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Journal of Operations Management 22 (2004) 209–217
JOURNAL OF OPERATIONS MANAGEMENT
www.elsevier.com/locate/dsw

Metrics and performance measurement in operations management: dealing with the metrics maze

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Accepted 16 January 2004

Abstract

Metrics provide essential links between strategy, execution, and ultimate value creation. Changing competitive dynamics are placing heavy demands on conventional metrics systems, and creating stresses throughout firms and their supply chains. Research has not kept pace with these new demands in an environment where it is no longer sufficient to simply let metrics evolve over time—we must learn how to proactively design and manage them. The intent of this paper is to convey the importance and need for metrics-related research. An outline of the important characteristics of the metrics research topic is provided. Specifically, we address the functions of metrics; their focus and tense; their operational and strategic contexts; as well as discuss the distinction between metrics, metrics sets and metrics systems. Some initial theoretical grounding for the research topic is provided through agency theory. We conclude with a discussion of the intent and process of the special issue, and introduction of the associated articles.

Keywords: Metrics; Performance measurement; Operations management

1. The metrics challenge

> One of the most powerful management disciplines, the one that more than any other keeps people focused and pulling in the same direction, is to make an organization's purposes tangible. Managers do this by translating the organization's mission—what it, particularly, exists to do—into a set of goals and performance measures that make success concrete for everyone. This is the real bottom line for every organization—whether it's a business or a school or a hospital. Its executives must answer the question, "Given our mission, how is our performance going to be defined?" (Magretta and Stone, 2002, p. 129)

The quote from Magretta and Stone (2002) suggests that metrics and performance measurement are the critical elements in translating an organization's mission, or strategy, into reality. Metrics and strategy are tightly and inevitably linked to each other. Strategy without metrics is useless; metrics without a strategy are meaningless. The importance of metrics has been long recognized. Manufacturing and management consultant Oliver Wight almost 30 years ago offered the oft-repeated maxim, "You get what you inspect, not what you expect." Every firm, every activity, every worker needs metrics. Metrics fulfill the fundamental activities of measuring (evaluating how

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doi:10.1016/j.jom.2004.01.004

we arc doing), educating (since what we measure is what is important; what we measure indicates how we intend to deliver value to our customers), and directing (potential problems are flagged by the size of the gaps between the metrics and the standard). Yet, performance measurement continues to present a challenge to operations managers as well as researchers of operations management. Operating metrics are often poorly understood and guidelines for the use of metrics arc often poorly articulated.

As a focus of research, little attention has been devoted to this topic within the field of operations management. A great deal of what we currently know about metrics comes from the managerial literature (e.g., Brown, 1996; Cooke, 2001; Dixon et al., 1990; Kaydos, 1999; Ling and Goddard, 1988; Lynch and Cross, 1995; Maskell, 1991; Melnyk and Christensen, 2000; Melnyk et al., in press; Smith, 2000; Williams, 2001). While there are numerous examples of the use of various metrics, there are relatively few studies in operations management that have focused on the development, implementation, management, use and effects of metrics within either the operations management system or the supply chain. Nascent examples can be found in the research of Beaumon (1999), Leong and Ward (1995), Neely (1998), Neely et al. (1994, 1995), and New and Szwejczewski (1995).

We should point out that topic of metrics as discussed by managers differs from the topic of measurement as typically discussed by academics. This is primarily a byproduct of different priorities between these groups. The academic is concerned with defining, adapting and validating measures to address specific research questions. The time required to develop and collect the measures is of less importance than the validity and generalizability of the results beyond the original context. Managers face far greater time pressures, and are less concerned about generalizability. They are generally more than willing to use a "good enough" measure if it can provide useful information quickly. However, as long as the difference in priorities is recognized there are undoubtedly many lessons academic measurement experts can contribute to managers' understanding of metrics.

Recent indicators suggest that metrics and performance measurement are receiving more attention. In 1999, the Education and Research Foundation of APICS commissioned a research program dealing with measuring supply chain performance. The 2002 POMS National Conference included a special session focusing on performance measurement. In late 2002, KPMG in conjunction with the University of Illinois at Champagne undertook a major research initiative aimed at funding and encouraging research in performance measurement (to the tune of US$ 2.8 million). Finally, the January 2003 *Harvard Business Review* case study focused on the miscues and disincentives created by poorly thought out performance measurement systems (Kerr, 2003). Why the increasing interest? We believe the answer is in the business environment faced by today's operations managers. Today's environment is characterized by: (1) "never satisfied" customers (McKenna, 1997); (2) the need to manage the "total" supply chain, rather than only internal factors; (3) shrinking product life cycles; (4) more (but not necessarily better) data; and (5) an increasing number of alternatives. These dynamics make static metrics systems obsolete, and call for new performance measures and metrics approaches that go beyond simple reporting to create means for identifying improvement opportunities and anticipating potential problems. Further, metrics are now seen as an important means by which priorities are communicated within the firm and across the supply chain. Metrics misalignment is thought to be a primary source of inefficiency and disruption in supply chain interactions.

Given this environment, the research challenge is to better understand the roles and impacts of metrics in operating systems, and using this knowledge to design metrics systems and guidelines that provide clarity of purpose, real-time feedback and predictive data, and insights into opportunities for improvement. In addition, these new metrics systems need to be flexible in recognizing and responding to changing demands placed on the operating system due to product churn, heterogeneous customer requirements, as well as changes in operating inputs, resources, and performance over time.

By way of introducing this special issue on performance measures and operating metrics, in the remaining sections of this article we:

- Identify the defining elements and different types of metrics.
- Position metrics within the operations management research environment.

- Identify the special research challenges associated with metrics.
- Introduce the articles that comprise the special issue.

Ultimately, the goal of this special issue is to direct, shape, and encourage research into this very important topic area.

1.1. Defining metrics—an overview

A metric is a verifiable measure, stated in either quantitative or qualitative terms and defined with respect to a reference point. Ideally, metrics are consistent with how the operation delivers value to its customers as stated in meaningful terms.

This definition identifies several critical elements. First, a metric should be verifiable, that is, it should be based on an agreed upon set of data and a well-understood and well-documented process for converting this data into the measure. Given the data and the process, independent sources should be able to arrive at the same metric value. Second, metrics are measures. They capture characteristics or outcomes in a numerical or nominal form. In order to interpret meaning from a metric, however, it must be compared to a reference point. The reference point acts as a basis of comparison, and can be an absolute standard or an internally or externally developed standard. Standards can be based on past metric values or based on metric values for a comparable process (e.g., a "benchmark"). Zero defects would be an absolute standard, for example, as would be 100% utilization. An operating budget is an internally developed standard, whereas environmental performance might be compared to external standards published by the Environmental Protection Agency (EPA). Because metrics are expressed relative to some reference point, they encourage comparison by the users of the metric or by external parties (as in the case of ISO 9000 auditors).

It is generally desirable that a metric be expressed in meaningful terms. If metrics are to be effective, they must be understood—they must make sense to the person using the metrics. In addition, metrics should be value-based. That is, a metric should be linked to how the operation delivers value to its targeted customers. Naturally, not all metrics will be directly related to customer value. Metrics may also be related to the values of other stakeholders in the process. For example, worker safety-oriented metrics are important, but indirectly related to customer value.

2. The fundamental need for metrics

Metrics provide data refinement. As the volume of inputs increases, through greater span of control or growing complexity of an operation, data management becomes increasingly difficult. Metrics provide a means of distilling the volume of the data while simultaneously increasing its information richness. Operations need these functions in order to operate effectively and efficiently on a day-to-day basis.

Finally, metrics exist as tools for people. Ultimately, the actions people take and the decisions they make determine the degree and nature of value that an operation creates. These actions and decisions can be greatly influenced by metrics.

Metrics provide the following three basic functions:

- *Control*: Metrics enable managers and workers to evaluate and control the performance of the resources for which they are responsible.
- *Communication*: Metrics communicate performance not only to internal workers and managers for purposes of control, but to external stakeholders for other purposes as well (e.g., Wall Street, the EPA or to a bank). Many times stakeholders and users of metrics do not understand the workings and processes of a firm or operation, nor do they need to. Well-designed and communicated metrics provide the user a sense of knowing what needs to be done without necessarily requiring him/her to understand the intricacies of related processes. Poorly developed or implemented metrics can lead to frustration, conflict, and confusion.
- *Improvement*: Metrics identify gaps (between performance and expectation) that ideally point the way for intervention and improvement. The size of then gap and the direction of the gap (positive or negative) provide information and feedback that can be used to identify productive process adjustments or other actions.

There are dynamic tensions inherent in requiring one system to perform multiple functions. One such tension stems from the desire to change metrics in re-

sponse to new strategic priorities, and the desire to maintain metrics to allow comparison of performance over time. This tension will dictate the metrics life cycle. Moreover, as the metrics reflect underlying priorities and decisions, metrics-related stress between various parties is often simply the first indicator of unobserved, unresolved conflicts between the customer, strategy, and operations of the firm.

3. A metrics typology

One source of complexity regarding the study of metrics is the variety of different types of metrics that researchers and managers encounter. We suggest that various metrics can be readily classified according to two primary attributes: *metrics focus* and *metrics tense*. Metrics focus pertains to the resource that is the focus of the metric. Generally, metrics report data in either financial (monetary) or operational (e.g., operational details such as lead times, inventory levels or setup times) terms. Financial metrics define the pertinent elements in terms of monetary resource equivalents, whereas operational metrics tend to define elements in terms of other resources (e.g., time, people) or outputs (e.g., physical units, defects). The second attribute, metrics tense, refers the how the metrics are intended to be used. Metrics can be used to both to judge outcome performance and to predict future performance. An outcome-oriented use of a metric implicitly assumes that the problems and lessons uncovered from a study of past outcomes can be applied to current situations. That is, by studying the past, we can improve the present. In general, managers who monitor and reward activities and associated personnel use metrics in an outcome-based way. Executives often use metrics in this way. Many of the cost-based metrics encountered in firms belong to this category. Similarly, many of the accounting based information systems observed in many firms typically generate outcome-based metrics.

In contrast, a predictive use of a metric is aimed at increasing the chances of achieving a certain objective or goal. Predictive metrics are associated to aspects of the process that will result in the outcomes of interest. If our interest is in reducing lead time, then we might assess metrics such as distance covered by the process, setup times, and number of steps in the process. Reductions in one or more of these areas should be reflected in reductions in lead time. An emphasis on identifying and using metrics in a predictive way is relatively new. Predictive metrics are appropriate when the interest is in preventing the occurrence of problems, rather than correcting them.

Combining of these two metrics attributes provides four distinct types of metrics: financial/outcome, financial/predictive, operational/outcome, and operational/predictive (Scheme 1). These different categories appeal to different groups within the firm. Top managers, for example, are typically most interested in financial/outcome. In contrast, operations managers and workers are most likely interested in operational/predictive or operational/outcome metrics since these two sets pertain to the processes that these managers must manage and change.

4. Levels of metrics

The term, “metrics” is often used to refer to one of three different constructs: (1) the *individual metrics*; (2) the *metrics sets*; and (3) the overall *performance measurement systems*. These terms are often used in-

		Metrics Tense	
		Outcome	*Predictive*
Metrics Focus	*Financial*	Return on Assets	Overtime Dollars (predictive for budget overruns)
	Operational	Elapsed Lead Time	Number of process steps and setups (predictive for lead times)

Scheme 1. Metrics typology.

terchangeably, thus contributing to the confusion. We suggest that recognition of the different levels of metrics and their interactions is important for the research and design of metrics.

At the highest level, the *performance measurement system* level integrates. That is, it is responsible for coordinating metrics across the various functions and for aligning the metrics from the strategic (top management) to the operational (shop floor/purchasing/execution) levels. For every activity, product, function, or relationship, multiple metrics can be developed and implemented. The challenge is to design a structure to the metrics (i.e., grouping them together) and extracting an overall sense of performance from them (i.e., being able to address the question of "Overall, how well are we doing?").

Several different approaches have been proposed for developing such an integrative system. These include: (1) the *balanced scorecard*, as presented by Kaplan and Norton (1992, 1996, 2001) and elaborated on by others (e.g., Ittner and Larcker, 1998); (2) the *strategic profit impact model* (otherwise known as the Dupont model (Lambert and Burduroglu, 2000); and (3) the *theory of constraints* (TOC) measurement system (Lockamy III and Spencer, 1998; Smith, 2000). Each of these major systems has strengths and weaknesses. For example, the balanced scorecard excels at its ability to force top management to recognize that multiple activities must be carried out for corporate success and the management and monitoring of these activities must be balanced. The strategic profit impact model provides the operations manager with a mechanism, whereby operational improvements such as reductions in inventory—changes of interest to the operating personnel—can be translated into its impact on financial performance, changes of interest primarily to top management. Finally, the TOC approach is attractive because of its ability to simplify the performance measurement problem and reduce the number of measures and areas actively and continuously monitored by top management.

The *performance measurement system* is ultimately responsible for maintaining *alignment* and *coordination*. Alignment deals with the maintenance of consistency between the strategic goals and metrics as plans are implemented and restated as they move from the strategic through the tactical and operational stages of the planning process. Alignment attempts to ensure that at every stage that the objectives set at the higher levels are consistent with and supported by the metrics and activities of the lower levels. In contrast, coordination recognizes the presence of interdependency between processes, activities or functions. Coordination deals with the degree to which the metrics in various related areas are consistent with each other and are supportive of each other. Coordination strives to reduce potential conflict that can occur when one area focuses on maximizing uptime (by avoiding setup and running large batches) and another focuses on quality and flexibility. Coordination tries to maintain an equivalence of activities, goals, and purpose across departments, groups, activities and processes.

To date, most research and managerial attention has focused on *performance measurement systems* or on *individual metrics*. Melnyk et al. (in press) suggest that these two levels are not sufficient by themselves. There exists another metrics construct—the *metrics set*. The metric set consists of the metrics assigned by a higher level of management to direct, motivate and evaluate a single person in charge of a specific activity, process, area, or function. The metrics set is critical because it is often the relevant unit of analysis, and because the scope and complexity of an individual's metrics set can be viewed as a load imposed upon that person's finite mental capacity.

These three levels of metrics are linked. At the base is the *individual metric*, the building block. *Individual metrics* are aggregated to form various *metrics sets*. Each set directs, guides, and regulates an individual's activities in support of strategic objectives. Coordinating and managing the development of the various *individual metrics* and the *metrics sets* is the *performance measurement system*.

4.1. Positioning metrics within the research environment

There has long been recognition of metrics and its importance within the operations management field. Wickham Skinner in 1974 identified simplistic performance evaluation as being one of the major causes for factories getting into trouble (Skinner, 1974). Subsequently, Hill (1999) recognized the role and impact of performance measures and performance measurement systems in his studies of manufacturing strategy.

In these and other studies, metrics are often viewed as being part of the infrastructure or environment in which manufacturing must operate.

However, while we have recognized the role of metrics as an influencing factor, there is still a need to position the topic of metrics within a theoretical context—a framework that gives metrics a central role. One such theoretical framework is *agency theory*.

Agency theory applies to the study of problems arising when one party, the principal, delegates work to another party, the agent (Eisenhardt, 1989a; Lassar and Kerr, 1996). The unit of analysis is the metaphor of a contract between the agent and the principal. Prior studies using agency theory as the theoretical framework have used "coordination efforts" (Celly and Frazier, 1996), "control" (Anderson and Oliver, 1987), and "management" (McMillan, 1990) as the unit of analysis.

There are numerous factors and variables that influence the most efficient "contract" in the dyadic relationship between a principal and agent. These include the information systems (Eisenhardt, 1989a), outcome uncertainty (Eisenhardt, 1989a), risk aversion (Anderson and Oliver, 1987; Celly and Frazier, 1996), programmability (Eisenhardt, 1989a), and the relationship length (Eisenhardt, 1989a; Celly and Frazier, 1996).

Within operations management, agency theory has been used to study such topics as decentralized cross-functional decision-making (Kouvelis, 2000), group technology (Beh-Arieh, 1999), international manufacturing (Change, 1999), scheduling (Gu, 1997; Kim, 1996), and inventory management (Allen, 1997). Yet, what makes agency theory so attractive is that the recognition that in most organizations the concept of a contract as a motivating and control mechanism is not really appropriate. Rather, the contract is replaced by the metric (Austin, 1996). It is the metric that motivates and directs; it is the metric that enables principals to manage and direct the activities of their various agents. The development, selection, use, and refinement of metrics becomes a major concern of both principals and agents. Consequently, agency theory provides a potentially interesting and useful theoretical context for operations management researchers to analyze this critical topic.

Dependency theory (Pfeffer and Salancik, 1978) might also be seen as a potentially fruitful lens through which to view the role of metrics in operations management. This theory states that the degree of interdependence and the nature of interactions among functional specialists within an organization are influenced by the nature of the collective task they seek to accomplish. In dynamic environments involving rapid product change and high degrees of heterogeneity in customer requests, agents responsible for different functional aspects of order taking, processing, and fulfillment become more and more dependent on each other for information necessary to complete their respective tasks. This theory has implications for the design of metrics systems. For example, questions such as "How should metrics reflect the interdependencies of different functional areas?" could be posed. And further, "How should the rotation or change in metrics be associated to the dynamics of demands placed on the operating system?" These types of research questions start to get at the coordination attributes of higher order performance measurement systems raised earlier in this article.

We have in several places noted that metrics provide a vital linkage between intended strategies and actual execution. This notion harkens to theories of strategic fit. Skinner (1969) offered one of the earliest operations management perspectives on strategic fit as he argued the need for strategic fit between manufacturing goals and decisions and other functional and corporate strategies. Wheelwright (1984) further defined the notion of strategic fit, stating the need for consistency between operations strategy and business strategy, other functional strategies, and the competitive environment, respectively. While the need for strategic fit is recognized, how to go about achieving it has received less attention in the operations strategy literature. Taking strategy fit theory as the frame of reference for the study of metrics might lead to insights into the role of metrics in achieving fit, and again, the implications of strategy fit for the design of metrics systems.

An information processing perspective (Galbraith, 1973) offers yet another potentially rewarding way to look at metrics. Presumably, a richer "metrics set" creates the basis for richer communications among decision makers, workers, strategy representatives, and customers of a process. However, there may be limits to the organization's (as well as individuals') ability to process larger sets of metrics, and increasing num-

bers of metrics could lead to greater conflict in the implied priorities, as well as greater equivocality regarding future actions. Given this apparent trade-off between metrics set richness and complexity, an information processing theoretical view could stimulate research into questions regarding the optimal size of a metrics set, or perhaps the optimal combination of outcome and predictive metrics included in the set.

Linkage research in services, beginning with the work of Schneider et al. (1980) and more recently reviewed in Pugh et al. (2002) has focused on validating and quantifying perceived relationships between internal actions of a firm (such as particular human resources practices) and important strategic outcomes (such as customer satisfaction and profitability). This research may be particularly applicable to addressing such questions as "How does one derive a predictive metric?" and "Is a perceived predictive metric truly predictive?" It may also help in illuminating the differences between the metrics system as conceived by management and its actual structure. This will be particularly relevant in understanding the relationships between metrics that are not mathematically derived, such as when metrics interact through a lens of altered behavior.

4.2. Overview of the special issue

As can be seen from the preceding discussion, metrics and performance measurement is inherently a complex topic. There is a need for research intended to better structure and to appropriately simplify the analysis of this topic. These and other factors formed the motivation for this special issue.

The announcement for this special was framed in very broad terms. Both theoretical and empirical papers, as well as rigorous case studies, were invited. Cross-functional studies were particularly encouraged. Suggested topics for the special issue included:

- Assessing the impact of operating/predictive metrics on system performance.
- Evaluating the relationship between financial and operating metrics.
- Measuring performance within the supply chain environment—practices, challenges, problems and opportunities.
- Assessing consistency of metrics, both within the set of metrics being used and between the metrics and corporate strategy (and the potential effects attributable to consistency or the lack of consistency within the metrics).
- Implementing performance measurement systems.
- Changing performance measurement system or metrics over time.
- Measuring performance of product/process design processes.
- Integrating environmental issues into the performance measurement systems.
- Integrating metrics with the real or perceived reward structure.
- Assessing performance measurement and metrics within services and manufacturing settings.

Papers that were submitted for the special issue were subjected to an initial review by the co-editors to assess the compatibility of the topic addressed by the paper with the theme and focus of the special issue. Papers that did not pass this initial screen were, at the authors' discretion, forwarded to the editor of the *Journal of Operations Management* to be included in the normal review process for the journal. Of 10 papers submitted, 8 passed this initial review. These eight papers were then subject to a normal double-blind review process with three being accepted for publication.

The first paper is "An exploratory study of performance measurement systems and relationships with performance results" by James Evans. Evans uses the metrics framework provided by the Malcolm Baldrige Award, which is similar to that of the balanced scorecard to conduct an empirical investigation of the relationship between the scope or types of metrics used and customer, financial and market performance. The paper addresses issues relating to both metrics and the metrics system.

The second paper by Shinn Sun is "Assessing joint maintenance shops in the Taiwanese army using data envelopment analysis". This paper is application oriented, and in it Sun develops a DEA-based performance assessment tool to evaluate the performance of multiple similar functional units, and identify opportunities for improvement. The tool is applied to a collection of maintenance shops to demonstrate its usefulness. Sun's tool directly addresses two of the functions of metrics: control through setting objective

standards and assuring comparability of the results; and improvement through identifying areas of relative inefficiency. Indirectly, the model supports the third function of communication in that it identifies similar but more efficient functional units to communicate with.

The final paper "Perceptual measures of performance: fact or fiction?" is from Mikko Ketokivi and Roger Schroeder. In it the authors investigate the reliability and validity of perceptual measures of performance. They introduce and empirically demonstrate a method for using multi-informant survey data, and conclude that the reliability and validity of such an approach is satisfactory. This has implications for practice in situations where perceptual data is the best or only source of assessment, and perhaps more importantly for future research on the linkage between metrics attributes and firm performance.

4.3. Concluding comments

The intent of our discussion has been to first convince the reader of the importance of metrics as a topic and the need for an increased understanding of metrics and their role in the firm, and to provide some organization to our current understanding of the topic. We have suggested an outline of what we see as important characteristics by which the research space can be organized, and provided some initial theoretical grounding for this research in agency theory, dependency theory, strategic fit theory, information processing theory, and linkage research. Taken in the greater context of the special issue, it should suggest many profitable avenues of inquiry to follow. It is our hope that it will serve to inspire other researchers to contribute to our understanding of this very important topic.

Acknowledgements

All papers contained in this special issue were subject to an exhaustive review process. Critical to the success of this review process were the various reviewers who gave extensively of their time and insights. We would like to acknowledge the following reviewers: Joe Biggs, California Polytechnic State University; Ken Boyer, Michigan State University; David Collier, Ohio State University; Kevin J. Dooley, Arizona State University; Janet L. Hartley, Bowling Green State University; Nancy Lea Hyer, Vanderbilt University; Jay Jayaram, University of Oregon; Chris McDermott, Rensselaer Polytechnic Institute; Linda G. Sprague, CEIBS; Srinivas Talluri, Michigan State University; Shawnee Vickery, Michigan State University; D.B. Waggoner, Cambridge University; Ravi Behara, Florida Atlantic University; Rohit Verma, University of Utah; Anthony Ross, Michigan State University; Daniel Krause, Arizona State University.

References

Allen, D.S., 1997. A multi-sector inventory model. Journal of Economic Behavior and Organization 32 (1), 55–87.

Anderson, E., Oliver, R.L., 1987. Perspectives on behavior-based versus outcome-based salesforce control systems. Journal of Marketing 51, 76–88.

Austin, R.B., 1996. Measuring and Managing Performance in Organizations. Dorset House Publishing, New York, NY.

Beaumon, B.M., 1999. Measuring supply chain performance. International Journal of Operations and Production Management 19 (3).

Beh-Arieh, D., 1999. Information analysis in a distributed dynamic group technology method. International Journal of Production Economics 60–61, 427–432.

Brown, M.G., 1996. Keeping Score: Using the Right Metrics to Drive World-Class Performance. Quality Resources, New York, NY.

Celly, K.S., Frazier, G.L., 1996. Outcome-based and behavior-based coordination efforts in channel relationships. Journal of Marketing Research 33, 200–210.

Change, E., 1999. Control in multinational corporations (MNCs): the case of Korean manufacturing subsidiaries. Journal of Management 25 (4).

Cooke, J.A., 2001. Metrics systems. Logistics Management and Distribution Report 40 (10), 45–49.

Dixon, J.R., Nanni Jr., Alfred, J., Vollmann, T.E., 1990. The New Performance Challenge: Measuring Operations for World-Class Competition. Dow Jones–Irwin, Homewood, IL.

Eisenhardt, K.M., 1989a. Agency theory: an assessment and review. The Academy of Management Review 14 (1), 57–74.

Galbraith, J.R., 1973. Designing Complex Organizations. Addison-Wesley, Reading, MA.

Gu, P., 1997. Bidding-based process planning and scheduling in a multi-agent system. Computers and Industrial Engineering 32 (2), 477–496.

Hill, T., 1999. Manufacturing Strategy: Text and Cases. McGraw-Hill, Burr Ridge, IL.

Ittner, C.D., Larcker, D.F., 1998. Innovations in performance measurement: trends and research implications. Journal of Management Accounting Research 10, 205–238.

Kaplan, R.S., Norton, D., 1992. The balanced scorecard—measures that drive performance. Harvard Business Review, January–February, pp. 71–79.

Kaplan, R.S., Norton, D., 1996. The Balanced Scorecard. Harvard Business School Press, Cambridge, MA.

Kaplan, R.S., Norton, D.P., 2001. The Strategy-Focused Organization: How Balanced Scorecard Companies Thrive in the New Business Environment. Harvard Business School Press, Boston, MA.

Kaydos, W., 1999. Operational Performance Measurement: Increasing Total Productivity. St. Lucie Press, Boca Raton, FL.

Kerr, S., 2003. The best-laid incentive plans. Harvard Business Review, January, pp. 27–37.

Kim, K.H., 1996. A distributed scheduling and shop floor control method. Computers and Industrial Engineering 31 (3–4), 583–586.

Kouvelis, P., 2000. Decentralizing cross-functional decisions: coordination through internal markets. Management Science 46 (8).

Lambert, D.M., Burduroglu, R., 2000. Measuring and selling the value of logistics. International Journal of Logistics Research 11 (1), 1–17.

Lassar, W.M., Kerr, J.L., 1996. Strategy and control in supplier–distributor relationships: an agency perspective. Strategic Management Journal 17, 613–632.

Leong, G.K., Ward, P.T., 1995. The six Ps of manufacturing strategy. International Journal of Operations and Production Management 15 (12), 32–45.

Ling, RC., Goddard, W.E., 1988. Orchestrating Success: Improve Control of the Business with Sales and Operations Planning. Wiley, New York, NY.

Lockamy III, A., Spencer, M.S., 1998. Performance measurement in a theory of constraints environment. International Journal of Production Research 36 (8), 2045–2060.

Lynch, R.L., Cross, K.F., 1995. Measure Up! How to Measure Corporate Performance. Blackwell, Malden, MA.

Magretta, J., Stone, N., 2002. What Management is: How it Works and Why it's Everyone's Business. Free Press, New York, NY.

Maskell, B.H., 1991. Performance Measurement for World Class Manufacturing. Productivity Press, Cambridge, MA.

McKenna, R., 1997. Real Time: Preparing for the Age of the Never Satisfied Customer. Harvard Business School Press, Boston, MA.

McMillan, J., 1990. Managing suppliers: incentive systems in Japanese and U.S. industry. California Management Review 32 (4), 38–55.

Melnyk, S.A., Christensen, R.T., 2000. Back to Basics: Your Guide to Manufacturing Excellence. St. Lucie Press, Boca Raton, FL.

Melnyk, S.A., Stewart, D.L., Calantone, Roger J., Speier, C. Metrics and the Supply Chain: An Exploratory Study. APICS, Alexandria, VA, in press.

Neely, A., 1998. The Performance Measurement Revolution: Why Now and What Next? International Journal of Operations and Production Management 18 (9–10).

Neely, A., Gregory, M., Platts, K., 1995. Performance measurement system design. International Journal of Operations and Production Management 4, 80–116.

Neely, A., Mills, J., Platts, K., Gregory, M., Richards, H., 1994. Realizing strategy through measurement. International Journal of Operations and Production Management 14 (3), 140–152.

New, C.C., Szwejczewski, M., 1995. Performance measurement and the focused factory: empirical evidence. International Journal of Operations and Production Management 15 (4), 63–79.

Pfeffer, J., Salancik, G.R., 1978. The External Control of Organizations: A Resource Dependence Perspective. Harper & Row, New York.

Pugh, S.D., Dietz, J., Wiley, J.W., Brooks, S.M., 2002. Driving service effectiveness through employee–customer linkages. Academy of Management Executive 16 (4), 73–84.

Schneider, B., Parkington, J.J., Buxton, V.M., 1980. Employee and customer perceptions of service in banks. Administrative Science Quarterly 25 (2), 252–267.

Skinner, W., 1969. Manufacturing—missing link in corporate strategy. Harvard Business Review, May–June, pp. 136–145.

Skinner, W., 1974. The decline, fall, and renewal of manufacturing plants. Harvard Business Review, May–June.

Smith, D., 2000. The Measurement Nightmare: How the Theory of Constraints can Resolve Conflicting Strategies, Policies, and Measures. St. Lucie Press, Boca Raton, FL.

Wheelwright, S.C., 1984. Manufacturing strategy: defining the missing link. Strategic Management Journal 5, 77–91.

Williams, B.R., 2001. Is your supply chain competitive? How do you know? In: 2001 APICS Conference, San Antonio, TX, October.