Measuring Cycle Time in Organizational Processes

by

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Although cycle time is of increasing interest to managers, very few mechanisms exist to measure cycle time consistently. Most organizations still rely on anecdotal evidence in their cycle time assessments, without having the opportunity to compare such findings across processes and over time. In addition, if an organization has invested the resources needed to implement a "fast cycle time" program, they generally rely on the common clock (i.e., minutes, hours, days, and so on) when assessing the cycle time of its organizational processes.

Little, if any, attention has been devoted to assessing the perceptions of cycle time that develop within organizational processes. Objective measures often do not fully capture the complete range of cycle time issues because they ignore perceptual factors that have the potential to significantly affect an organizational process. Thus, the development of a subjective scale could offer managers a tool to better assess cycle time in organizational processes than is possible through objective measures alone.

In this study, we use data from a variety of supply chains to develop a subjective measure of cycle time. Based on the analysis, we developed and tested ten subjective cycle time items, with six of the items being generalizable across the five supply chain samples studied. These subjective items can serve as a supplement to objective measures of cycle time and should be used in continuous improvement efforts of cycle time. Effectively managing the cycle time of organizational processes is a key performance metric in the dynamic global marketplace.

Cycle time refers to the duration of an organizational process. In a retail context, for example, cycle time refers to the time it takes for a customer's order to be processed and filled (Wetherbe, 1995). Managing cycle time is a key to success in modern dynamic markets, but it is difficult because organizational processes are complex and subject to interpretation (Hult, Hurley, Giunipero, Nichols, 2000). Indeed, organizational actors face a wide array of issues, each of which is confounded by situational and perceptual factors. To cope with such ambiguities, actors develop "rule of thumb" guidelines for assessing processes that define acceptable and unacceptable cycle times. Thus, actors mark time in ways that differ from objective measures such as minutes, hours, and days (Gersick, 1989). To date, however, research attention has not been focused on developing a qualitative mechanism to assess cycle time. This paper is devoted to helping to fill this need.
Specifically, the purpose of this paper is to develop a subjective multi-item cycle time measure for use in conjunction with traditional objective measures. Objective measures often do not fully capture the conceptual domain of cycle time because they ignore perceptual factors that have the potential to significantly affect an organizational process. Thus, the development of a subjective scale could offer researchers and managers a tool to better assess cycle time in organizational processes than is possible through objective measures alone.

Background

To be directly tied to important managerial elements of organizational processes, our subjective cycle time scale is tied to Håkansson’s (1982, 1987, 1989) organizational process perspective. From this perspective, an organizational process always contains elements of both cooperation and conflict. These elements arise through the confluence of three elements: actors, activities, and resources (Håkansson, 1982, 1987, 1989; Håkansson & Johanson, 1984).

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Thus, an organizational process is represented by a set of actors drawing on shared resources and linked together by the performance of complementary or competitive activities.

Actors within an organizational process control activities and resources. Individuals, groups of individuals, and parts of organizations, and groups of organizations can be actors. Regardless what type of actor is involved in a process, actors have five characteristics (Håkansson & Johanson, 1984). First, actors perform and control the activities within the organizational process. Second, through exchange processes, actors develop relationships with each other. Third, actors base their activities on direct or indirect control over resources. Fourth, actors are goal oriented. Fifth, actors possess certain knowledge level about activities, resources, and other actors in the organizational process.

Activities within an organizational process occur when one or several actors combine, develop, exchange, or create resources (such as information) by utilizing other resources. There are two types of activities: transformation and transfer (Håkansson, 1987). Transformation activities are always carried out within the control of one of the actors. They are characterized by one resource being improved by the use of other resources. Transfer activities link transformation activities, forming chains of activities (such as supply chains), and creating relationships with other actors involved in the process.

Resources within an organizational process represent a necessary condition for all process-activities to occur. Specific to an organizational process, five resources can be identified, each related to some parts of the environment interacting with the process activities: input goods, financial capital, technology, personnel, and marketing (Håkansson, 1982, 1989; Waluszewski, 1989). An underlying assumption of the organizational process perspective is the assumption that these process resources are interdependent. For example, the performance of an employee depends on those with whom he or she interacts. Thus, the value of a resource is thought to not be a constant, but instead to be shaped by interaction with other resources.

Given this assumption, discovering the appropriate combinations of resources for a specific process (e.g., more or less actor involvement) is a key task. Indeed, an organization is expected to thrive when it is better at creating appropriate combinations of actors, activities, and resources than are other organizations. As such, in operationalizing the cycle time construct, we focused on including subjective indicators that account for the actors,
activities, and resources inherent in organizational processes. Our specific focus was on actors, activities, and resources within supply chains, the context wherein significant cycle time research has been focused (Hult, Frolick & Nichols, 1995).

**Operationalization of the Scale**

After specifying the theoretical foundation for organizational processes, the next step in the scale development process is the generation of a set of items to capture subjective cycle time. Specific to our area of application (i.e., supply chains), cycle time is defined as the time it takes from initiation to completion of the activities involved in the supply chain process (e.g., Hult, 1998; Hult, et al., 2000; Wetherbe, 1995).

First, a set of cycle time items was generated by the authors, drawing on the theoretical concepts serving as the foundation of an organizational process: actors, activities, and resources. Next, a separate set of items was generated through in-depth interviews with 32 supply chain managers from 20 organizations. Each interview lasted about one hour and followed a standard format addressing: the structure of the supply chain process, obstacles and opportunities for cycle time improvement, and "best" and "worst" practice cycle time scenarios. The items from the interviews were developed to represent practical and managerial components of cycle time. From the two-item generation efforts, 35 items were initially selected for their appropriateness, uniqueness, and ability to convey different shades of meaning to informants.

**Pretests**

The pool of 35 items was subjected to two pretests. The pretests were conducted to assess the face and content validity of the measurement items. In the first pretest, a questionnaire containing the items was administered to fifteen expert judges (eight academics and seven supply chain executives) with knowledge of or working experience with cycle time concepts. The judges were asked to point out any item that was ambiguous or otherwise difficult to answer. An a priori decision rule specified retaining an item only if all judges considered the item to be easily understandable and representative of cycle time. Based on the judges' comments, some items were modified and others were deleted. This resulted in a 10-item scale.

We then obtained input from 36 supply chain and non-supply chain executives. These executives were asked to critically evaluate each of the 10 items relative to the provided definition of cycle time to provide a verification of the content validity of the scale items. Again, the respondents were asked to identify any item that was ambiguous or difficult to answer. In this phase, only minor changes were suggested. Some items were modified, but none of the items were deleted. This resulted in all the 10 cycle time items being retained for the full-scale empirical test of the cycle time (CT) scale. Viewed collectively, the individual scale items address cycle time attributes that incorporate facets of the

<table>
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<th>Table 1: Study Samples</th>
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<td>Internal SBU$^2$ Customer Sample, 1994 (IC94) n=346</td>
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<td>Internal SBU Customer Sample, 1999 (IC99) n=141</td>
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<td>Corporate Buyer Sample, 1999 (CB99) n=115</td>
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<td>External Supplier Sample, 1999 (ES99) n=58</td>
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<td>National Association of Purchasing Management Sample, 1999 (NAPM99) n=200</td>
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organizational process perspective described earlier: actors (CT4, CT5, CT6, and CT9), activities (CT1, CT2, and CT7), and resources (CT3, CT8, and CT10).

Data Collection

To examine the robustness of the developed cycle time scale, five samples were collected as a part of this study (See Table 1).

The two internal SBU customer samples (IC94 and IC99) were collected from the same respondents to obtain longitudinal data on cycle time, with 141 of the original 346 internal SBU customers from 1994 completing the survey in 1999. The internal SBU customer (IC99) sample collected in 1999 are members along with two other samples (CB99, n=115; and ES99, n=58) of the supply chains involving one Fortune 500 multinational corporation (MNC). Additionally, for generalization purposes beyond one MNC's supply chains, data was obtained from the member organizations of the National Association of Purchasing Management (NAPM99) (n=200). In testing the developed cycle time scale, the IC94 sample serves as the purification sample, while the other four samples are used to test the reliability and validity of the purified solution. Each of the five samples is described in more detail in the following paragraphs.

Internal SBU Customer Sample, 1994 (IC94)

The IC94 sample included the internal SBU customers of one MNC. The sample focused on examining cycle time of the supply chain process based on the perceptions of the internal customers. As such, the internal customers (n=416) were asked to assess cycle time issues that arose in the relationships with their assigned corporate buyers (n=400) (a relationship that is defined as a strategic sourcing unit). Each internal customer sampled was assigned to a different corporate buyer. The survey garnered 346 of the MNC's 416 SBUs, representing an overall response rate of 83.2%. These 346 SBU respondents had an average tenure in the organization of 10.1 years and had participated in 2.8 sourcing requests per month.

Internal SBU Customer Sample, 1999 (IC99)

The respondents targeted in the IC94 study were again targeted in 1999 (IC99) to obtain longitudinal data on cycle time (as well as to assess the purified solution of the cycle time scale from five years earlier). As such, this sample focused on examining cycle time longitudinally based on the perceptions of the internal SBU customers. Of the original 346 respondents, 141 responded to the survey in 1999, representing 40.8% of the original respondents and 33.9% of the MNC's 416 SBUs. These 141 SBU respondents had an average tenure in the organization of 13.4 years and had participated in 12.9 sourcing requests per month.

Corporate Buyer Sample, 1999 (CB99)

The CB99 sample included the corporate buyers of the company studied in the IC94 and IC99 samples. These corporate buyers were a part of the MNC's "strategic sourcing and supply unit" (SS&S). SS&S is an organizational buyer behavior unit focused on facilitating relationships between external suppliers and internal SBU customers. The buyers were asked to focus on the last supply chain process in which they had been involved with one of the targeted internal SBU customers as well as one of the targeted external suppliers. Surveys were sent to the unit's 338 individuals; 115 responded for a response rate of 34.0%. The corporate buyer's average

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1 CT1 – CT10 indicates the individual scale items. Each of these items is described in the Cycle Time Scale section which follows.

2 Strategic business unit.
length of service in the corporation was 10.0 years and they facilitated on average 34.8 purchase requests from the internal customers per month.

External Supplier Sample, 1999 (ES99)
The ES99 sample consisted of the company’s 235 major suppliers that had been involved with the organization for several years. To provide for quality responses, the external suppliers were initially asked “qualifying questions” dealing with their knowledge of the MNC’s supply chain involving corporate buyers and internal customers. Only external suppliers with a thorough understanding of the overall supply chain system were included in the sample. Fifty-eight external suppliers “passed” the qualifying questions and responded to the survey (58/235=24.7%). The respondents had been with their current organizations an average of 11.8 years; 90% of the supplier organizations operated internationally. They had an average of 19,181 employees, with an average of 40.7 years of business experience, and focused primarily on services (61.4%) as opposed to manufacturing (38.6%).

National Association of Purchasing Management Sample, 1999 (NAPM99)
The NAPM99 sampling frame comprised 2,000 members of the National Association of Purchasing Management (NAPM). The NAPM members are purchasing professionals involved in procurement for manufacturing, distribution, services, and government organizations. The survey directed these individuals to select and report on cycle time attributes related to the last supply chain process in which they had participated prior to receiving the survey (involving both external suppliers and internal customers within their supply chain organizations). To obtain a sample size that allowed for a rigorous coarse-grained analysis, the goal was to obtain participation from 200 firms. The initial survey mailing resulted in responses from senior corporate buyers in 162 firms. Follow-up calls were conducted with randomly selected corporations until the desired sample size of 200 firms was reached. Incorporating the 127 undeliverable surveys (e.g., wrong address, no longer with the corporation), the response rate was 10.7% (200/1873). The NAPM respondents had been with their companies an average of 11.1 years and completed an average of 22.2 sourcing requests per month. These firms were established on average 63.8 years ago, employed an average of 3,887 employees, and were almost evenly divided among services (46.5%) and manufacturing (53.5%) firms, with all of them operating internationally.

The Cycle Time (CT) Scale
We performed a purification analysis using the IC94 sample, followed by reliability and validity assessments using the IC99, CB99, ES99, and NAPM99 samples. Table 2 (see Appendix) summarizes the correlations between the purified cycle time items and the objective cycle time indicator in each of the study samples (IC94, IC99, CB99, ES99, and NAPM99). Table 3 (see Appendix) reports the means and standard deviations of the cycle time items in all five samples. These tables, the technical scale development procedures, and statistical tests are presented in the Appendix. Each scale item is described in the following paragraphs. The subjective scale items (CT1 to CT10) were measured using a seven-point Likert-type scale with response alternatives of "strongly disagree" (1), "disagree" (2), "disagree somewhat" (3), "neither agree nor disagree" (4), "agree somewhat" (5), "agree" (6), and "strongly agree" (7).
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**Item CT1:** The length of the supply chain process is getting shorter every time. Because the primary focus of cycle time performance is the reduction in time it takes from initiation to completion of an organizational process, the objective of this item is to assess the respondent's sense of consistent and constant reduction in cycle time. The foundation rationale for the item is that the reduction in cycle time is an ongoing systematic process that never ends. Improvements can always be made to the existing process.

**Item CT2:** I have seen an improvement in the cycle time of the supply chain process recently. While item CT1 addresses the continuous reduction in cycle time, item CT2 measures the cycle time reduction based on a time definite interval. Commonly, organizations evaluate their operating behaviors at certain points in time.

**Item CT3:** I am satisfied with the speediness of the supply chain process. Item CT3 measures the cycle time based on the respondent's experience with the organizational process. As such, item CT3 incorporates "speed" as a qualifier to the respondent's level of satisfaction with the cycle time.

**Item CT4:** Involving all the participants in decision-making shortens the supply chain process. Item CT4 focuses on the cycle time improvements that may be made if all of the participants involved throughout the process were a part of the decision-making activities pertaining to the process.

**Item CT5:** The length of the supply chain process can be shortened by involving all of the participants in the process. Item CT5 addresses the total cycle time of the organizational process, as opposed to examining specific parts of the process, as is the focus of items CT3 and CT4. Thus, item CT5 can be interpreted to mean that involving all of the supply chain participants in at least some parts of the process will reduce the total cycle time of the process.

**Item CT6:** Compared with the "old" supply chain process, the "new" supply chain process involving all the participants is faster. While item CT1 addresses the continuous reduction in cycle time and item CT2 measures the cycle time reduction based on a time definite interval, the intention of item CT6 is to assess cycle time improvements over a longer time period — after structural changes have been implemented to involve all of the participants in the process more directly.

**Item CT7:** Based on our knowledge of the supply chain process, I think it is short and efficient. Item CT7 asks the respondents to provide their perceptions of the cycle time of the organizational process based on their knowledge of the activities that have to be performed to complete the process. As such, item CT7 provides the respondents a direct opportunity to voice their opinion on the cycle time of the organizational process incorporating their specific background and involvement in the process.

**Item CT8:** If I perform the tasks involved in the supply chain process rather than having all the participants involved, the process would be much longer. Item CT8 directly incorporates the idea of "teamwork" in the process to achieve cycle time effectiveness. Many organizations would argue that cycle time effectiveness can be best achieved when all the key players in the process operate as a team.

**Item CT9:** Even if I had more control and the other participants had less control, the supply chain process would not be much shorter than it is today. Item CT9 builds on item CT8 regarding the involvement of the key players in the process. However, item CT9 extends the notion of "teamwork" by asking more directly about the cycle time effectiveness as it relates to who has control — who is the leader — in the process.

**Item CT10:** The length of the supply chain
process could not be much shorter than it is today. Item CT10 assesses the level of effectiveness of the current organizational process. Conceivably, some organizational processes operate as effectively as possible within the constraints of their current resources. In such cases, only additional or refined resources can improve cycle time effectiveness (as is the focus of item CT1).

Conclusions

To facilitate the measurement of cycle time and the implementation of cycle time reduction mechanisms, a ten-item cycle time (CT) scale was developed in this study. As described in the Appendix, 6 of the 10 items survived assessments of dimensionality, reliability, and validity to be generalizable across a broad variety of supply chain settings. Overall, the CT scale is intended to measure the cycle time of an organizational process, incorporating the theoretical concepts serving as the structural foundation for an organizational process: actors, activities, and resources. The individual scale items broadly address cycle time attributes that incorporate facets of actors (CT4), activities (CT1, CT2, and CT7), and resources (CT3 and CT10).

The six-item cycle time scale offers a potentially useful tool for managers. Specifically, the scale provides a means to capture perceptions about the cycle time of organizational processes (Hult et al, 2000). Of particular interest to managers may be the overlap between objective and subjective measures of cycle time. We found that the correlation between our (reverse-coded) subjective scale and the average number of days to complete a supply chain cycle ranged between -.19 and -.38 across the five samples examined. In three of the samples, the correlation was -.20 or less. These significant, but moderate, associations should encourage inquiry into the implications of various levels of overlap. Perhaps the modest overlap we found indicates that organizational actors in general are unsatisfied with cycle time even when it is objectively impressive. If so, organizations with little overlap might be expected to aggressively seek improvement, while those with high levels of overlap might be less aggressive. Whether or not this aggression for improvement influences organization-level outcomes such as profitability could be a promising topic for managers (and researchers alike) in their quest to implement fast cycle time mechanisms in organizations.

The subjective cycle time scale may be of particular value as a tool to compare disparate processes. It is often difficult to compare objective cycle time measures across processes. For example, if the item to be procured is a complex made-to-order item (e.g., replacement part for discontinued capital equipment), the time to complete this process will generally be longer than if the organization is procuring basic commodity items such as office supplies. Thus, the objective cycle time of these two items cannot be related, nor can they be compared with each other. When looking only at objective cycle time measures, an organization has to have a preset standard for each activity in every organizational process to be able to effectively measure ongoing cycle time performance and improvements. However, a multi-attribute cycle time measure such as the CT scale developed in this study allows organizations (and researchers) to compare cycle time issues in a relatively simple and straightforward manner.

Lastly, turning to content validity, a key managerial property of the CT scale is its focus on the actors, activities, and resources that theoretically form the structure of organizational processes. As such, the CT scale is modeled on general philosophical adherence to certain cycle time principles in organizational processes.

Therefore, interventions can be targeted to certain areas as reflected in the scale items. For example, if the organization scores poorly on the item pertaining to "actors" (CT4), further analysis may reveal specific areas for improvement. Issues that may be relevant with respect to "actors" may
include, but are not limited to, knowledge, teamwork, and power relationships (Håkansson, 1982; 1989). Similarly, if the organization scores low on the items pertaining to "activities," further analysis may also reveal improvements in areas related to items CT1, CT2, and CT7. Such improvement efforts may include focusing on issues such as parallel processing of certain activities, improving technology to enhance the effectiveness of the activities, and perhaps even providing more communication about process improvements that may not have been fully shared with participants (Håkansson, 1982; 1989). Also, if the organization scores low on the items pertaining to "resources," further analysis may also reveal improvements in areas related to items CT3 and CT10. Improvement in resource-related areas may include clearly identifying the core capabilities necessary for process operations, and then focusing on these resources over others in achieving cycle time effectiveness (Håkansson, 1982; 1989).

Lastly, the modern organization confronts a staggering array of complex challenges. Effectively managing the cycle time of organizational processes is a key performance metric in the dynamic global marketplace. Managers and researchers have relied on objective measures such as minutes, hours, and days when measuring cycle time of organizational processes, but perceptual issues lead actors within organizational processes to mark time in ways that differ from these indicators. Thus, attention to capturing the subjective elements of cycle time is potentially valuable. In response, this study relied on five samples to develop a subjective cycle time scale. This scale offers organizations a useful tool to assess the less tangible, but important, elements of cycle time.

References


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APPENDIX
Tables, Scale Development Procedures and Statistical Tests

TABLE 2
Correlations Among the Purified Indicators

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<td>Means and Standard Deviations of the Cycle Time Items</td>
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Scale Development

Our expectation was that all of the items address a single construct — cycle time. As such, the operationalization of cycle time dictates a measurement model where the covariation among the 10 observed cycle time items can be accounted for by a unidimensional latent factor, and where each of the 10 measured variables is only reflective of that single factor. Thus, the measurement model for cycle time can be specified as:

\[ x_{1-10} = \lambda_{s1-10} \xi_1 + \delta_{1-10}, \]

where \( x_{1-10} \) is observed variables for cycle time, \( \lambda_{s1-10} \) correspond to indicator loadings for the \( x \) variables, \( \delta_{1-10} \) = measurement errors associated with each \( x \) variable, and with \( \xi_1 \) = the latent variable of cycle time. Inherent in this model, and any measurement model, is the assumption that \( \xi_1 \) and \( \delta_{1-10} \) are random variables with zero means and that the \( \delta_{1-10} \) are uncorrelated with the \( \xi_1 \).

Therefore, the above equation represents the regression of \( x_{1-10} \) on \( \xi_1 \), so that the elements \( \lambda_{s1-10} \) of \( \Lambda \) is the partial regression coefficient of \( \xi_1 \) in the regression of \( x_{1-10} \) on \( \xi_1 \). Thus, the covariance matrix of \( x \) is:

\[ \Sigma = \Lambda \Phi \Lambda' + \Theta \delta, \]

where \( \Phi \) and \( \Theta \delta \) are the covariance matrices of \( \xi \) and \( \delta \) respectively.

Purification Analysis

To assess the measurement model, the purification analysis using the IC94 sample (n=346) involved a series of dimensionality, reliability, and validity assessments. The psychometric properties of the modeled cycle time construct were evaluated via confirmatory factor analysis (CFA) using LISREL (Jöreskog & Sörbom, 1996). The model fit was evaluated using the DELTA2 index (Bollen, 1989), the relative noncentrality index (RNI) (McDonald & Marsh, 1990), and the comparative fit index (CFI) (Bentler, 1990), which have been shown by Gerbing and Anderson (1992) to be the most stable fit indices. The \( \chi^2 \)-statistic with corresponding degrees of freedom was included for comparison purposes.

Using these criteria, the results revealed a moderate fit to the data (DELTA2=.80, RNI=.80, CFI=.80, \( \chi^2=487.58 \), df=35). To evaluate the initial measurement fit, we used several criteria, including each item's error variance, modification index (<3.84), and residual covariation (<2.58) (Anderson & Gerbing, 1988; Forrell & Larcker, 1981; Jöreskog & Sörbom, 1996; Jöreskog et al., 1999). These criteria led us to eliminate four items: CT5, CT6, CT8, and CT9. This left six items for subsequent analysis. Using the rationale provided by Anderson and Gerbing (1988), we refitted the measurement model to the reduced set of six cycle time items. The refitted model resulted in considerable improvement in fit (DELTA2=.90, RNI=.90, CFI=.90, \( \chi^2=137.89 \), df=9), at the common cut-off level for CFA models (Mulaik et al., 1989).

Within the CFA setting, composite reliability for the cycle time scale was calculated using the procedures outlined by Forrell and Larcker (1981) based on the work of Werts, Linn, and Jöreskog (1974). The formula specifies that:

where \( \bar{\lambda} \) = composite reliability for scale \( c_i \) = standardized loading for scale item \( \delta_{i} \) = measurement error for scale item

We also examined the parameter estimates and their associated t-values and assessed the average variance extracted (Anderson & Gerbing, 1988; Bagozzi & Yi, 1988). Average variance extracted was calculated using the following formula:
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\[ \text{where } \text{average variance extracted} = \text{standardized loading for scale item} \pm \text{measurement error for scale item} \]

The composite reliability for cycle time was .89. The factor loadings ranged from .50 to .90 (p<.01), and the average variances extracted was 58.17%, results above the commonly accepted criteria (e.g., Fornell & Larcker, 1981).

Reliability and Validity Analysis

Based on the statistical analysis using the IC94 sample, in conjunction with theory and content considerations (Anderson & Gerbing, 1988), the six purified cycle time items were further considered in four samples (IC99, CB99, ES99, and NAPM99).

IC99 Sample. Using the IC99 data (n=141), the hypothesized CFA model resulted in an excellent fit to the data (DELTA2=.94, RNI=.94, CFI=.94, \( \chi^2=56.49, \text{df}=9 \)). The composite reliability for cycle time was .94. The factor loadings ranged from .54 to .95 (p<.01), and the average variances extracted was 72.17%, results above the commonly accepted criteria (e.g., Fornell & Larcker, 1981).

CB99 Sample. Using the CB99 data (n=115), the hypothesized CFA model resulted in an excellent fit to the data (DELTA2=.92, RNI=.92, CFI=.92, \( \chi^2=40.15, \text{df}=9 \)). The composite reliability for cycle time was .88. The factor loadings ranged from .52 to .89 (p<.01), and the average variances extracted was 56.50%, results above the commonly accepted criteria (e.g., Fornell & Larcker, 1981).

ES99 Sample. Using the ES99 data (n=58), the hypothesized CFA model resulted in an excellent fit to the data (DELTA2=.93, RNI=.92, CFI=.92, \( \chi^2=33.27, \text{df}=9 \)). The composite reliability for cycle time was .93. The factor loadings ranged from .59 to .94 (p<.01), and the average variances extracted was 68.17%, results above the commonly accepted criteria (e.g., Fornell & Larcker, 1981).

NAPM99 Sample. Using the NAPM99 data (n=200), the hypothesized CFA model resulted in a moderate but acceptable fit to the data (DELTA2=.84, RNI=.84, CFI=.84, \( \chi^2=68.31, \text{df}=9 \)). The composite reliability for cycle time was .73. The factor loadings ranged from .28 to .91 (p<.01), and the average variances extracted was 37.63%, results above the commonly accepted criteria except the variance extracted which fell below 50% (e.g., Fornell & Larcker, 1981).

Validation Analysis

The validation analysis for the subjective cycle time scale follows the format used in a number of scale development studies. As such, technically, the process of measurement or operationalization involves "rules for assigning numbers to objects to represent quantities of attributes" (Nunnally, 1967: 2). Two key notions are inherent in this definition. First, attributes of the object are measured, not the actual object. Second, no specification of the rules by which the numbers are assigned is provided by the definition. At the same time, the rigor with which the rules are specified and the skill with which they are applied determine whether the cycle time construct has been captured correctly.

A fundamental principle in scale development is that any particular construct should be measurable by at least two different methods. This somewhat stringent criteria in scale development research prevents possibility of the measured construct being a simple artifact of the measurement procedure.
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A common way of determining the *convergent validity* of a measure is to correlate two measures intended to be measurements of the same underlying construct. Another, more rigorous, alternative is to test the alternative measure as an indicator of the latent construct studied. In this case, we opted to measure cycle time objectively, and then use the objective measure as an indicator (x) of the latent cycle time construct. Because the objective cycle time measure simply assesses "time" without taking into account the contingencies and perceptions inherent in organizational processes, we expect the loadings for objective cycle time to be lower than that of the subjective indicators in all five samples.

Based on these parameters, we specified a measurement model similar to that in the purification analysis:

with two exceptions: (1) only the six subjective items which were purified using the IC94 sample were included and (2) \( x_7 \) represent the objective cycle time indicator. The results indicate that \( x_7 \) is significant in all five samples (in addition to \( x_{1-6} \) remaining significant at the \( p<.01 \) level). In the IC94 sample, the loading of \( x_7 \) is .35 (t-value = 6.49, \( p<.01 \)). In the IC99 sample, the loading of \( x_7 \) is .22 (t-value = 2.53, \( p<.05 \)). In the CB99 sample, the loading of \( x_7 \) is .18 (t-value = 1.81, \( p<.10 \)). In the ES99 sample, the loading of \( x_7 \) is .42 (t-value = 3.28, \( p<.01 \)). Lastly, in the NAPM99 sample, the loading of \( x_7 \) is .20 (t-value = 2.64, \( p<.01 \)). The various fit indices (DELTA2, RNI, and CFI) are also good to excellent and consistent with the earlier analysis (ranging from .85 to .94). Additionally, the correlations between the summated subjective cycle time scale and the objective cycle time item are significant in all five samples, including the IC94 (\( r = -.34, p<.01 \)), IC99 (\( r = -.20, p<.10 \)), CB99 (\( r = -.19, p<.10 \)), ES99 (\( r = -.38, p<.05 \)), and NAPM99 (\( r = -.20, p<.05 \)) samples.
Measuring Cycle Time in Organizational Processes