Breaking the Boundaries: The Fractal Organization

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NONTRADITIONAL RESEARCH

Breaking the Boundaries

The Fractal Organization

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During the past 25 years, the problems of organizational change and complexity have loomed large in management thought and practice. If Thomas Kuhn's (1970) book *The Structure of Scientific Revolutions* marked the end of gradualist theories about the accumulation of scientific knowledge, so did Drucker's writings (Drucker 1968, 1980) presage the end of managerial paradigms based on the relatively smooth economic growth and social stability (at least in the Western World) that had characterized the post-World War II period. In the past few years, management writings, sensitive to both theoretical and empirical realities, have become increasingly concerned with organizational change as opposed to stability (Vaill, 1989), processes rather than structures (Mackenzie, 1989), and the evolution of organizations over time rather than their cross-sectional classification into categories (Kimberly, Miles, & Associates, 1980).

The growing requirement to study dynamic phenomena requires new metaphors and new theories. For example, Doz and Prahalad (1991) have argued that a new paradigm is needed to understand and manage the complexity found in diversified multinational firms (DMNCs). Although they have limited their comments to DMNCs, we would contend that their concerns with state-of-the-art literature apply equally well to all complex organizations. They suggest, for example, that much of the empirical research on DMNCs, such as that based on contingency theory, ignores process elements in organizational change and restructuring. Doz and Prahalad suggest that much of the literature assumes either implicitly or explicitly a "functionalist top management-driven perspective, in which adaptation is primarily organization design and development" (p. 151). The unanswered question in this literature is "how top management perceives the need for adjusting the 'fit' " (p. 151).

In this article, we intend to explore, in a preliminary way, the use of some elements of dynamical systems theory (Abraham & Shaw, 1987), especially nonlinear dynamics as lenses through which to view organizational complexity and change. Nonlinear dynamics and a subset, nonequilibrium (chaos) dynamics are proving to be valuable for scientists in many fields in understanding complexity (Loye & Eisler, 1987). Their application to the social sciences is growing fast (Drazin & Sandelands, 1992; Gersick, 1991; Leifer, 1989; Smith & Gemmill, 1991; Stacey, 1991).

Some management researchers have been drawn to chaos theory as a particularly useful lens to understand dynamic organizational processes and change (Goldstein, 1988; Kagono, Nonaka, Sakakibara, &

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Okumara, 1985; Nonaka, 1988a, 1998b; Zimmerman, 1991, 1992, 1993a, 1993b). Chaos highlights an organization's need to create (rather than process) information for self-renewal (Nonaka, 1988a), to manage changeability instead of managing change (Zimmerman, 1992). It also emphasizes the need for uncertainty for organizational evolution (Zimmerman, 1993a) and the role of middle management in innovation (Nonaka, 1988b).

We intend to demonstrate that the use of dynamical concepts derived from the study of physical systems can be used explicitly as metaphors and analogies to reveal valuable insights into the functioning of business organizations. To support our use of concepts in this way, a brief review of the role of metaphor in the study of organizations is in order.

THE ROLE OF METAPHOR IN THE STUDY OF ORGANIZATIONS

The role of metaphor in science and, indeed, in thought itself has always been a contentious issue. Ortony (1979) attributes to Aristotle the origin of what he calls the "nonconstructivist" view of metaphors as being "nice" rather than "necessary." Given this view of reality, metaphors are seen as "fuzzy and vague, inessential frills, appropriate for the purposes of the politician and the poet, but not for those of the scientist, who is attempting to furnish an objective description of physical reality" (p. 4). This faith in the efficacy of literal language was to reach a peak in the heyday of logical positivism. In recent times, however, there has been a resurgence in the constructivist view. The debate has moved from *whether* metaphors are necessary to *in what way* they are necessary (Pinder & Bourgeois, 1982; Tsoukas, 1991) and to what extent their use can or should be controlled (Bourgeois & Pinder, 1983; Morgan, 1983). Metaphors are seen as essential to creativity (Arieti, 1976; Koestler, 1964; Rothenberg, 1979), innovation (Schon, 1963, 1979), scientific explanation (Hesse, 1966), the creation of meaning (Lakoff & Johnson, 1980; Pepper, 1942; Wheelwright 1962), and the development of personal identity (M. Bateson, 1972).

More direct applications to the study of organizations have outlined particular roles for metaphors. It has been argued that metaphors in their different forms shaped scientific writing and the gathering of quantitative data in social science (Manning 1979). Morgan (1980) suggests that metaphors are the foundation of schools of thought or "communities of theorists subscribing to relatively coherent perspectives" (p. 607) and that they play a mediating role between the Kuhnian paradigms and the puzzle-solving activities of normal science. More recently, Tsoukas (1991) following Beer (1984), has proposed a transformation process whereby metaphorical insights into the flow of experience are transformed into literal language for explanatory and predictive purposes.

THE PLAN OF THE ARTICLE

In this article, we will be viewing organizations as having the capacity to behave as dissipative systems (Nicolis & Prigogine, 1977) capable of self-organization (Jantsch, 1980) and generating fractal structures (Mandelbrot, 1983). We will refer to this perspective as a *fractal framework*. We will be looking at three interrelated aspects of the fractal framework that we believe are of particular relevance to human systems. These interrelated aspects are (a) fluctuations or tensions, (b) self-similarity or redundancy, and (c) boundaries. The article itself is divided into five sections. After this introduction we discuss nonlinear dynamics to give the reader the necessary background to understand the unique features of the approach. The third part of the article reviews the evolution of a large steel distribution business over a period of 30 years, paying special attention to two periods of rapid change. In the fourth section we interpret the complexity of this organization using the fractal perspective. The article concludes with a summary of implications for practice and theory and suggestions for further research.

NONLINEAR DYNAMICS

Dissipative Structures

Nonlinear dynamics and chaos theory are still in their early stages of development, but they are fast growing to the status of science (Gleick, 1987), a paradigm (Jantsch, 1980), or even a "metaparadigm" for science (Abraham, 1991). Current perspectives are the culmination of a series of attempts by scientists to grapple with systems exhibiting progressively more complex dynamics—static equilibrium, cyclical or dynamic equilibrium, and chaos. The discovery in the 1960s and 1970s of this third class of dynamical patterns or chaos in a number of apparently unrelated

fields precipitated the extraordinary interest that the field has now attracted (Gleick, 1987).

One particularly fruitful field for the generation of understanding about chaos theory has been thermodynamics, where it was developed to deal with a class of systems that have an internal friction known as *dissipative* structures. The term was coined (Nicolis & Prigogine, 1977) for two reasons. The first objective was to distinguish such far-from-equilibrium systems from the energy-conserving, equilibrium (or near-equilibrium) structures that had been the traditional objects of study of classical thermodynamics. The second reason for the choice was to capture the paradoxical nature of the systems; they consume or dissipate energy while preserving a structure.

Thus, in chaos theory, nonequilibrium or fluctuations are seen as a source of order: "order and organization can actually arise 'spontaneously' out of disorder and chaos through a process of self-organization" (Prigogine & Stengers, 1984, p. xv). This is in complete contrast to the conclusions of classical thermodynamics, where the consumption of energy by a system is seen as producing entropy or disorder.

Self-Organization

Self-organization has been an important subject of study in cybernetics and general systems theory (Andrew, 1989), where this property has been described by systems theorists as *autopoiesis* (Maturana & Varela, 1972). These systems create themselves: "An organization may remain constant by being static, by maintaining its components constant, or by maintaining constant certain relations between components otherwise in continuous flow or change. Autopoietic machines are organizations of the latter kind" (p. 81). Thus self-organizing systems exhibit both *homeostatis* and *homeorhesis* (Sahal, 1979). The concept of homeostasis is well-known, referring as it does to the ability of a system to return to a stable state after being disturbed. But, as Sahal (1976) points out, homeostasis is a special case of homeorhesis. Coined by Waddington (1968), homeorhesis refers to the ability of a system "to seek out new developmental pathways through successive instabilities. It appears that this is generally accompanied by an increase in disorder" (Sahal, 1979, p. 130). Jantsch (1980) expresses a similar idea in the case of cognitive systems when he writes that self-organization leads to "a new information theory which is based on the complementarity of novelty and confirmation in pragmatic (i.e., effective) information" (p. 11). These are the cognitive counterparts of homeorhesis and homeostasis, with novelty representing the generation of new patterns and confirmation representing the repetition or replication of old ones.

Fractal Structures

The term *fractal* was coined by Benoit Mandelbrot (1983) to describe mathematical phenomena he discovered that did not seem to fit traditional Euclidean concepts of forms. Mandelbrot's interest was in the irregularity of shapes and forms that exist in the natural world. Clouds, mountains, coastlines, ferns, and broccoli did not exhibit Euclidean shapes and yet had clearly recognizable patterns. Mandelbrot found that the wrinkled, unpredictable boundaries of fractals were the outcome of the dynamic resolution of tensions between forces and energy gradients that existed over a wide scale. These forces and gradients constituted irreconcilable competing "basins" of attraction on many levels, and fractals were formed as the result of these dynamics.

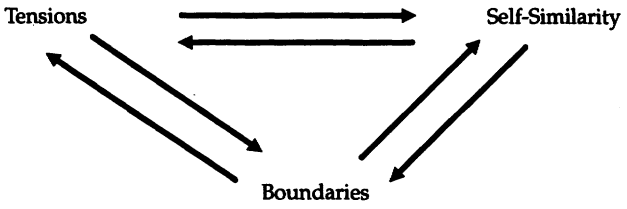
Besides exhibiting complexity at many levels, fractal shapes tend to be scale invariant, which implies that their irregularity is similar across many scales. Thus fractals exhibit self-similarity (Mandelbrot, 1983). The concept of micro-macro complexity is another way of understanding the scaling invariance of fractals. As one "zooms" in for a closer view of either a computer-generated fractal or a natural fractal, such as a coastline, the irregularity or complexity of the pattern is not decreased. As Mandelbrot says, "The degree of irregularity and/or fragmentation is identical at all scales" (p. 1).

Fractal structures then, can be thought of as the past tense or evidence of self-organizing systems. Fractals represent the discernible outcomes, or histories, that reveal the self-organizing propensities of dissipative structures. The intimate connection between these concepts allows one to use the notions of dissipative structure/self-organizing system/fractal structure almost interchangeably.

Characteristics of Fractals

Three attributes of fractals are of particular interest to us for this article: (a) the role of fluctuations and the accompanying tensions in their formation, (b) their holographic nature or self-similarity, and (c) the nature of their boundaries. As the diagram below suggests,

each of these elements interacts. This section will briefly outline these three characteristics of fractals before we relate the concepts to organizations.



Fluctuations and Tensions

Any deviation of a system from the second law of thermodynamics implies that it is under tension or stress of some kind. The second law of thermodynamics states that the entropy (unusable energy or degree of disorderliness) of a closed system increases with time. In effect, the system becomes increasingly disordered because it is losing usable energy. Thus nonequilibrium conditions can be sustained only for as long as there is an input of energy into the system.

Many concepts (attractors, bifurcations, energy gradients, fluctuations, forces, and oscillations) used in the discussion of dissipative structures suggest that tensions are an attribute of far-from-equilibrium systems. Prigogine and Stengers (1984) argue that "all systems contain subsystems, which are continually fluctuating" (p. xv). Drawing an analogy to the mutation-selection model in biological evolution, fluctuations can be thought of as the physical counterpart to mutations, whereas selection is analogous to a search for stability (Nicolis, 1989, p. 334). These concepts imply that a sense of order can emerge in far-from-equilibrium conditions—as Prigogine and Stengers (1984) argue "order out of chaos." Balanced between chaos and order, a dissipative structures epitomizes the tensions that are found in all living structures.

Thus fractal structures are created in part by constant fluctuations, and this enhances their capacity to survive. Holling (1987) has illustrated the ways in which fluctuations in various natural ecosystems actually build resiliency into these systems. For example, the shrub community known in the United States as chaparral relies on fire for its propagation and renewal. The flammability of plants that are 15 years and older increases significantly as they age (Biswell, 1974). In effect, the chaparral creates its own vulnerability to fire every few years. Fire destroys decadent growth and clears out accumulated litter, making room for new growth. Fires in forests perform a similar function. The short run instability created by the fires introduces variety into the forest that is essential for its long-run resiliency.

Conversely, human interventions to damp out these fluctuations or protect the systems from stress have often had the effect of rendering the systems fragile and prone to catastrophic failure. For example, forest fire suppression activities in national parks reduce the probability of occurrence of fires of any size but raise the risk of large, catastrophic fires. (Despite the abandonment of this policy in the United States 20 years ago by the National Parks Service, unusually dry weather conditions and the legacy of the old policy contributed to the huge fires in Yellowstone National Park in 1988 [Jeffery, 1989].)

The Self-Similarity of Fractals

"When each piece of a shape is geometrically similar to the whole, both the shape and the cascade that generate it are called self-similar" (Mandelbrot, 1983, p. 34). In other words, the part reflects the structure of the whole.

Many natural structures, ranging from ferns and broccoli to human proteins, exhibit self-similarity. For example, if one breaks off a piece of broccoli from the head of the vegetable, it retains the basic shape of the original. This fragmentation process can be repeated several times with the same self-similar result. Euclidean geometric shapes do not share this characteristic. If one magnifies a small portion of a triangle, for example, it no longer resembles a triangle.

Self-similarity provides a sense of order for seemingly irregular structures. This allows them to maintain their essence—the relationships that constitute their identity—across a wide range of scales. Using systems theoretic and cybernetic principles, Sahal (1976) concludes that "conditions of self-regulation are conditions of self-similarity . . . a self-regulatory system . . . is best understood as a system capable of preserving self-similarity of a systemic nature" (p. 306). He suggests that in homeorhetic regulation the best regulator of the system is a model of the system itself.

An important systems concept closely related to self-similarity is that of redundancy. In communications theory, redundancy implies repetition or lack of independence between successive events (Sahal, 1979). G. Bateson (1972) regards redundancy as synonymous with pattern or meaning: "In sum, 'redundancy' and 'meaning' become synonymous whenever both words are applied to the same universe of discourse . . . this way of thinking about communi-

cation groups all methods of coding under the rubric part-for-whole" (p. 414). Self-similarity that is essentially part-for-whole coding is generated by rules that are applied recursively across many scales.

Fractal Boundaries

Fractal boundaries are wrinkled and complex. Because this complexity exists on many scales, the length of a fractal boundary is not independent of the yardstick used to measure it.

This paradoxical aspect of a fractal boundary can be demonstrated by considering the geographic coastline of a land mass. Depending on the length of the yardstick being used by the measurer, it can be shown that, as the unit of measure is reduced, the length of the coastline will increase without limit (Mandelbrot, 1983). This result runs totally counter to the commonplace belief that, as the unit of measure shrinks, one ought get a more accurate measure of the "correct" length of the coastline.

We believe that this aspect of a fractal boundary applies to cognitive boundaries as well as to physical boundaries. For example, Richardson (1961, cited in Mandelbrot, 1983) found that, when a small and a large country share a common border, the smaller country will tend to come up with a longer border measurement by virtue of having used a shorter unit of measure. The Portuguese, for example, measure the length of their common border with Spain at 1,214 kilometers, whereas the Spanish measure it to be only 987 kilometers. This difference is consistent with the Portuguese unit of measure being half the size of that used by the Spaniards. There is at least a hint here that small organizations, by using smaller yardsticks, can create boundaries longer than those created by large organizations if the latter use a large yardstick.

Another feature of fractal boundaries is their permeability. For example, at a distance, clouds often seem to have a distinct boundary; a place where the cloud ends and the cloudless sky begin. Yet, as one moves closer to the cloud, the boundary seems to become increasingly blurry. At very close range, it is impossible to tell exactly where the cloud begins and ends, to separate the structure from its environment. Thus the apparent permeability of the boundary depends on the position of the observer. A cloud is permeable over a wide range of scales—opportunities for exchange with the environment exist at many levels.

McWhinney (1990) points out that theoretically, a fractal, being created of lines that have no width, can never fully occupy (define) the space in which it grows. He finds this concept useful in understanding the changes currently taking place in politics, society, and organizations in general, as previously impermeable boundaries fragment. There will always be some points in the space through which no line has passed. The fractal boundary is infinitely permeable, at least in theory.

Fractals and Firms

If fractals are outcomes of iterative self-organizing processes—resolutions of tensions in space and time—then social organizations that have the capacity to behave as dissipative structures (Prigogine, 1980) characterized by nonlinear processes (Stacey, 1991) should also exhibit fractallike qualities. One might expect these to occur in all dimensions: behavioral fractals; conceptual fractals; recurrent patterns of relationships, values, symbols, and gestalts; and repetitive structural configurations. The concept of fractal organizations and the aspects of them that we have identified have important implications for how both managers and researchers look at organizations.

Organizations in Tension

The creative role of conflict, dilemmas, and tensions in organizations has been noted by a number of observers (Hampden-Turner, 1990; Kagano et al., 1985; Pascale, 1990; Peters & Waterman, 1982). Typically businesses deal with "wicked" problems (Rittel & Webber, 1973) that are characterized by tensions between contradictory physical, temporal, and cognitive elements. Often the creative act appears as a reduction in the tension through some form of resolution in which the apparently contradictory opposites are transcended and reconciled (Arieti, 1976; Koestler, 1964; McKim, 1980; Rothenberg, 1979).

An organization that achieves such a reconciliation may appear to be *relatively* stable until a new challenge to the status quo arrives or another dilemma arises. Each new challenge or fluctuation is the creation of a tension that, if the organization is far from equilibrium, will create a bifurcation, a "decision point," that allows the organization to branch and grow into a new phase space. This is a process of fractalization.

Self-Similarity in Organizations

Two kinds of self-similarity or redundancy have been identified in human organizations. Emery (1967), in distinguishing between conventional bureaucratic organizations and organizations capable of innova-

tion, separates redundancy of parts and redundancy of functions. Redundancy of parts is the mechanistic division of labor into atomistic, easily replaced elements. Redundancy of functions consists of the expansion of the skill repertoires of each component system (by cross-training individuals, for example), even though these skills cannot be used simultaneously. Clearly, these two concepts of redundancy are mutually exclusive or, at least, define the opposing extremes of a continuum.

Redundancy of parts is closely connected with what Ulanowicz (1987) has called the degree of *articulation* of a system. When a system is highly articulated, there are few alternative pathways within it: redundancy of function is low and that of parts is correspondingly high. Redundance of parts would seem to improve a system's capacity for homeostasis, but at the expense of its resilience, its capacity for homeorhesis. As Ulanowicz (1987) points out, "Decreasing [redundancy of function] results in a more streamlined and efficient network topology . . . however, it can also make for a more fragile structure" (p. 177). Holling's (1987) work on ecosystems, mentioned earlier, clearly supplies evidence in support of this contention. Holling associates redundancy of parts with the consolidation phase of an ecosystem's cycle where the system exhibits what biologists (MacArthur & Wilson, 1967) call a "K-strategy" (low birth rate, high survival rate, territorial protection). In contrast, redundancy of function is associated with the exploitive phase of a system's development, the so-called r-strategy (high birth rate, low survival rate, nonterritorial).

The implication of this for organizations is that a high redundancy of parts is indicative that the system is near equilibrium. Conversely, redundancy of function is required to take a system to far-from-equilibrium conditions. Morgan (1986) reached a similar conclusion using the metaphor of the holographic organization to describe their self-organizing properties. From this perspective, the keys to self-organization are to create a high degree of connection and redundancy of function within the organization (Morgan, 1986, p. 98).

Boundaries in Organizations

The notion of a fractal boundary has particularly intriguing implications for the process of organizing. For example, it has often been assumed that an organization can expand its boundaries only by increasing its size, by adding new products or entering new geographic regions. The idea of a fractal boundary suggests that a firm can also increase its boundaries prospectively by shrinking the cognitive yardstick, that is, by paying attention to smaller and smaller detail and developing a finer grained pattern.

A familiar example of what we mean by a cognitive yardstick is from the language of the Inuit in Northern Canada, who are said to have a great number of words to describe snow in its many aspects.[1] Their cognitive yardstick, when used to describe snow, is clearly "shorter" than that used by people who do not live under the same conditions, and *is hence capable of describing snow in much finer detail.* This, in turn, allows the Inuit to take action with extreme sensitivity to their situation. Similarly, many other North Americans can make fine distinctions among types of automobiles (between Oldsmobiles and Buicks, for example) that might not be meaningful to the Inuit.

This capacity to see new detail also implies that individuals and, via them, organizations can reframe an existing pattern retrospectively by developing new interpretations of past events. Nonaka (1988b) suggests that such processes take place in the cognitive activities of some Japanese companies and that information is "created" within the organizations because of them. Reinterpreting past events serves to increase the ambiguity and tensions as reality is implicitly thought to be socially constructed. In this state, ambiguity, tension, and fluctuations work to create a self-organizing system with its own dynamic order (Takeuchi & Nonaka, 1986, p. 140).

Another way to create information throughout the organization is to open the external organizational boundary, to make the boundary permeable.[2] Some companies seem to have permeable boundaries, which, rather than protecting the technical core (Thompson, 1967), include customers and suppliers in their "internal" processes (Doz & Prahalad, 1991). This openness would expose parts of the organization to potentially destabilizing information, thus allowing innovation and change without the mediation of the institutional level of the organization (Thompson, 1967).

In the next two sections of the article, the changes in the structures and processes of one organization over three decades are described before using a fractal lens to interpret the findings.

THE EVOLUTION OF FEDMET, 1962 TO 1991

This is the story of the growth and development of a business that began as a small group of steel service

centers in the 1960s and became a large, successful steel distribution and supply business in the 1990s. The description of the evolution of the organization/group of organizations now known as Fedmet, Inc. follows an inductive and intensive method similar to that used by Mintzberg and Waters (1982). The data for the story were derived from multiple sources including archival data (minutes of meetings, memos, letters, annual reports, etc.), participant-observation,[3] and interviews. The description has been reviewed by managers of the organization as a member check (Lincoln & Guba, 1985).

The businesses that today are Fedmet, Inc. have their origins in the trading activities of several families of Scottish heritage, who emigrated to Canada in the 18th and 19th centuries and made their living by trading goods between the "old country" and their chosen land. Over the years, these trading activities developed into local distribution businesses, often dealing in iron, steel, and manufactured goods.

One such familiy, named Russel, had been in trading for over 100 years before one of its members founded a small steel distribution business in Montreal in 1936. By 1962, when the family business went public (and this history begins), the business consisted of five branches in Quebec and Ontario with sales of $14 million. (Note: All dollars are Canadian dollars.) The trading name of this business became Russelsteel.[4]

Steel service centers act as warehousers and distributors of steel and related metals (typically, aluminum, copper, brass, nickel, stainless steel, and other steel alloys). Usually, they buy metal in bulk from the primary producers and add value by making the product available at the time and in the place and form required by the customer, who is usually a manufacturer or fabricator of durable or semidurable goods. Russelsteel was typical of the so-called heavy carbon service centers, which sold mainly carbon steel products, such as plate, structural shapes, bars, pipes, sheet, and coil.

Economic Environment (1962-1991)

The consumption of steel in an industrial economy is highly sensitive to the rate of growth and the stage of industrialization reached by the economy as a whole. Economic conditions during the early part of the period under review were favorable to the steel distribution business. Apart from the cyclicality of the economy (which is evident throughout the period), increasing consumption of steel, growing service center share of shipments (their share doubled between 1962 and 1988), and rising prices all contributed to increased revenues and profits. As the long-run growth of the economy slackened in the second half of the period, however, conditions become less favorable. Steel consumption slowed, service center market share stabilized, and the rate of increase in steel prices lagged behind the consumer price index.

Performance (1962-1991)

Figures 1 and 2 summarize the financial performance of the company's steel distribution business from 1962 to 1991. They show sales and earnings before interest and taxes (EBIT) for the 30-year period.

Over the period, sales growth reflected expansion of the territories covered, the growth in market share of service centers and the significant increase in the prices of steel. EBIT (Figure 2) also shows a pattern of growth, but the cyclical periods of growth and decline are particularly pronounced. The sharp declines in 1982-1983 and 1990-1991 will be the twin foci of the cross-sectional analysis, as we zoom in on these apparent discontinuities.

Management, Structure, and Strategy (1962-1991)

This section falls naturally into two phases: (a) 1962 to 1979, when Russelsteel was partially owned (but completely controlled) by the Russel family, and (b) 1980 to 1991 when the steel distribution business was controlled by others. Figure 3 records the ownership of the business during this time. Figure 4 shows the evolution of the steel distribution business' organizational structure over the period.

Phase 1 (1962-1979)

In 1962, when the company went public, the structure was a simple one. The senior management team consisted of Guy and Archie Russel, who owned the majority of the stock between them. Together with two nonfamily operating managers, a controller, and a secretary/treasurer, they formed the management team. Their stated strategy was to be a dependable, profitable steel distributor.

Over the next 3 years, however, Archie Russel became preoccupied with growth and diversification outside the core business. The 1964 annual report announced a "programme of planned corporate growth." In 1965, as Guy Russel withdrew from day-

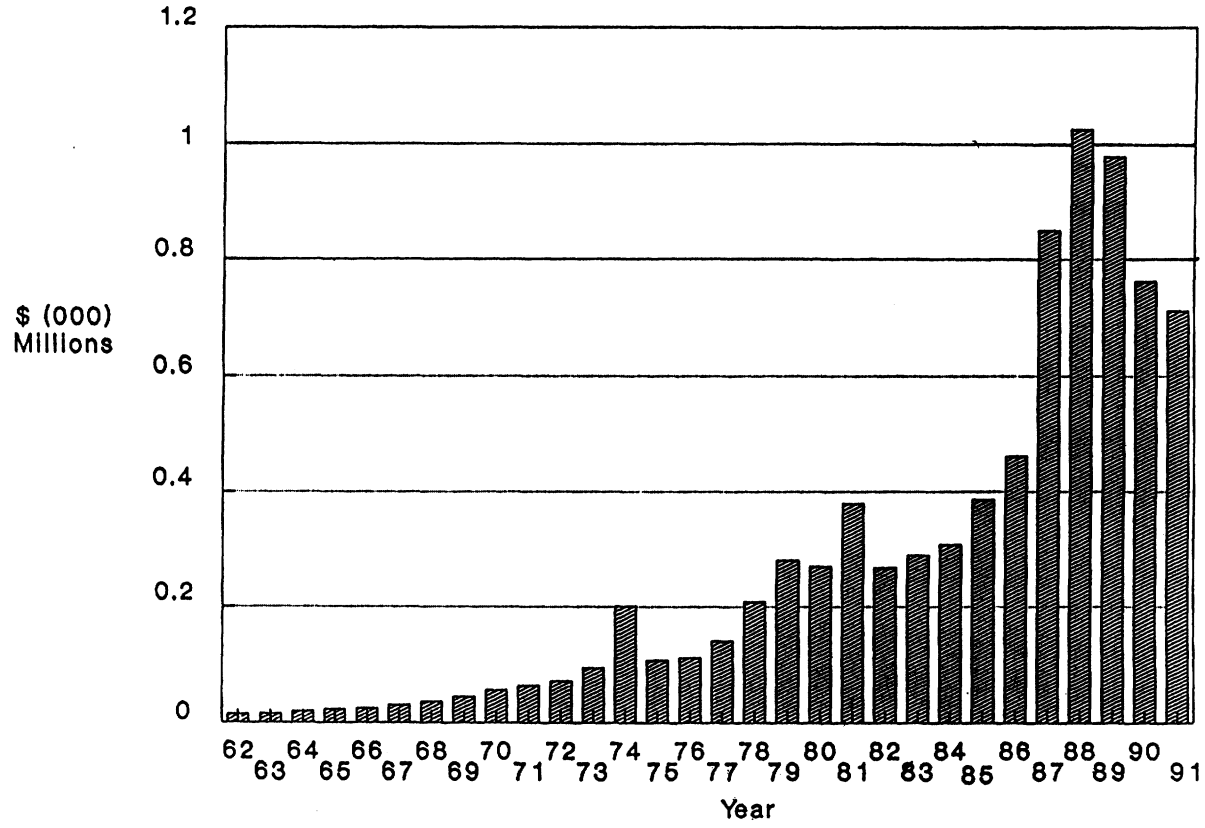


Figure 1: **Sales (1962-1991), Steel Distribution Business**
Source: Company annual reports.

to-day activities, Archie Russel augmented the management team with the addition of Peter Foster. Foster, an aeronautical engineer and Harvard Business School graduate, had spent 15 years with Proctor and Gamble before running a small conglomerate. He would be responsible for the diversification of Russelsteel into areas other than the distribution of steel.

As Russelsteel grew during the next few years, several reorganizations took place as the organization developed into a divisionalized bureaucracy. By 1975, a fully divisionalized organization had emerged, with the Metals Division (Russelsteel) itself being divisionalized and replicating the structure of the parent company. This divisionalized structure lasted until 1981, when it was dismantled during the turbulent years of the 1982-1983 recession.

Phase 2 (1980-1986)

Early in 1980, Russelsteel was acquired by and merged with a large steel fabricator. The business entity created by this merger soon got into financial trouble for a variety of internal and external reasons. Internally, the steel fabrication operations, as well as many of Russelsteel's purchases outside the steel distribution business, were both illiquid and unprofitable. In addition, the deal took the form of a leveraged buyout, which effectively replaced all of Russelsteel's common equity with floating rate debt. Externally, the inflationary economic boom of the late 1970s ended in a precipitous decline in 1982, characterized by soaring interest rates and plunging demand for the business' products.

Archie Russel retired in 1980 and the new owner took over as chairperson and chief executive officer. In 1981 Peter Foster resigned as president with Wayne Mang as successor. An accountant by training but with lengthy experience in the steel business, Mang had spent a good deal of his career working with troubled business organizations. As the full scope of the financial disaster became apparent, Mang formed a senior management team around him to deal with the survival crisis that the company now faced. During the next 3 years, a series of teams and task forces, composed of people from all over the organization, worked in an environment of crisis, selling or closing all the nonsteel distribution businesses and most of the manufacturing and fabrication operations.

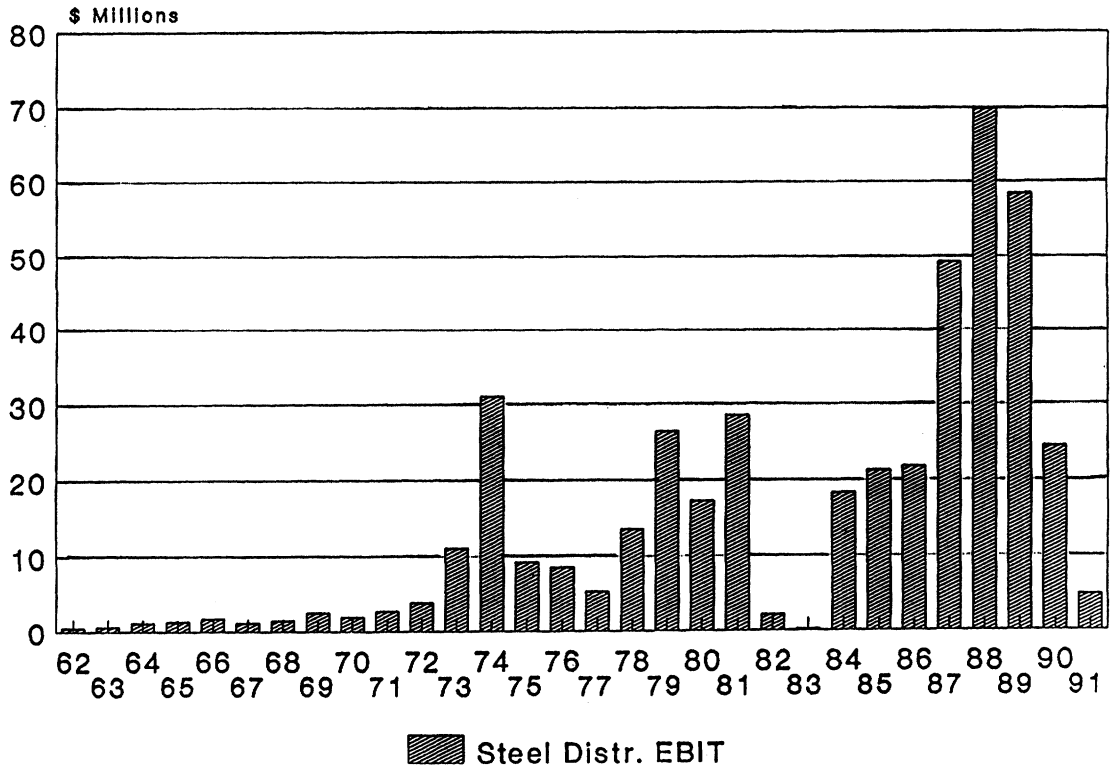


Figure 2: **Earnings Before Interest and Taxes (1962-1991), Steel Distribution Business**
Source: Company records.

The senior management team soon found that the company was facing complexities that the formal, divisionalized structure was unable to cope with. Previously benign stakeholder groups, such as bankers, shareholder, suppliers, customers, and employees, became vocal and threatening in their attitudes toward the company. Forced to deal with a multitude of conflicting demands simultaneously, the senior management group set up 19 task forces to deal directly with the most pressing issues. There was minimal hierarchy and significant heterogeneity of membership, as people from all levels within the old formal structure were selected on the basis of their ability to contribute. The integration of the work of these teams was accomplished by paying special attention to the need for a process facilitator and ensuring that each team had a person designated to play such a role.

Information that had previously been regarded as confidential was now widely shared with a number of audiences, both internally and externally. Suppliers, for example, who were concerned about their ability to collect their receivables, were given regular briefings in which extensive, detailed information about the company's financial situation and expectations was shared with them. They received periodic updates on the state of negotiations with bankers and shareholders. Extensive networks were established within the company to brief employees on fast-breaking events *before* they either heard or read about them in the media. All members of the top management team mentioned the role of communication during the restructuring period (Zimmerman, 1991). They spoke of the intensity of the communication within the organization and beyond.

Not only were bankers, suppliers, and customers kept informed of all company news, but they were also used as a source of information and learning. Alec Shkut, a key manager during the first period, commented on this aspect of the organizational processes:

> "Our interest payment weekly in 1981 was $1 million.... Communications with the banks were impeccable. Communications with the vendors were impeccable. We had to go to them and say we were technically bankrupt. We lost $100 million that year and none of it had to do with operations. All of it had to do with interest payments to service the debt. Only one mill cut us off . . . every one of them should have

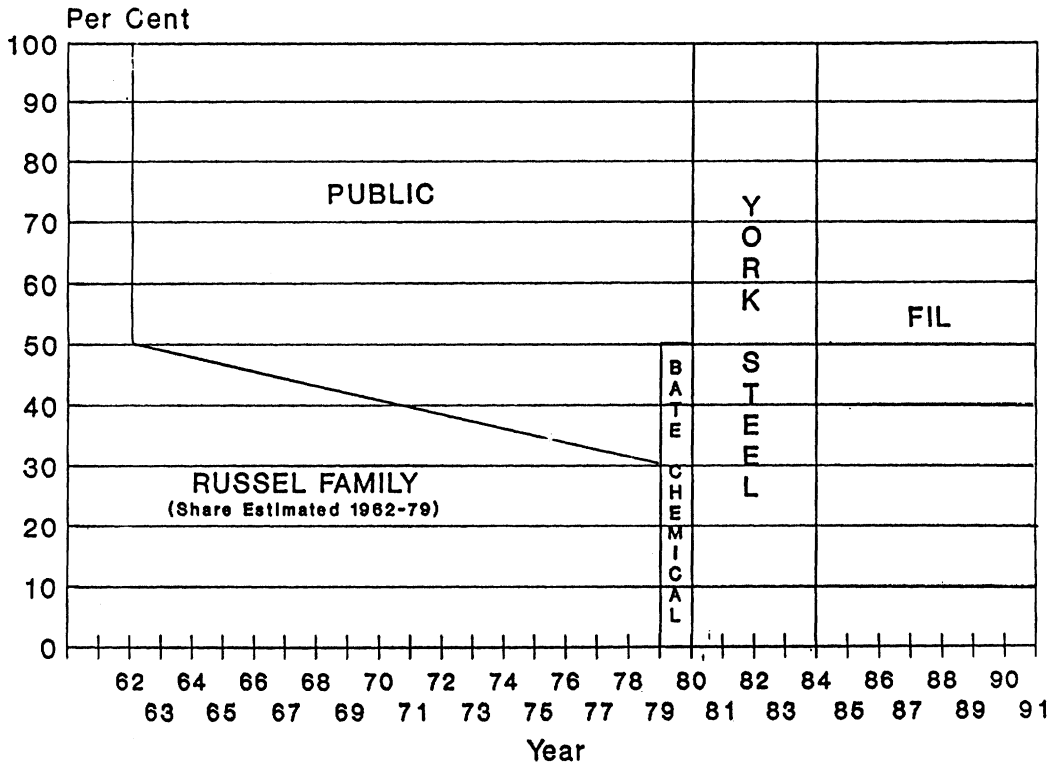


Figure 3: **Ownership of Steel Distribution Operations**
Source: Company annual reports and archives.

if they had looked beyond the relationship and the communications." (Zimmerman, 1991, p. 167)

After the inception of these new relationships and the delayering of the old bureaucracy, small teams formed and dissolved apparently spontaneously to deal with particular issues. People who had not been part of a discussion on a given topic would make unexpected contributions to the process at just the right time. The atmosphere of crisis, the intense communication, and the camaraderie led to a fierce commitment to the survival of the core business felt by all managers and many others.

At the end of 1983 the owner of Russelsteel, under pressure from his bankers, sold all the steel distribution operations to Federal Industries, Ltd. (FIL), a publicly owned conglomerate based in Winnipeg, Manitoba. Russelsteel became known internally as Fedmet, one of FIL's four industry groups.

With the purchase of the business by FIL and the steady improvement taking place in business conditions, the atmosphere of crisis, which had pervaded the company in 1982 and 1983, ended abruptly for the Russelsteel management team. Strategically, their position as managers was not dissimilar to that in Russelsteel in the early 1960s. They could concentrate on the steel distribution business, whereas financing and diversification became the preoccupations of the corporate head office (FIL).

Phase 3 (1987-1992)

With the recapitalization of the business and the economic recovery of the mid-1980s, growth via the acquisition of steel distribution and trading businesses resumed. Acquired operations were either brought into the division as coherent entities or grouped together to create logical divisions, each with their own management hierarchy. By 1988, a fully divisionalized bureaucracy had emerged.

The two major elements of the divisional structure were Russelsteel and Drummond McCall (DMC). The latter business, a major competitor of Russelsteel, with 10 branches and revenues over $200 million, had been acquired in late 1986. The net effect of this was to create twin divisions competing from east to west across Canada, a situation that prevailed during the cyclical economic boom from 1987 to 1989.

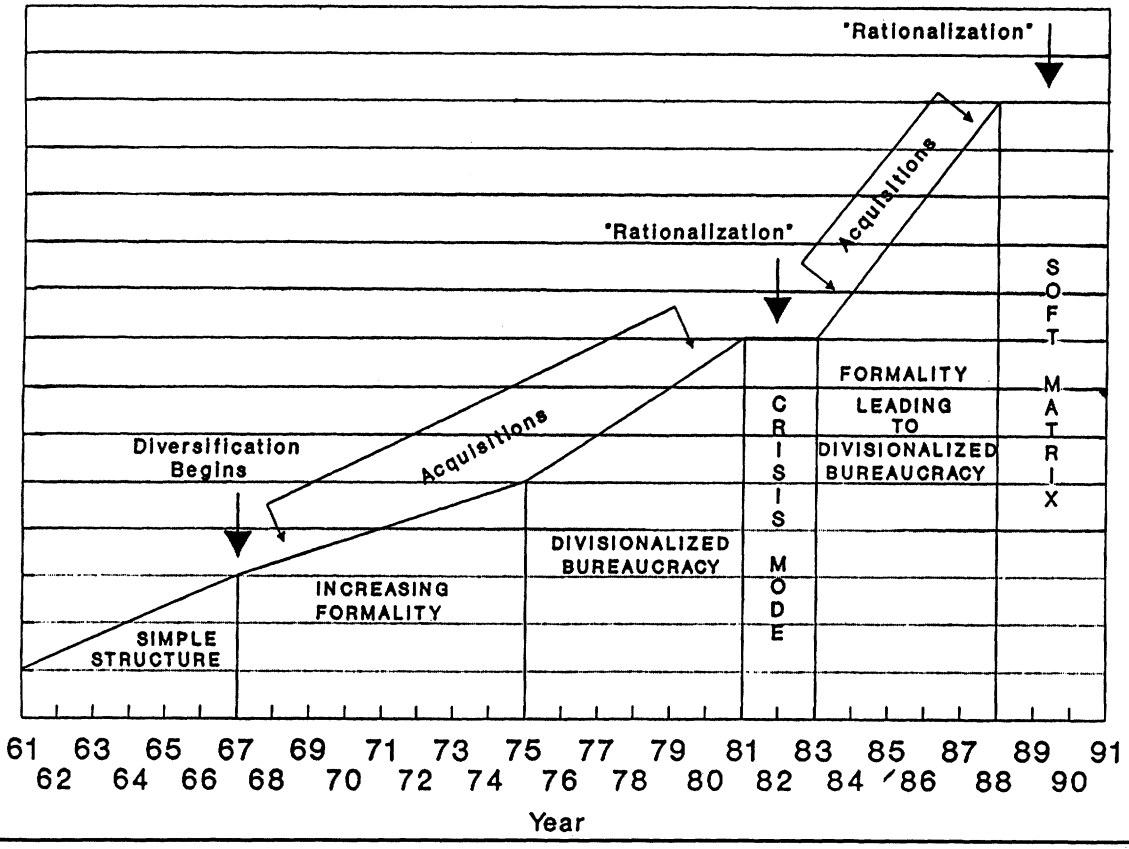


Figure 4: **Organizational Evolution**
Source: Company annual reports and archives.

As the economic upturn began to weaken during 1989, increasing dissatisfaction began to be expressed by Wayne Mang and members of the senior management team with the divisionalized structure. The camaraderie of the crisis years of 1982 and 1983 had long since faded, and communication with the divisional presidents had become increasingly formal and stilted. Bureaucracies had formed in both divisions, hampering communication and preventing divisional management from responding to the business cycle. The single-minded focus on financial returns by both FIL and Fedmet, while producing excellent financial returns, had damaging side effects on customer service and market share. In particular, it was suspected that specialist distributors carrying a narrow but deep range of products had taken share away from Fedmet.

In addition, as the recession grew deeper, cost considerations made it clear that the two divisions would have to be merged in some way. A further complication in the external environment was the concurrent negotiation between Canada and the United States on a free trade agreement (FTA). The primary implication of the FTA was that Canada had to throw its lot into the North American market. This meant that the geographical orientation of the steel distribution business would have to be "turned" 90°. The traditional east-west "political" orientation would in the future have to be reconciled with a north-south "economic" orientation.

The presence of these contradictions and the numerous issues raised by them immediately suggested to all those who had been through the 1982-1983 turnaround the need to recreate the organization structure that had worked so well then. One major difference was that, whereas the 1982-1983 team had formed spontaneously under crisis conditions, now it was being designed deliberately. A second major difference had to do with economic conditions. Whereas things gradually improved in the early 1980s, over the next 3 years the need for planned reorganization was underscored by a long slide in Canadian economic fortunes.

From the beginning, the reorganization, particularly the integration of the two divisions, created significant management challenges. For example, each division had its own data processing system, which was totally incompatible with the other. In addition, each system had significant organizational design prob-

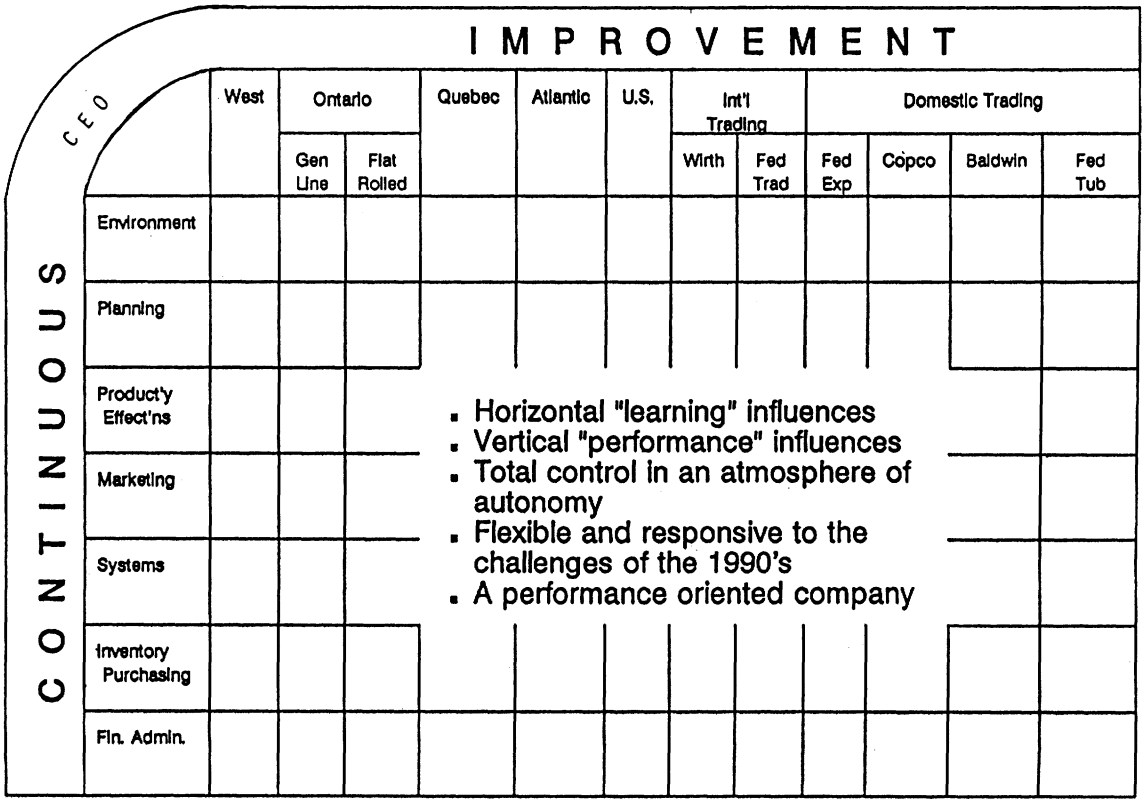


Figure 5: **Federal Metals Service Centre Division: A Continuous Improvement Organization**
Source: Company records.

lems that demanded early attention. Cross-functional task forces, composed of people from all over the organization were formed to address these and a multitude of other issues.

The natural clusters into which critical issues fell were seen as being orthogonal to the business' routine activities. They became known as "horizontal" or "learning" initiatives to distinguish them from "vertical" or "performance" issues. The structure created by the overlaying of the "soft" learning initiatives on the "hard" performance structure was called a *soft matrix*. The soft matrix was conceived by top management and then articulated throughout the organization.

The idea of a matrix organization is not new to the literature (Gailbraith, 1977) but Fedmet's management team articulated their concept as a soft matrix to distinguish it from the traditional hard matrix (Goggin, 1974). The vertical and horizontal dimensions were not dual lines of authority. Although the vertical lines represented the standard line of authority and responsibility for performance, the horizontal lines represented task forces or teams to address particular issues in the organization. The diagrams were sometimes shown as a woven mat with the horizontal learning initiatives lacing through the vertical performance requirements. Figure 5 shows the soft matrix at Fedmet at the senior level in 1991.

Once the task forces had been set up at the group office and initial discussions had begun, similar task forces dealing with subsets of the major issues began to appear at operational levels lower in the performance structure. The genesis of this process was the explicit measurement and reporting of indicators of customer service and satisfaction. For example, the senior marketing task force soon came up with on-time delivery as an easily obtained proxy for customer satisfaction. Each branch was requested to report monthly the percentage of orders delivered to customers on or before the time promised when the order was taken. Almost immediately, each branch started to track the reasons behind the late deliveries so that the causes could be addressed. These "reason codes" as they were called, were soon standardized by the task force and installed on the central computer so that comparisons could be made across the service centers:

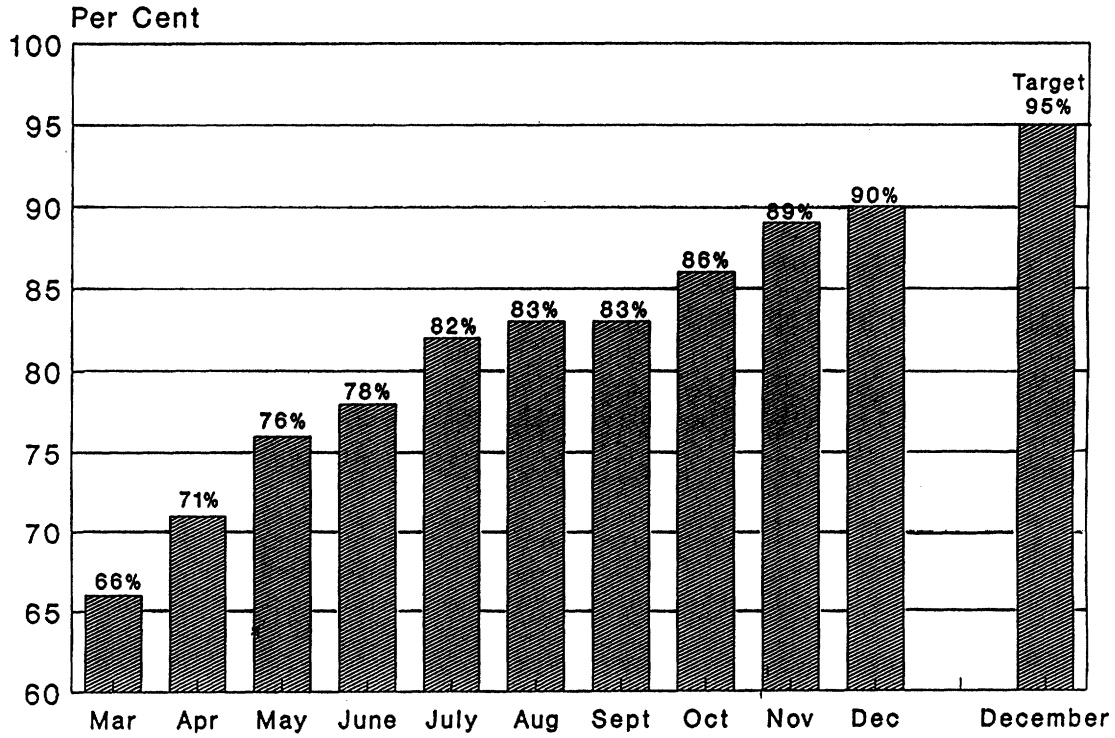


Figure 6: **On-Time Delivery**
Source: Company records.

Late Delivery Reason Codes

1. sales lead time too short
2. credit hold
3. processing delay
4. quality hold
5. inventory location delay
6. delivery truck delay
7. third-party delivery delay
8. outside processor delay
9. interbranch delay

This categorization scheme had the effect of fragmenting the dimensions of on-time delivery, forcing the operating units to measure yet more variables. To improve performance, each unit set up yet smaller teams composed of people closer to operations to investigate these subdimensions. Again, although there was improvement in both on-time performance and market share (see Figures 6 and 7), the units found themselves subdividing the reason codes to make finer and finer distinctions. By early 1992, one unit had subdivided the original nine reason codes into 43 subcodes, and there was no reason to believe that they had reached the end of the process.

The pursuit of causes for lack of on-time performance often took the teams into supplier organizations. For example, two major sources of on-time delivery problems were poor-quality material and the late receipt of steel from the producing mills. Supplier evaluations were used to pinpoint such problems, measure supplier performance, and guide purchasing decisions.

A similar process took place within the other learning initiatives. As a result, the soft matrix became duplicated at several levels within the organization. For example, each branch operation as well as some departments within branches set up their own continuous improvement teams to deal with emerging issues (see Figure 8).

A FRACTAL INTERPRETATION

This section of the article provides a fractal interpretation of the 30-year history of Fedmet (including its Russelsteel predecessor), paying special attention to the two crisis periods, 1982 to 1983 and 1990 to 1991. During these two periods, Fedmet's "system" appears to have behaved in a way that was qualitatively different from

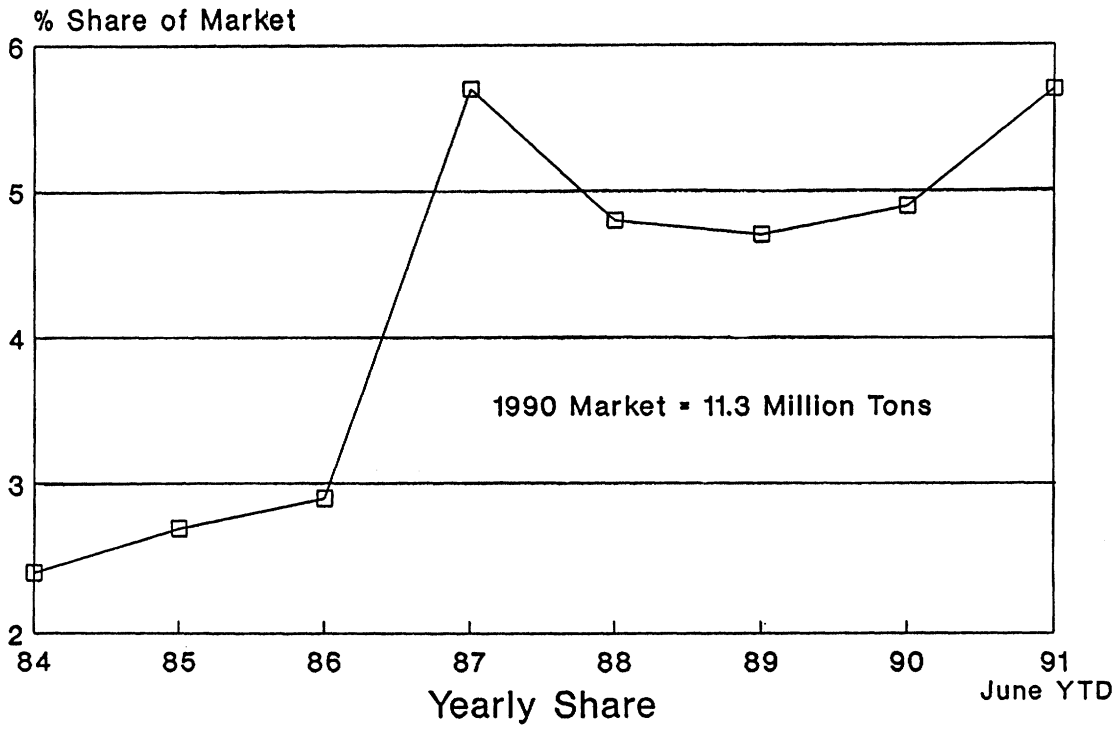


Figure 7: **Fedmet Market Share, Based on Domestic Consumption**
Source: Canadian Steel Products Association, Statistics Canada.

operations during the remainder of the period. In these short, turbulent intervals of far-from-equilibrium conditions the Fedmet structure changed significantly, demonstrating, we believe, many aspects of a dissipative structure: fluctuations and tensions that contribute to order, self-organization, and fractallike boundaries.

Once the crises had passed, Fedmet reverted to stable conservative, near-equilibrium structures that incorporated some of the lessons learned in the turbulent times and remained relatively stable until the next upheaval. This uneven pace of change appears to support Sahal's (1976) distinction between the short- and long-term requirements for regulation in self-regulating systems and fits with the findings of other observers of organizational evolution (Greiner, 1972; Tushman & Romanelli, 1985).

Fluctuations and Tensions

The onset of each of the crisis periods was signaled by the appearance of tensions and dilemmas between apparently irreconcilable opposites, in which the survival of the firm was threatened. A major source of the tensions seems to have been exogenous in the form of fluctuations in the level of business activity and economic indicators, and changing political arrangements (the FTA). Additional stresses were created by changing ownership, particularly by the highly leveraged buyout in 1981. In the second crisis period, endogenous issues (for example, management's dissatisfaction with the status quo) seem to have played a larger role in precipitating the crisis. The president of Fedmet, Wayne Mang, had a history of creating crises. A manager in human resources commented, "Whenever Wayne senses that everyone is becoming too complacent in their everyday operations, he creates a crisis. The best comes out of people when there is a crisis to deal with" (Zimmerman, 1991, p. 167). The crises created by these endogenous activities were not always deliberate: The acquisition of Drummond McCall, for example, created all sorts of unanticipated tensions between it and the Russelsteel division and between the divisions and the group office.

In both periods of crisis, the issues that had to be addressed for survival were multifaceted and fraught with emotional content. In the first case, management was overtaken by the crisis, and the tensions were

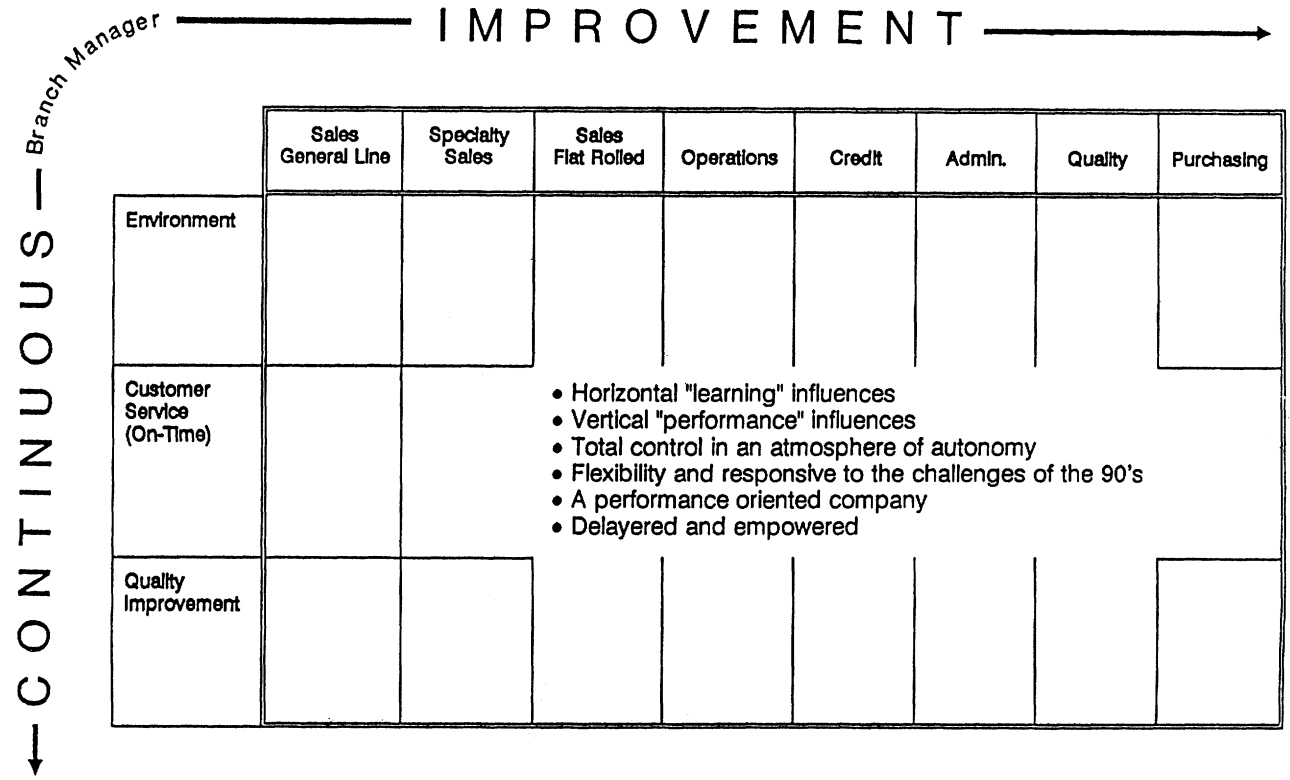


Figure 8: **Federal Metal Service Centre Division: A Continuous Improvement Organization, Drummond McCall Hamilton**
Source: Company records.

made explicit only retrospectively. In attempting to describe the organization's structure during the 1982 to 1983 period, one observer (Hurst, 1984) described the temporary teams as "bubbles" and contrasted them with the more permanent "boxes" composed of branch operations. This tension between the temporary and the permanent, between process and structure, was a feature of the organization during the period of change that began in 1982.

In the second period, the dilemmas were articulated in advance, although they were subsequently made more severe by the unexpected depth of the economic recession. The tensions introduced into the organization by various factors of importance identified by the management and the issues they generated were summarized as follows:

Financial performance	←–→	Customer service
Stability	←–→	Change
Cost focus	←–→	Market focus
East-west orientation	←–→	North-south orientation
Past (apparent success)	←–→	Future (success threatened)

These tensions, in aggregate, were seen as forming a contradiction between an organization in its performance mode and its learning mode. The terms *learning mode* and *performance mode* were used in company documents, presentations, and discussions. The performance mode was characterized by an emphasis on financial efficiency and the repetition of successful routines and procedures. In contrast, the learning mode emphasized effectiveness (customer satisfaction) and experimentation.

The formal measurement and reporting of on-time delivery statistics in addition to financial performance seem to have been instrumental in creating a tension between effectiveness and efficiency that percolated throughout the organization. As the reason codes fragmented, dilemmas were highlighted at finer and finer levels of detail. Indeed, the whole soft matrix organization, together with its replication across all scales, was designed to weave a fabric of tension within the organization.

Self-Similarity

In the 30-year history of Fedmet, there is a clear oscillation between redundancy of parts and redundancy of functions. In the stable periods, the organization is well articulated, both in Ulanowicz's (1987)

technical definition of the term and the usual meaning of the word. During these stable times, members of the company's management, both Fedmet and the parent company, were able to describe their strategies with considerable sophistication and precision. There was extensive redundancy of parts in the elaborate hierarchies and bureaucracies that were constructed in these periods. In Fedmet, this type of redundancy increased when the company was growing by acquisition. It reached its peak after the acquisition of DMC when there were two national distributors whose structures effectively duplicated each other across the country.

In the turbulent times, on the other hand, there was much less articulation in the technical sense, and management was often reduced to incoherence in their attempts to explain what was happening. With the old hierarchy swamped and inoperative due to overload, individuals were free to act spontaneously to deal with emergencies, usually by forming teams. This created redundancy of function as people were taken out of their routine jobs and required to play roles on teams whose tasks were often unclear. Well-established procedures, such as the capital expenditure approval process, broke down and those who needed projects approved had to explore multiple pathways through the organization. These efforts, in their turn, generated numerous interactions that otherwise might not have taken place.

The construction of the soft matrix and its replication throughout the business created redundancy of function as it formalized the requirement that each individual be involved in at least one learning initiative in addition to his or her regular job. Each initiative produced its own communication network and a host of activities and interactions. The fragmentation of the reason codes for late delivery, in particular, became a preoccupation for all of the branch operations and for the departments within them. As a result of such fragmentation and the change in performance measures, managers in the branches began to depict their organizational structures as soft matrices. The content of these matrices changed continually. Teams reorganized either as the progressive fragmentation of the reason codes dictated new issues or as the composition of the teams was changed to get a more effective mix of players. All the time, the teams continued to search for finer and finer distinctions at levels of analysis that became progressively deeper. Here the notion of "zooming" seems an appropriate metaphor. As the organization zoomed in on the issues, processes became replicated on smaller and smaller scales, eventually reaching from the organization in its totality to the level of the individual.

Thus the standardization of the reason codes and the techniques used to track the root causes of late delivery set up recursive processes across all scales of the organization. The redundancy of function produced by this approach became even clearer in the latter part of Fedmet's history, as the total quality management (TQM) and continous improvement efforts demanded formal cross-training of all members of the organization.

Boundaries

Theorists interested in dynamic systems identify several survival advantages arising from the fractal structures that many natural and physiological structures exhibit:

> Fractal branches or folds greatly amplify the surface area available for absorption (as in the intestine), distribution or collection (by the blood vessels, bile ducts and bronchial tubes) and information processing (by the nerves). Fractal structures, partly by virtue of their redundancy and irregularity, are robust and resistant to injury. (Goldberger, Rigney, & West, 1990, p. 46)

In the early part of Fedmet's history the length of its boundaries seems to have varied with the circumstances. When things were going well and the organization was profitable, its structure was highly articulated and the boundaries were relatively well defined and impermeable. Suppliers, bankers, and even the board of directors were kept at arm's length during economic booms. When times became tough, however, the boundaries became blurred. This is clear in the nature and the volume of communication with external constituencies that took place during the crisis periods. Effectively, the organization's boundaries were expanded to include suppliers, bankers, directors, government agencies, and consultants. Anyone who could be of use was given the most intimate details of the corporation's situation. At the same time, internal barriers were broken down by the emergence of the informal teams. This allowed freer internal communication via multiple pathways.

In more recent times, Fedmet seems to have tried to institute a permanent boundary-extending process in the form of the soft matrix. All members of the organization were now seen as "boundary spanners" (Thompson, 1967) operating in an environment of continuous improvement. Previously clear-cut barriers, such as those between Fedmet and its suppliers,

for example, became blurred as Fedmet teams moved further into their suppliers' operations in pursuit of better quality and service.

From a fractal perspective, then, the emergence of the informal team structure in Fedmet, together with the attendant increase in interactions and communication, can be seen as the organization extending its boundaries to maximize sensitivity to events. Effectively, this was achieved by shortening the cognitive yardstick—by getting individuals closest to operations involved in issues that affected the organization as a whole. At the same time, the number of pathways for internal communication was greatly increased.

CONCLUSIONS AND IMPLICATIONS

The fractal framework as a metaphor and analogy (Tsoukas, 1991) is valuable for its fertility. We believe that we have shown that it is a live metaphor with considerable heuristic value. There are a number of implications for both management practice and theory from taking this metaphor seriously.

Implications for Practice

Bartlett and Ghoshal (1990) have suggested that matrix management is not a structure but a frame of mind. The experience of Fedmet and a fractal framework suggest how one might go about building such matrices of the mind, creating the conditions for learning to take place within the organization. By de-emphasizing and neutralizing the top-down power of the existing hierarchy in response to the challenges faced by the organization, the senior management constructed an environment in which teams could act as "communities of practice" (Seely Brown & Duguid, 1991). These organizational "microclimates" in their turn created the conditions for individual learning to take place.

The emergent nature of the teams during the turbulent periods was later recorded by Wayne Mang and his team as one of their guiding management principles: "Let it happen" (Zimmerman, 1993b). This injunction did not mean that the senior management was to do nothing. Rather it meant that they were to let the self-organizing process run its course—by creating the appropriate environment and facilitating the process itself. Although some new patterns of interaction were initiated by design, they soon took on a life of their own. Many other initiatives emerged almost simultaneously throughout the organization as the new aspects of the crisis were communicated and understood by the organizational members.

The formation of such ephemeral organizations under conditions of crisis parallels the social behavior observed in response to natural disasters (Lanzara, 1983). It has been suggested (Drazin & Sandelands, 1992) that the emergence of such structures in the absence of a hierarchical designer resembles closely the patterns generated in cellular automata, where cells, acting on the basis of rules applied recursively to local conditions, can generate complex, coherent patterns over time (Poundstone, 1985).

Fedmet's soft matrix was as dynamic as the horizontal elements were temporary. The matrix mind-set involved constantly balancing the permanent activities with the evolving initiatives. The management team said that horizontal initiatives either evolved into permanent vertical elements or the teams dissolved.

In the other words, to be incorporated into the vertical elements of the organizations, individual learning had to be institutionalized via the modification of existing practices, policies, and procedures. From a fractal perspective, this process of institutionalization can be thought of as a reverse zoom: a progressive abstraction and codification of rules derived from the experience of individuals that will constitute the "permanent," observed structure of the organization (Drazin & Sandelands, 1992). Institutionalization represents the articulation of "recipes for success," which achieve their generality by ignoring details that appear to be unimportant at the time.

The contrast between Fedmet's strategies in the stable and the turbulent times bears a striking resemblance to the distinction between K-strategies and r-strategies discussed earlier (MacArthur & Wilson, 1967). In the stable periods, Fedmet behaved as a near-equilibrium structure, highly articulated and formally structured. In the turbulent periods, an r-strategy became apparent with an emphasis on the discovery and exploitation of new opportunities. The fact that ecosystems exhibit similar strategies without the presence of an obvious designer suggests that much management strategizing may in fact be retrospective sense making (Weick, 1979): That is, the espoused strategy of an organization may be the retrospective rationalization and expression of the self-organizing properties of complex systems.

Finally, a fractal framework may offer some clues about the elusive idea of leadership. Clearly, leadership has to do with the sustaining of creative tension

in organizations (Senge, 1990). Creative tension is derived through strategic imbalance, which occurs when operating at the limits of organizational consensus (Itami, 1987, p. 154) or working at the cognitive boundaries of the organization. Innovation takes place on the edges of the organization where the potential for far-from-equilibrium conditions is optimal. In established organizations, the cognitive boundaries are constrained by history and thus history needs to be rewritten or recreated to extend the boundaries and allow new organizational forms to emerge. Leadership consists of nurturing the processes that allow such things to happen.

Implications for Theory

Future research lies in several directions.

1. *Further use of the fractal framework at the metaphorical and analogical levels of resemblance.* We limited our attention to only three aspects of fractals: fluctuations, self-organization, and boundaries. Fractal qualities of rapid, discontinuous change and simple algorithms creating the whole are also worth investigating.

2. *Application of the fractal framework and chaos theory to other related aspects of management.* This article focused on corporate restructuring. The enhancement of innovation, organization learning, and the creation of external and internal networks are other areas where fractal analysis should prove insightful.

In support of such an agenda, it is helpful to clarify the relationship between a fractal framework and the traditional literature. In the case of boundaries, for example, the fractal framework emphasizes novel aspects of organizations in its own right. But, we believe, when applied to turbulent situations, it plays a role complementary to that of traditional methods when applied to equilibrium situations.

This latter role is important. For, although space considerations have prevented us from making the case explicitly, there is implicit in this article a criticism of the role of boundaries as they are conceived in the traditional literature of functionalist sociology. This criticism implies that the role of boundaries as conceived in this literature is relevant only to organizations in equilibrium conditions. As Buckley (1967) has pointed out in his similar criticism of this framework, the bias is enhanced by the pervasive use of organismic analogies, which naturally emphasize cooperation as the primary function of the "organs" of the entities under study. The role of boundaries in such a framework is conservative—they define the organization. In criticizing the work of Talcott Parsons, Buckley (1967) describes the role of boundaries as follows:

> Looking closely at Parson's scheme we see that his conserving orientation is built tightly into the model. The boundary of the system is defined in terms of "constancy patterns" that are tied to a harmonious set of common norms and values, mutually supporting expectations and the like. Equilibrium, in turn, is defined in terms of the boundary-maintaining system of constant, harmonious, mutual, common, reciprocal, complementary, stabilized, and integrated patterns. (p. 28)

Our suggestion is that, although the organismic metaphor may be suitable for use under equilibrium conditions, the fractal framework is far more suitable for use in organizations that are in far-from-equilibrium conditions. Because most organizations exhibit evidence of both conditions, the use of a "binocular" perspective will not only yield a more complete picture, but the "figure-ground" relationship between stability and change (and vice-versa) will be enhanced by the contrasting approaches. Attempts to deal with dynamic complexity using traditional concepts as exemplified by hard matrixes have not been successful (Davis & Lawrence, 1978). From a fractal framework, this may represent failure of concepts based on Euclidian geometry to grasp nonlinearity and change.

Functionalist sociology has had a pervasive influence on the field of management. For example, James D. Thompson (1967) employs an equilibrium model when he suggests in his first proposition that "under norms of rationality, organizations seek to seal off their core technologies from environmental influences" (p. 19). Under Thompson's assumptions, a key goal of the organization is efficiency. Efficiency will be at a maximum if the organization is made into a closed system. It follows, then, that the environment is a source of disturbance from which the efficient technical core of the organization is to be buffered. Thus boundary-spanning roles are established to "absorb" uncertainty by scanning the environment for changes and trends and feeding the information back to decision makers so that the technical core can adjust in an orderly way.

Protecting the technical core and efficient transfer of information implicitly suggest creating internal boundaries and articulated information patterns. During the two crisis periods examined in this article, Fedmet broke the internal and external boundaries in

the organization. In both instances, the internal boundaries became fuzzy and information patterns were less articulated and more networklike. Breaking the boundaries internally facilitated the creation of fuzzy boundaries and networked relationships for the organization as a whole with its environment. Using a fractal lens, we see the *parts* of the organization are iterative reflections of the *whole* organization and vice versa.

A second criticism implicit in this article is that of the information-processing model of problem solving. Weick and Van Orden (1990) have suggested that the major problem in complex, global organizations is that of equivocality rather than uncertainty; confusion or problem finding rather than ignorance or problem solving. The information-processing model is concerned with problem solving under uncertainty and ignorance, the search for more information to answer a given question. Weick and Van Orden (1990) (following Daft & Lengel, 1986) suggest that if problem finding or defining is an issue, then the concept of information richness is more appropriate. It is the quality rather than quantity of information that is important, if an organization has to search for the right question. Information is richest in face-to-face and small-group processes (Draft & Lengel, 1986) of the kind observed in Fedmet during its crisis periods.

The fractal perspective yields a picture of an organization growing into physical, temporal, and cognitive niches that it discovers through a creative process of growth. The process consists of the elaboration of the organization's boundaries in the face of dilemmas—tensions between opposing, apparently contradictory values. During the process, information is literally created as the dynamics operate on smaller and smaller scales and new ways are found to measure, control, and improve finer and finer aspects of performance. As Nonaka (1988a, 1988b) has pointed out, the information being created is rich in meaning. Semantic information is the focus instead of syntactic information.

A third criticism implicit in our arguments is that of the traditional view of the strategist at the institutional level of the organization as bearing the primary responsibility for "opportunistic surveillance" of the environment (Thompson, 1967) and therefore for the creation of competitive advantage. A fractal organization is clearly as complex at the bottom as it is at the top. *Everyone* in the organization has a privileged position on a boundary from which *only* he or she can "see" certain aspects of reality. If this is the case, the notion of senior management at the institutional level of the organization being capable of scanning the environment is critically flawed; they are embedded in a portion of the fractal like everyone else. Nevertheless, in a fractal organization senior management does have a privileged position. For their mobility within the organization gives them the potential to identify and articulate the similarities that exist *across* the branches and levels of the fractal organization. That is, they can recognize the way in which the organization *resembles itself* at different levels and in different places and promote processes that develop these patterns on smaller scales.

Although they have not been recognized as such, it is these self-similarities or redundancies that, we believe, have recently received prominence as the core competencies of the organization (Prahalad & Hamel, 1990). For example, Prahalad and Hamel (1990) talk of core competencies as

> the collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technologies. . . . Core competence is communication, involvement, and deep commitment to working across organizational boundaries. It involves many levels of people and all functions. . . . The skills that together constitute core competence must coalesce around individuals whose efforts are not so narrowly focused that they cannot recognize the opportunities for blending their functional expertise with those of others in new and interesting ways. (p. 82)

The critical look at long-established frameworks provided by the fractal ideas shows why it may help both academics and practitioners achieve a better understanding of the nature of competitive advantage and the continuous learning required for its sustenance. Advantage does not reside in the self-similarity of the fractal pattern (the articulation of which one might call strategy or competence) alone, neither does it reside in the detail. Advantage lies in the interaction between the two, in both the appropriateness of the pattern and the extent to which it pervades the organization on all scales.

NOTES

1. This is a well-known but controversial claim. A comprehensive view is contained in Pullum (1991) who argues that the number of Eskimo words for snow has been greatly exaggerated. We have no quarrel with Pullum's reservations

about the accuracy of the supporting evidence. Pullum finds the knowledge that Eskimos do have several words for snow as "utterly boring" as the fact that printers have a special language to differentiate between very small font differences. Whereas Pullum finds this unremarkable, it is this capacity of people closest to the phenomena to generate the finest detail that we find to be of the most interest.

2. Barnard (1938) made a similar observation about organizational boundaries. He argued that organizations include not only their "employees and officers" but all their interrelationships that may contribute to the "goodwill" of an entity (p. 69).

3. One of the coauthors of this article, David Hurst, was the executive vice president of Fedmet. He collected data during his 14-year tenure with the company (Hurst, 1984, 1989). Brenda Zimmerman, the other coauthor, was a full-time participant-observer in the organization for 5 months in 1989 (Zimmerman, 1991, 1993a 1993b).

4. The business was known as Hugh Russel, Inc. until 1980 when it changed its name to York Russel. It became Russelsteel in 1983. For the ease of understanding the story we have referred to the organization as Russelsteel throughout.

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