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# OM Forum

## Process Management Instead of Operations Management

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In this article a challenge is provided to the operations management community to broaden our perspective from the traditional, functional one to the cross-functional (interdisciplinary) view of process management. At the same time, the challenge is to de-emphasize mathematical optimization and instead seek improvements through better representations of problems or situations of real interest to management. I believe that adoption of these suggestions will enhance the opportunities and reputation of our research and educational activities.

*Key words:* process management; interdisciplinary; improvement/redesign

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### 1. Introduction

Garrett van Ryzin, the Editor-in-Chief of this journal, asked the Manufacturing and Service Operations Management (MSOM) Fellows to consider submitting articles to the Operations Management (OM) Forum on topics that would generate discussion on broad issues of OM research. This paper is my response to that invitation.

I decided to write on a topic that has become central to my thinking and my research, teaching, and consulting activities over the later years of my career. It is based on my extensive experience in teaching (undergraduate, graduate, and executive workshops), research, and consulting. A component of the teaching-related experience was the redesign in 1997 of an introductory, undergraduate, required course on OM in a business school. This included the design and use of a widely circulated questionnaire seeking (and receiving considerable) input on a number of issues related to the design and delivery of such a course. In addition, in the early 1990s I developed an MBA interdisciplinary elective course titled "Business Process Improvement and Creative Problem Solving."

Both the website of the MSOM Society and the editorial statement of this journal refer to the

operations *functional* area. I am personally convinced that it is time for a broadening of perspective by those conducting research and teaching in the OM field. In particular, the perspective should be a cross-functional one of process management, rather than the traditional functional orientation of OM. Quite independently, Gene Woolsey (2003a) has recently advocated that INFORMS be branded "The Process Improvement People." This broader perspective also implies more emphasis on improvement, rather than optimization. As will be discussed later, this changed perspective is not really new, but it is my belief that it should be more central to our intellectual perspective on the field, our research, and our teaching.

In §2 background definitions of operations management, process, and process management are given. Then, §3 points out that the major issues of concern to management require a cross-functional (interdisciplinary) perspective, and that there are associated opportunities for major improvements. Next, in §4, the message conveyed is that improvement or redesign of processes is usually more important than optimizing under existing conditions. The paper ends with a brief summary in §5.

## 2. Some Definitions

### Operations Management

There are many possible definitions of OM. Below are two illustrative, traditional ones from well-known textbooks.

Operations management (OM) is defined as the design, operation and improvement of the systems that create and deliver the firm's primary products and services. Like marketing and finance, OM is a functional field of business... (Chase et al. 2001, pp. 6–7).

Production and operations management is the process of managing people and resources in order to create a product or a service.... Marketing, finance and production are the three major functional areas of the firm (Nahmias 1997, p. x).

Note that both of these definitions include the traditional functional perspective.

### Process

Again, there are several possible definitions of a process. The following is one of mine that I have used in my teaching.

A process is a collection of activities that takes one or more kinds of inputs and creates outputs (or outcomes) that are of value to customers external and internal to the organization.

Besides manufacturing and services, this definition encompasses so-called business processes. Examples of the latter include billing and accounts receivable, budget preparation, contract changes, employee (annual) evaluation, financial reporting, forecasting, hiring and termination, maintenance, order entry, order fulfillment, patent preparation, payroll, product development, proposal preparation, purchasing, sales, training, and travel planning.

### Process Management

Again, there are numerous definitions of process management. One of mine I have used is as follows.

Process management is the design, control, improvement and redesign of processes.

## 3. A Cross Functional (Interdisciplinary) Perspective—Where the Action Is

Historically, firms have been organized into functional areas (or departments). A major reason for this

organizational structure is the so-called *transaction costs* associated with communicating, sharing information, and making decisions. The new world of information technology (IT) has dramatically reduced these transaction costs, enabling new organizational structures and supporting processes that cut across departmental and firm boundaries. The field of transaction cost economics is concerned with the above issues as well as with which processes to own and which to contract for externally, who governs the processes (and their transactions), who has property rights on the decisions, and so on. See, for example, Williamson and Masten (1995).

### 3.1. Recent Major Developments

Consider the recent major developments in OM. In most cases these were due to practitioner, rather than academic, initiatives. Moreover, each, by and large, encompasses a process perspective. I'll now comment on some of these.

**Just in Time.** In manufacturing the just-in-time (JIT) revolution was based on a process improvement philosophy, i.e., changing what were taken as givens in manufacturing (e.g., long or costly setup times, long lead times, poor initial quality, and so on), rather than optimizing inventory levels, production scheduling, and so on subject to the givens.

**Total Quality Management and Six Sigma.** Total quality management (TQM) encompasses a broad (process) perspective, beginning with the customer viewpoint of what is meant by quality. Quality considerations are taken into account in product design, process design, motivation and remuneration systems, and so forth. Six Sigma is a systematic *process* for revising and redesigning processes so that waste and resources are minimized while increasing customer satisfaction.

**Business Process Reengineering.** Business process reengineering (BPR) involves the complete redesign of business processes. It typically makes heavy use of information technology and is closely linked to the next topic. Despite numerous problems (and failures) in implementation, BPR certainly has increased managerial awareness of a process perspective.

**Enterprise Resource Planning.** Enterprise resource planning (ERP) systems are based on a consideration of the interrelationships among the myriad processes within a firm, including ensuring consistent associated data. They facilitate cross-functional decision making and have been widely adopted in practice.

**Supply Chain Management.** There has been enormous interest in the understanding and management of supply chains. As the following quotes indicate there are opportunities for huge improvements (in costs, quality, response time, and so on) through integration of *processes*, not just across functions within a firm, but across the boundaries of different organizations.

In my mind, business practices of the future will be defined in a new unit of analysis: the supply chain (not the individual organization). As a result of environmental shocks and global competition, organizations now find that it is no longer enough to manage their internal processes. They must also be involved in the management of the network of all upstream firms that provide inputs (directly or indirectly), as well as the network of downstream firms responsible for logistics, delivery and after-market service for the product/service to the end customer (Handfield in Meredith et al. 2002, p. 11).

The breadth and power of supply-chain management comes across in the process view of supply-chain management.... When the multi-company nature of the supply-chain diagram is combined with a process-flow diagram, one can see that supply-chain management is not just about order fulfillment; it must be part and parcel of product design, introduction, promotion, fulfillment, and recycling. Furthermore, to achieve its full impact, it must be embedded fully in business strategy and considered throughout the product life cycle (Kopczak and Johnson 2003, p. 28).

**Flexibility.** Related to the JIT and supply-chain perspectives, there has been increased attention to ensuring flexibility in products and processes to cope with more variable demand for individual items (goods or services), shorter required response times, more-volatile pricing of inputs, etc. This includes modularity and commonality; postponement (physical or geographical); more flexible contracts (including sharing of risks and profits); greater flexibility of workers and equipment; and so on. These can all be considered ways of introducing flexibility by better managing the multistage process that delivers goods and services.

### 3.2. Opportunities

What opportunities does the process perspective create? The following quote gives some indication.

Many existing processes developed haphazardly in environments with limited or poor information. Therefore, buffers of various types were needed, poor quality was tolerated partly because it was too expensive or time consuming to collect and process the information required to improve it, etc. The revolution in IT over the past several decades means that data of unprecedented richness, detail, timeliness and (relative) accuracy are now readily available/acquirable and easily shared. This changes everything! Now the process change/integration opportunities are dramatically greater than they used to be (Adapted from Grossman 2003).

Do organizational leaders care about these issues? Mehrotra (2003a) in a recent *OR/MS Today* column makes reference to the results of a poll of business leaders. One of the two leading questions of concern to executives was, "Today, can we simply organize ourselves to do our job?" A process viewpoint is central to "organizing to do the job."

There are continued major opportunities related to some of the developments mentioned earlier. For example, a recent issue of *Interfaces* (Guide and Van Wassenhove 2003) was devoted to closed-loop supply chains, i.e., chains that recognize backward flow of materials (collection, recycling, reuse, remanufacturing, and so on). In addition, here is a sampling of some other application areas where a process perspective is likely to provide major rewards:

**Applications of New Developments in Communication Technologies.** New technological developments (such as mobile communication devices, wireless fidelity, voice-over-Internet protocol, and so on) will open up countless new opportunities for customer-to-customer, customer-to-business, and business-to-business transactions, many of which will be Web based.

**Management of Call Centers.** Call centers are increasingly being utilized by organizations to handle customer-related matters. There are complex interactions between forecasting aggregate volumes of calls, microforecasting incoming calls, setting staffing levels, training staff, designing jobs and associated processes (who handles which types of requests),



call routings, staff training, compensation plans, and so on.

**Medical Decision Making.** The availability of abundant information and new (but usually very expensive) technology, and the rapid spread of infectious diseases (such as SARS and variations of the flu) creates many opportunities for process improvements and innovations related to the administration of medical decision making. Below are two specific examples in the city of Calgary.

(1) Hospital emergency departments were experiencing long waiting times. The reaction was to just increase emergency department capacity. This really did not help that much because supporting downstream activities (e.g., surgery, admittance to the hospital, and so on) turned out to be just as much bottlenecks. Working procedures, attitudes of doctors, and union regulations all must be taken into account. There is also the broader issue of how to reduce the demand for emergency services without degrading health care.

(2) I was involved in a consulting study for Calgary Laboratory Services who are under contract to provide medical testing services to several hospitals and a broad range of physicians in the Calgary area. This involves the drawing of samples at hospitals and remote clinics; collection and delivery of samples to the main processing laboratory; preparatory steps and the actual execution of the tests (a multistage process); reporting of results; storage or disposal of samples; and so on. The study was concerned with the ramifications of acquiring automated equipment for registering and sorting the incoming samples. The volume and daily arrival patterns of different types of samples could also be influenced by priority rules for specific tests, the attitudes and behavior of the physicians prescribing the tests, and so on. Also of importance are union regulations and worker attitudes and skill levels (regarding modifying, redefining, or resequencing portions of the process).

**Security Systems.** Recent national and international developments have dictated that increased attention be directed to security issues related to travel, communication systems, operations (financial and otherwise) of individual organizations, and so on. An interdisciplinary process perspective should prove

valuable in developing systems (including incentives and disincentives) to ensure cost-effective, high levels of security. As an example, consider the screening of passengers and carry-on luggage at airports. An obvious OM decision area is the scheduling of staff to meet a stochastic time-varying need for screening (see Atkins et al. 2003). However, there are broader, process issues. For example, what are the impacts of new technology such as biometric identification? Also, can client (passenger) behavior be influenced to improve the throughput time or lower the security risk, or both?

### 3.3. Processes Are Relevant Across and Within Other Functional Areas

As has been argued earlier, many important processes span functional boundaries. In process management, besides worrying about operational issues (throughput rates, cycle times, costs, error rates, and so on) the researcher has to focus on the customer (traditionally in marketing's domain), behavioral considerations such as training and remuneration (traditionally the domain of human resources), and, of course, financial issues.

In addition, there are important processes primarily within single functional areas, other than operations. Examples include preparing a marketing campaign, closing the books (accounting area), recruiting (human resources), preparing a financial report, and so on. In our introductory OM course at the University of Calgary, we have found it very helpful to bring out these process illustrations early on (as well as pointing out that all employees, including managers, are involved in or concerned with processes on a daily basis), thus capturing the attention of students initially interested in other functional areas. Pursuing this perspective considerably further we have developed (jointly with the management information systems area) a new concentration in business process management that both students and employees have found quite appealing. (A similar type of concentration already existed at Indiana University before we made this change.)

### 3.4. Is This Process Perspective Really New?

A process perspective is very consistent with a system's viewpoint, in that a system can be considered as a collection of interrelated processes (see Earl

and Khan 1994, Melão and Pidd 2000). The OM, management science (MS), and strategic management fields have certainly had strong advocates of systems thinking for many years (e.g., Ackoff 1974, Beer 1960, Checkland 1981, Churchman 1968, Daellenbach 1994, Starr 1996, Sterman 2000). Recently, Cooke and Rohleder (2003) stated, “In the sense that people are part of the system and are continually changing it, operations management is much more like the social sciences than the physical sciences” (p. 18).

Leschke (1998) argued for teaching OM from a process perspective. In a more general sense, Hammer (1996) pointed out the implications of process-centered organizations. More-recent references on business process management include Hammer and Stanton (1999) and Becker et al. (2003). There are OM textbooks that use a process focus (e.g., Finch and Luebbe 1995 and Melnyk and Denzler 1996). In addition, here are definitions from two other, well-known books.

The term operations management refers to the direction and control of the processes that transform inputs into products and services. Broadly interpreted, operations management underlies all functional areas, because processes are found in all business activities. Narrowly interpreted, operations refers to a particular department (or more likely several departments). The operations area manages the processes that produce the primary services or products for the external customers but is closely involved with the other areas of a firm (Krajewski and Ritzman 2001, p. 6).

Operations management is the set of activities for creating, implementing, and improving processes that transform resource inputs into output goods and services. OM activities may be appropriately applied anywhere in organizations and may target any level of effort from a single step in a job sequence to the entirety of company activity (Knod, Jr. and Schonberger 2001, p. 9).

Thus, what I am advocating in this paper is not really new. However, in my opinion many academics have only paid lip service to the process or system perspective, especially from a research perspective. To the best of my knowledge, no one similar to me, with many years of teaching and research as a member of operations research (OR), MS, or OM areas, has taken as strong a stance on the issue, namely one of de-emphasizing the functional orientation of OM and

instead adopting the broader process management perspective in our research and teaching. I believe that the process management framework substantially increases the opportunities for researchers, students, and practicing managers to make major impacts on the performance of all types of organizations.

#### 4. Process Change (Improvement and Redesign) vs. Optimization Under Existing Conditions or Questionable Assumptions

Let me begin this section with Table 1, adapted from Cooke and Rohleder (2003). The MSOM Society is part of INFORMS. Over the years, one of the major emphases of INFORMS has been mathematical rigor in modeling and associated optimization. Moreover, a substantial portion of OM faculty had their doctoral training in operations research, management science, or industrial engineering, all of which stress the aforementioned rigor and optimization. Certainly there are frequent occasions where such modeling and optimization provide very useful insights that influence the actual choices to ultimately be made in practice. However, in my experience it is far better to develop a reasonable solution to a *real* problem of interest to management than to optimize a mathematical abstraction that is a poor representation of the real problem. (For more on this point see Silver 2004.) This is closely

**Table 1** Reductionist—Holistic Dimension Applied to OM

The <i>reductionistic</i> approach to OM is concerned with:	The <i>holistic</i> approach to OM is concerned with:
Reducing complex phenomena or structures to simpler ones for the purpose of analysis. Understanding of the whole comes from analysis of the parts.	Considering complex phenomena or structures in their entirety for the purpose of analysis. Understanding the parts comes from analysis of the whole.
Modeling and simulation of well-defined problems.	Understanding and managing complex operational systems.
Optimization based on given parameters.	Improving system performance in the face of uncertainty and continual change.
Building theories from mathematical models and laboratory experiments.	Building theories from cases, surveys, action research, and field experiments.
Quantitative models for decision making.	Qualitative models for decision making.

related to the so-called Type III error, namely working on the wrong problem. A related theme of my consulting, research, and publications (e.g., Silver et al. 1998) has been to “change the givens” rather than just to optimize subject to the usual constraints and assumptions. Also, the major benefits of a consulting study often turn out to be an improved understanding of the processes and improved data collection and reporting mechanisms, as opposed to the use of an optimization model. In particular, so-called streamlining (the rapid identification and elimination of as many non-value-adding activities as possible) may not even require significant numerical data, let alone construction of a mathematical model, yet usually can lead to major, relatively easily obtained benefits in most business processes (see Zangwill 1995). One might argue that most consulting does not constitute research. However, in the R&D spectrum consulting is often the critical link in developing (or engineering) the operational version of concepts originating from more basic research. In addition, ideas for further research are frequently generated by academics through participation in consulting assignments.

As discussed above, taking an overall process viewpoint leads naturally to improvement or redesign options, as opposed to the formulation of a mathematical model of a decision problem, where the latter tends to evolve to optimization efforts. Furthermore, as pointed out by Rohleder and Silver (1997), who presented a framework for business process improvement, a key element in improving (and redesigning) processes is the ability to creatively solve problems, as well as to identify and take advantage of opportunities for improvement. Creative problem solving (see, for example, Couger 1995, Evans 1991) requires divergent, not just convergent, thinking. This has been a recurring theme in the columns of Vijay Mehrotra (2003b), Doug Samuelson (2002), and Gene Woolsey (2003b).

## 5. Summary

In summary, I have argued that there are far wider and more relevant opportunities for research and consulting and education if the membership of MSOM (and other OM professionals) broaden their viewpoint to a process management perspective, rather than retaining the traditional, functional orientation, and

at the same time if the membership puts more focus on improvement instead of optimization. I know from personal experience that it can be gratifying to develop and optimize an abstract model of a decision problem. Besides this mindset, there are other stumbling blocks for my proposal. In particular, dealing with broader issues in research, rather than a more narrowly defined optimization problem, will lead in most cases to a longer time until publication. The granting of tenure in most major educational institutions requires significant publication output within a fairly short time period. Thus, there is a higher risk associated with what I have proposed. However, at the very least, I would hope that tenured faculty would be responsive to adopting the process management perspective. Also, there would be needed changes in most doctoral programs related to OM (e.g., inclusion of the basics of process design and improvement, more emphasis on approximate solutions to realistic models of real world problems, and so on).

I hope that these constraints can be overcome, because I believe that there are enormous potential benefits to our students, organizations, clients, and society as a whole of using a process management focus to deal with the many types of challenging issues, some of which are listed in §§3.1 and 3.2.

As mentioned earlier, the major developments in OM and process management have been largely driven by practitioners. One could argue that academics should watch what practitioners are doing because they are likely to be significantly ahead of academics, i.e., practitioners provide direction for relevant problems to be researched. I agree that most research should be grounded in problems of interest to practitioners, but surely at least some researchers should be trying to influence or even lead practice.

Finally, some might say that it's just a matter of semantics, but the idea of a process can be more easily understood than operations by our audiences. Have you ever experienced the following conversation? “In what field are you working?” “Operations management.” “Oh, you work in a hospital!” I have!

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## References

- Ackoff, R. L. 1974. *Redesigning the Future: A Systems Approach to Societal Problems*. Wiley, New York.
- Atkins, D., M. A. Begen, B. Kluczny, A. Parkinson, M. L. Puterman. 2003. Right on queue: OR models improve passenger flows and customer service at Vancouver International Airport. *OR/MS Today* 30(2) 26–29.
- Becker, J., M. Kugeler, M. Roseman, eds. 2003. *Process Management: A Guide for the Design of Business Processes*. Springer-Verlag, Berlin, Germany.
- Beer, S. 1960. *Cybernetics and Management*. Wiley, New York.
- Chase, R. B., N. J. Aquilano, F. R. Jacobs. 2001. *Operations Management for Competitive Advantage*, 9th ed. McGraw-Hill Irwin, New York.
- Checkland, P. 1981. *Systems Thinking, Systems Practice*. Wiley, Chichester, U.K.
- Churchman, C. W. 1968. *The Systems Approach*. Dell, New York.
- Cooke, D. L., T. R. Rohleder. 2003. Toward an integrated research philosophy of operations management. Working paper, Haskayne School of Business, University of Calgary, Canada.
- Couger, J. D. 1995. *Creative Problem Solving and Opportunity Finding*. Boyd and Fraser, Danvers, MA.
- Daellenbach, H. G. 1994. *Systems and Decision Making*. Wiley, Chichester, U.K.
- Earl, M., B. Khan. 1994. How new is business process redesign? *Eur. Management J.* 12(1) 20–30.
- Evans, J. R. 1991. *Creative Thinking in the Decision and Management Sciences*. Southwestern, Cincinnati, OH.
- Finch, B. J., R. L. Luebbe. 1995. *Operations Management: Competing in a Changing Environment*. Dryden Press, Orlando, FL.
- Grossman, T. A. 2003. Private communication.
- Guide, Jr., V. D. R., L. N. Van Wassenhove, eds. 2003. Special section: Closed-loop supply chains: Practice and potential. *Interfaces* 33(6) 1–71.
- Hammer, M. 1996. *Beyond Reengineering: How the Process-Centered Organization Is Changing Our Work and Our Lives*. HarperBusiness, New York.
- Hammer, M., S. Stanton. 1999. How process enterprises really work. *Harvard Bus. Rev.* 77(6) 108–118.
- Knod, Jr., E. M., R. J. Schonberger. 2001. *Operations Management: Meeting Customers' Demands*. McGraw-Hill-Irwin, Boston, MA.
- Kopczak, L. R., M. E. Johnson. 2003. The supply-chain management effect. *Sloan Management Rev.* 44 27–34.
- Krajewski, L. J., L. P. Ritzman. 2001. *Operations Management: Strategy and Analysis*, 6th ed. Prentice Hall, Upper Saddle River, NJ.
- Leschke, J. 1998. A new paradigm for teaching introductory operations management. *Production Oper. Management* 7 146–159.
- Mehrotra, V. 2003a. Every CEO's worst nightmare. *OR/MS Today* 30(8) 12.
- Mehrotra, V. 2003b. The power of teamwork. *OR/MS Today* 30(1) 14.
- Melão, N., M. Pidd. 2000. A conceptual framework for understanding business processes and business process modelling. *Inform. Systems J.* 10 105–129.
- Melnyk, S. A., D. R. Denzler. 1996. *Operations Management: A Value-Driven Approach*. Irwin, Chicago, IL.
- Meredith, J. R., L. Krajewski, A. V. Hill, R. Handfield. 2002. Introduction: 20th Anniversary of JOM: An editorial retrospective and prospective. *J. Oper. Management* 20 1–18.
- Nahmias, S. 1997. *Production and Operations Analysis*, 3rd ed. Irwin, Chicago, IL.
- Rohleder, T. R., E. A. Silver. 1997. A tutorial on business process improvement. *J. Oper. Management* 15 139–154.
- Samuelson, D. A. 2002. The harbor pilot's parable. *OR/MS Today* 29(5) 20.
- Silver, E. A. 2004. An overview of heuristic solution procedures. *J. Oper. Res. Society* 55 936–956.
- Silver, E. A., D. F. Pyke, R. Peterson. 1998. *Inventory Management and Production Planning and Scheduling*, 3rd ed. Wiley, New York.
- Starr, M. K. 1996. *Operations Management: A Systems Approach*. Boyd & Fraser, Danvers, MA.
- Sterman, J. D. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin-McGraw-Hill, New York.
- Williamson, O. E., S. Masten, eds. 1995. *Transaction Cost Economics*, Vols. I & II. Edgar Elgar Ltd., Brookfield, VT.
- Woolsey, G. 2003a. An immodest proposal to brand the profession. *OR/MS Today* 30(1) 59–61.
- Woolsey, G. 2003b. The fifth column: On wet consultants, dry consultants, and humanware simulation. *Interfaces* 33(3) 70–71.
- Zangwill, W. I. 1995. Fast quality for fast results. H. V. Roberts, ed. *Academic Initiatives in Total Quality for Higher Education*. Quality Press, Milwaukee, WI, 471–481.