) + b_5(CM)^2 + e \]

To test Hypothesis 3, we first regressed plant performance on the main effects of managers and operators’ control values (model 1). Although the main effect for operators’ control values was found to be significant, no higher order effects were found to be significant (model 2). Therefore, results shown in Table 5 do not support Hypotheses 3a and 3b.

Table 6 summarizes the regression analysis of value–practice interactions. We examined whether the relationship between values (as perceived by managers) and plant performance is moderated by complementary practices (as perceived by operators). Specifically, we tested for interaction effects between flexibility values and operator discretion, and between control values and AMT objectives. We found support for Hypothesis 4a, but not for Hypothesis 4b. Results indicate a statistically significant interaction effect between flexibility values and operator discretion.

To interpret the interaction effect, we applied the procedures detailed by Aiken and West (1991). We centered the measures of flexibility values and of operator discretion on the mean. Next, we used the unstandardized beta coefficients and constants from the saturated regression equation to plot the relation between operator discretion and performance at different levels (i.e., one standard deviation above the mean indicated that the managers perceived high flexibility values; one standard deviation below the mean indicated low flexibility values). The interaction illustrated in Fig. 2, however, is contrary to Hypothesis 3a. When managers perceived high flexibility values, plant performance decreased with greater levels of operator discretion.

---

Table 5
Polynomial analysis: control value congruence (b)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control values – mgrs</td>
<td>Betas (S.E.)</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>.22 (.09)**</td>
<td></td>
</tr>
<tr>
<td>Control values – oprs</td>
<td>.01 (.08)</td>
<td></td>
</tr>
<tr>
<td>Control values – mgrs</td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td>Control values – oprs</td>
<td>.01 (.08)</td>
<td></td>
</tr>
<tr>
<td>Control values – mgrs</td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td>Control values – oprs</td>
<td>.01 (.08)</td>
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</tr>
<tr>
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</tr>
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<td></td>
</tr>
<tr>
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<td>.01 (.08)</td>
<td></td>
</tr>
<tr>
<td>Control values – oprs</td>
<td>.01 (.08)</td>
<td></td>
</tr>
</tbody>
</table>

Slopes for line of perfect fit; linear: \( a_1 = b_1 + b_2 = .23 \); Slopes for line of misfit; linear: \( a_1 = b_1 + b_2 = .21 \). Note: no higher order effects were significant; only main effects can be estimated. * \( p < .10 \); ** \( p < .05 \); *** \( p < .01 \).

Table 6
Regression analysis: value–practice interactions (Hypotheses 4a and 4b)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Flexibility</th>
<th>Control</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R^2 )</td>
<td>.18</td>
<td>.10</td>
<td>.23</td>
</tr>
<tr>
<td>Adj. ( R^2 )</td>
<td>.15</td>
<td>.07</td>
<td>.17</td>
</tr>
<tr>
<td>( F )</td>
<td>6.18</td>
<td>3.12</td>
<td>3.97</td>
</tr>
<tr>
<td>( p )</td>
<td>.001</td>
<td>.03</td>
<td>.002</td>
</tr>
<tr>
<td>Flexibility values – mgrs</td>
<td>1.23**</td>
<td>1.18***</td>
<td></td>
</tr>
<tr>
<td>Operator discretion</td>
<td>1.13*</td>
<td>1.66*</td>
<td></td>
</tr>
<tr>
<td>Flexibility values – oprs</td>
<td>−1.52*</td>
<td>−1.57*</td>
<td></td>
</tr>
<tr>
<td>Flexibility values – mgrs</td>
<td>1.23**</td>
<td>1.18***</td>
<td></td>
</tr>
<tr>
<td>AMT objectives</td>
<td>.60</td>
<td>.36</td>
<td></td>
</tr>
<tr>
<td>Control values – mgrs</td>
<td>.50</td>
<td>.26</td>
<td></td>
</tr>
<tr>
<td>Control values – oprs</td>
<td>−.51</td>
<td>−.25</td>
<td></td>
</tr>
</tbody>
</table>

\( p < .10 \); * \( p < .05 \); ** \( p < .01 \).
5. Discussion

This study seeks to deepen understandings of innovation-supportive culture by exploring the impact of organizational values. Specifically, we examined the role of value profiles, value congruence and value–practice interactions. We now discuss three, related findings (for summary, see Table 7).

First, innovation studies often note the need for value profiles that stress flexibility and control (e.g., Dougherty, 1996; Quinn and Kimberly, 1984). At first glance, our results appear more one-sided. Only a flexibility value profile seems critical for AMT implementation—a finding predicted by some theorists (e.g., Cleland et al., 1995; Zammuto and O’Connor, 1992). Our exploratory, post hoc analysis, however, suggests that control values may play a more subtle role as flexibility values

Table 7
Summary findings

<table>
<thead>
<tr>
<th>Value profile</th>
<th>Plant performance will be positively related to the congruence between flexibility values as perceived by manager and by operators</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1a</td>
<td>Flexibility values (value profile perceived by managers) will be positively related to plant performance</td>
<td>Partial support$^a$</td>
</tr>
<tr>
<td>H1b</td>
<td>Control values (value profile perceived by managers) will be positively related to plant performance</td>
<td>Partial support$^a$</td>
</tr>
<tr>
<td>Value congruence</td>
<td>Plant performance will be positively related to the level of flexibility values perceived by managers and operators</td>
<td>Not-supported</td>
</tr>
<tr>
<td>H2a</td>
<td>Plant performance will be positively related to the congruence between flexibility values perceived by managers and operators</td>
<td>Supported</td>
</tr>
<tr>
<td>H2b</td>
<td>Plant performance will be positively related to the level of flexibility values perceived by managers and operators</td>
<td>Not-supported</td>
</tr>
<tr>
<td>H3a</td>
<td>Plant performance will be positively related to the congruence between control values perceived by managers and operators</td>
<td>Not-supported</td>
</tr>
<tr>
<td>H3b</td>
<td>Plant performance will be positively related to the level of control values as perceived by managers and operators</td>
<td>Not-supported</td>
</tr>
<tr>
<td>Value–practice interactions</td>
<td>Operator discretion (as perceived by operators) will moderate the relationship between flexibility values (as perceived by managers) and plant performance. Specifically, the positive impact of higher flexibility values on plant performance will be greater when operator discretion is high</td>
<td>Supported</td>
</tr>
<tr>
<td>H4a</td>
<td>Operator discretion (as perceived by operators) will moderate the relationship between flexibility values (as perceived by managers) and plant performance. Specifically, the positive impact of higher flexibility values on plant performance will be greater when operator discretion is high</td>
<td>Supported</td>
</tr>
<tr>
<td>H4b</td>
<td>AMT objectives (as perceived by operators) will moderate the relationship between control values (as perceived by managers) and plant performance. Specifically, the positive impact of higher control values on plant performance will be greater when AMT objectives are more explicit</td>
<td>Not-supported</td>
</tr>
</tbody>
</table>

$^a$ Post hoc analysis revealed complete mediation effect (see Table 3).
completely mediated the control values–performance relationship.

One explanation is that control values enable flexibility values and their benefits. Flexibility values encourage employee empowerment and creative freedom. Yet, as Mills and Ungson (2003) explain, managers may avoid flexibility for fear of losing control. A foundation of control values and supporting practices may alleviate such concerns, as stable routines and explicit goals, for example, facilitate trust in operators to innovate within appropriate boundaries.

The enabling potential of control values is consistent with improvisation approaches to innovation. For instance, Lewis et al. (2002) stress that control aids improvisation during product development. They find that a planned style of project management (e.g., formal reviews, milestones) provides a vital framework for brainstorming and experimentation. Moreover, control can aid managers in monitoring and evaluating the impact of innovation (Dougherty, 1996). For example, Spear and Bowen (1999) state that the Toyota Production Process – a system that enables continuous process innovation – requires a culture of discipline (e.g., a mindset and routines that stress the monitoring of quality to identify problems and spur creative problem solving).

Second, although we find that flexibility values most directly affect innovation, results regarding value congruence elaborate this understanding. Specifically, the more managers and operators shared perceptions of flexibility values (high or low), the more plant performance improved after AMT implementation. In comparison, congruence around control values was not found to significantly affect plant performance. One explanation is that the ambiguity of flexibility-related norms (e.g., empowerment and creativity) increases the importance of shared values, whereas, norms influenced by control values (e.g., efficient routines) may be promoted via explicit policies and procedures. For example, imagine a case where managers perceive high flexibility values, while operators perceive low flexibility values. Managers may presume that operators are creatively debugging the AMT as needed, making continuous adjustments that improve performance. Meanwhile, operators assume that creative problem solving is a low priority. In response, operators view themselves – then act – as “button-pushers” and “screen watchers” for the new automation. Managers become frustrated by this lack of initiative, while operators feel increasingly alienated from their work. The resulting vicious spiral impedes performance. While extreme, studies depict such scenarios in plants implementing AMT (e.g., Cleland et al., 1995; Kelley, 1990).

Collectively, our findings suggest that the role of control values, however, is complex. For instance, findings suggest that when perceived by managers, control values work through flexibility values to impact plant performance. In contrast, when operators’ perceptions of control values and practices are taken into account, as revealed through the insignificant roles of control value congruence and control value–practices interaction (see Table 7), control does not seem to affect performance. A possible explanation is that control perceptions reflect distinct managerial and operator sub-cultures, whereas, perceptions of flexibility may be more reflective of overarching organizational culture (e.g., Cameron and Quinn, 1999; Von Meier, 1999).

Finally, the most counterintuitive finding involves the interaction between flexibility values and operator discretion. Results indicate that performance is highest when flexibility values are high and operator discretion is low. This combination suggests a strong mixed message: “the organization values empowerment, but operators cannot determine the timing, methods and pace of their own work.” Historically, researchers have stressed that a key issue when implementing AMT is operator discretion—determining whether operators manage the AMT (making day-to-day decisions regarding its use) or whether engineers program the machinery and operators simply monitor operations. The former task design signals a culture of flexibility, while the latter indicates a deskilling approach (Cleland et al., 1995; Kelley, 1990).

Our study, however, supports an alternative view of operator discretion. As Dean et al. (1992) explain in AMT contexts the most critical discretion entails autonomous problem solving away from the machinery. Minimizing operators’ machine responsibilities allows focus on higher impact issues—those that foster continuous process innovation. For instance, operator teams may put their knowledge of the factory floor to greater use by informing the design of the production system (Adler, 1993; Kern and Schumann, 1992). Indeed, Garud and Kotha (1994) propose that flexible manufacturing demands such adaptive capabilities. A related explanation, however, is that there may be a time lag in the need for operator discretion. The potential of AMT requires the capacity to learn. Over time, operators, engineers and managers may become increasingly capable of revising the flow and layout of production activities (e.g., inventory, loading/unloading of machinery, etc.) for ongoing improvement.
6. Implications

This study explores innovation-supportive culture by examining the basic building block of organizational values. For researchers, findings offer theoretical insights and may spark subsequent studies. Consistent with past work, this research supports and elaborates a paradoxical view of innovation-supportive culture. Specifically, results suggest possible, underlying sources of paradox. For example, we found that flexibility values may mediate the role of control values. Flexibility values foster a culture of experimentation and empowerment, whereas, control values may set boundaries that facilitate managerial trust and evaluation. Further, while flexibility values enable operators to engage in creative problem solving or debug routine machine-related problems (e.g., Zammuto and O’Connor, 1992), operators may see control as inhibiting innovation. Thus, innovation-supportive culture may appear paradoxical because of flexibility and control co-existing in underlying values and practices, but also may stem from conflicting views held by occupational and hierarchical sub-cultures within the organization.

Future work could elaborate the paradoxical interplay between flexibility and control values, investigating whether this relationship varies during the innovation process or in the presence of other contextual factors (e.g., organizational structure, environmental uncertainty). Subsequent studies might suggest how managers can foster shared values, while identifying practices that reinforce those values to fuel innovation. For instance, in AMT settings, flexibility values may need to be paired with more specialized conceptualizations of operator discretion or related practices of empowerment. Lastly, research could benefit by going beyond managers and operators to study other groups involved in process innovation, such as suppliers and customers (Ettlie and Reza, 1992).

Similarly, our results offer insights for managers. For example, this study highlights the paradoxical need for control and flexibility value profiles. Such findings encourage managers to avoid viewing such values as conflicting, seeking instead to empower employees and to establish supporting policies and systems. In essence, managers should nurture an organization that offers explicit controls for evaluating and most decision-making, but also offers the flexibility for operators to depart from routine work procedures. Likewise, effective managers may provide independence, while interacting frequently. Such managers may encourage AMT operators to be creative and autonomous problem solvers, while interacting with operators frequently to set limits and help codify the learning that occurs via experimentation.

To illustrate, we offer an expanded example from one firm. Following AMT implementation, the company used a 2-month training and ramp-up period. Once “steady state” production was reached, the company continued to hold monthly meetings with all of the equipment operators and the department supervisor. These meetings were used to discuss problems with the equipment, brainstorm for solutions and improved approaches, and document the learning that occurred. The goal was to encourage flexibility, but also to develop controls that could be shared with future users of the equipment and to standardize the knowledge.

7. Limitations

Limitations of our study also suggest research needs and opportunities. For instance, our subjective measures of plant performance present a serious limitation. As with any subjective measures of performance, caution must be exerted in interpreting the results because of the possibility of managerial bias. Findings should be replicated in future studies that use objective measures, such as quality improvement, and/or multiple data sources, such as suppliers and customers’ assessments. Another limitation is that we examined innovation within the context of AMT. Focusing on a particular process innovation reduces the effect of confounding variables, but raises concerns over generalizability. Subsequent work may attempt to replicate these findings in different settings of process or product innovation. While controlling for variables such as plant size, AMT investment, and AMT training build confidence in our findings, future work could benefit from including other indicators of a firm’s support for manufacturing R&D. For example, Ettlie and Reza (1992) note that integrating mechanisms, such as centers for advanced manufacturing engineering, may serve as enablers of process innovation.

Furthermore, the cross-sectional nature of this study calls for future longitudinal studies that might account for potential lagged effects associated with process innovation. For instance, it might prove insightful to investigate the changing roles of operators and managers over time. Finally, our research design relied on self-report surveys, raising the threat of common method variance. Gathering responses from both managers and operators builds confidence, but cannot eliminate concerns. Future studies could benefit from using different respondents to examine complementary...
practices and plant performance, and from supplementing subjective measures with more objective data. In addition, the proliferation of innovation research poses tremendous potential. As qualitative and quantitative studies accumulate, triangulating results may deepen understandings (Lewis, 1998). Weaving together studies of innovation and culture may identify supportive configurations of values and practices. As Jassawalla and Sashittal explain, “the challenge of developing significantly higher levels of collaboration, creativity, and innovation appears to relate to the way in which the fuzzy, amorphous nature of culture is integrated with the hard, cold analysis of technology, customers, markets, and competitors” (2002: 53).

References

Cameron, K.S., Quinn, R.E., 1999. Diagnosing and Changing Organizational Culture: Based on Competing Values Framework. Addison-Wesley, Reading, MA.


