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Vicious and Virtuous Circles in the Management of Knowledge: The Case of INFOSYS Technologies

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VICIOUS AND VIRTUOUS CIRCLES IN THE MANAGEMENT OF KNOWLEDGE: THE CASE OF INFOSYS TECHNOLOGIES[1]

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Abstract

We adopt a systems perspective to explore the challenges that organizations face in harnessing knowledge. Such a perspective draws attention to mutually causal processes that have the potential to generate both vicious and virtuous circles. Based on a longitudinal study at Infosys Technologies, we conclude that knowledge management involves more than just the sponsorship of initiatives at and across different organizational levels. It also involves an active process of steering around and out of vicious circles that will inevitably emerge.

Keywords: Knowledge management, increasing returns, systems dynamics, vicious circles

Introduction

Knowledge is an important organizational resource (Penrose 1995; Winter 1987). Unlike other inert organizational resources, the application of existing knowledge has the potential to generate new knowledge (Leonard 1998; Zuboff 1984). Not only can knowledge be replenished in use (Giddens 1986; Schon 1983), it can also be combined and recombined to generate new knowledge (Garud and Nayyar 1994; Grant 1996a; Hargadon 2003; Kogut and Zander 1992; Okhuyzen and Eisenhardt 2002). Once created, knowledge can be articulated, shared, stored and recontextualized to yield options for the future (Sambamurthy et al. 2003). For all of these reasons, knowledge has the potential to be applied across time and space to yield increasing returns (*Fortune* 1991; Shapiro and Varian 1999).

[1]V. Sambamurthy and Mani Subramani were the accepting senior editors for this paper.

Harnessing knowledge for increasing returns, however, is not an easy task. Leidner (2000), for instance, pointed out that many knowledge management initiatives have yet to yield significant organizational improvements. Others have written about "knowledge management as a double edged sword" (Schultze and Leidner 2002), the "deadliest sins of knowledge management" (Fahey and Prusak 1998) and "knowledge traps" (Soo et al. 2002). Some have documented unsuccessful knowledge management efforts, concluding that managing knowledge is not easy (Nidumolu et al. 2001).

These difficulties arise because knowledge processes have to be managed at and across different organizational levels (Nonaka and Takeuchi 1995). At each level, there are forces at work that can easily stifle the generation of new knowledge (March 1991). Across levels, the coupling of different knowledge processes can give rise to unanticipated negative consequences (Senge 1990).

Over time, processes that yield such negative outcomes can degenerate into vicious circles (Masuch 1985). Vicious circles arise when mutually causal processes feed back into one another to lock a system into a mode of operation that yields progressively negative outcomes (Maruyama 1963; Masuch 1985; Senge 1990; Weick 1969). In contrast, virtuous circles are those that yield increasing returns. The challenge for an organization is to harness its knowledge processes to generate a virtuous circle of increasing returns despite the ever existing potential for vicious circles to emerge.

We adopt a systems perspective (Maruyama 1963; Masuch 1985; Perrow 1984; Senge 1990; Weick 1969) to gain an understanding of the micro-processes that give rise to this challenge. Such a perspective conceptualizes knowledge processes unfolding at and across different organizational levels as a system. It also draws attention to the mutually causal processes constituting the organization's knowledge system.

We apply this perspective to a longitudinal study of knowledge initiatives at Infosys Technologies, a company acknowledged globally for its knowledge management practices. We explore how Infosys attempted to couple knowledge processes at and across the individual, group, and collective organizational levels. We find that the very initiatives undertaken to harness an organization's knowledge system by generating a virtuous circle of knowledge accumulation, reuse, and renewal can just as easily generate vicious circles. Based on these findings, we suggest that knowledge managers must employ process interventions to steer an organization's knowledge system around or out of the vicious circles that are bound to arise.

Organizing for Knowledge

Organizing is a knowledge intensive activity. It involves all of the resources that an organization possesses: its employees and the patterns of interactions among them, its knowledge repositories, and its rules and routines that provide cohesion. In other words, knowledge management issues pervade an organization's people, structures, systems, and processes (Govindarajan and Gupta 2001; Grant 1996b; Hutchins 1995; Subramaniam and Youndt 2004).

Much research has focused on knowledge processes and techniques with the potential to yield increasing returns. Consider, for instance, Nonaka and Takeuchi's (1995) knowledge spiral. The knowledge spiral is based on employee interactions which result in repeated conversions of knowledge between its tacit and explicit forms. As such interactions and conversions occur, knowledge spirals up from the individual to the collective levels of the organization, thereby generating a virtuous circle.

In drawing attention to interactions at and across different levels of an organization, the knowledge spiral sensitizes us to a need to manage knowledge processes within an organization as a system (Spender 1996). A system is a set of relationships among constituent variables, and the fate of the system is determined not by any single relationship, but by an overall pattern. This is because

system variables are coupled by mutually causal relationships[2] that have the potential to generate complex nonlinear dynamics (Maruyama 1963; Weick 1969). Indeed, as Nonaka and Takeuchi concluded, "the actual process by which organizational knowledge creation takes place is nonlinear and interactive" and "knowledge creation is a never-ending, interactive process" (p. 225).

Senge (1990) pointed out that mutually causal processes, which constitute a system, have to be maintained in a dynamic balance between forces that provide continuity and those that bring about change (see also Jelinek and Schoonhoven 1990). Such a balance must be maintained at and across organizational levels, and a failure to do so can easily generate negative consequences. Often, these negative consequences are manifest only after a time lag, thereby resulting in interventions that compound problems instead of mitigating them.

Employing a systems perspective as an interpretive frame, we provide a summary review of the vast and growing literature on knowledge management. In our review, we focus on opposing forces that arise at and across different organizational levels (see Figure 1 for a summary). Such an approach facilitates a deeper understanding of the processes that render the management of knowledge a rewarding yet challenging task.

Dynamics at Each Organizational Level

Individual level dynamics. Employees play a critical role in generating and applying knowledge within organizations. As "men on the spot" (Hayek 1945), they deal with emergent situations in meaningful, contextualized ways without relying on instructions from above (Markus et al. 2002; Tsoukas 1996). In deploying available knowledge to address emergent situations, these employees have the potential to generate new knowledge. Such "exploration" through "exploitation" (March 1991) can happen to the extent that employees have the capacity to reflect-in-action. As Schon (1983, p. 68) noted,

> When someone reflects-in-action, he becomes a researcher in the practice context. He is not dependent on the categories of established theory and technique, but constructs a new theory of the unique case. Because his experimenting is a kind of action, implementation is built into his inquiry.

Yet, opposing forces may drive out such reflection. Specifically, employees accumulate and refine the knowledge required to deal with their contexts through a process of learning-by-doing (Argote 1999; Arrow 1962; Dutton and Thomas 1985). Although learning-by-doing can generate expertise in a specific area, it can also lead to a "competency trap" (Levitt and March 1988). This is because learning-by-doing is a path dependent process (David 1985). Consequently, in the very act of refining existing knowledge within a taken-for-granted framework, employees may forgo opportunities to renew and expand their knowledge tool kit (Swidler 1986). Moreover, as habituation sets in through learning-by-doing, an employee's very capacity to reflect-in-action may be compromised.

In sum, learning-by-doing can be at odds with reflection-in-action. Whereas learning-by-doing represents single-loop learning, reflection-in-action represents double-loop learning (Argyris and Schon 1978). The balance that an organization strikes between these two types of learning can have an important bearing on whether or not it can harness its knowledge system to yield a virtuous knowledge circle.

Group level dynamics. A dynamic balance also needs to be maintained between the continuity that an epistemic community offers and the impetus for change that connections across epistemic communities can provide. To appreciate the need for

[2]According to Weick (1968, p. 81) mutual causation means that "the amount of influence that variable X exerts over variable Y determines the amount Y exerts over X; and the influence of Y over X then determines the subsequent influence of X over Y" (see also Maruyama 1963).

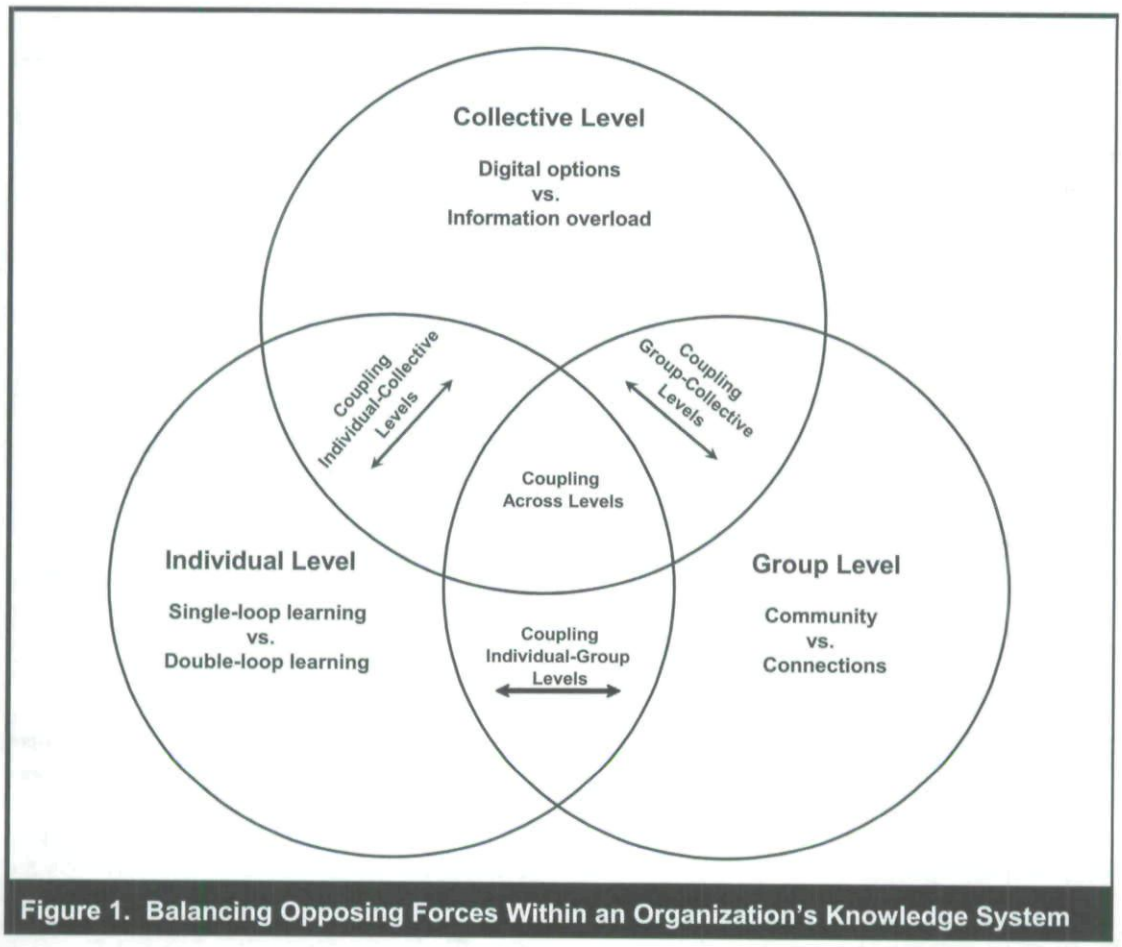

Figure 1. Balancing Opposing Forces Within an Organization's Knowledge System

this balance, consider two key perspectives on group knowledge. A "community of practice" perspective (Brown and Duguid 1991; Lave and Wenger 1994; Orlikowski 2002; Orr 1990) draws attention to shared identities and beliefs among a community of practitioners with a common "thought world" (Dougherty 1992). As Lave and Wenger (1994, p. 98) pointed out,

> [A] community of practice is an intrinsic condition for the existence of knowledge, not least because it provides the interpretive support necessary for making sense of its heritage. Thus, participation in the cultural practice in which any knowledge exists is an epistemological principle of learning.

Group cognition is also constituted by the set of connections established between members of a work group. Within a work group, group cognition is constituted by the strength of the ties between members with different epistemological leanings (Garud and Kotha 1994; Sandelands and Stablein 1987; Weick and Roberts 1993). Because work group members have different epistemologies, it is possible for the work group to "respond as a complete system to meet situational demands even though the complexity of the task is beyond the cognitive capabilities of individual team members" (Faraj and Sproull 2000, p. 1556). Such a response is possible to the extent that unproductive conflict is minimized by carefully shaping interdependencies among group members with different epistemologies (Raghuram et al. 2001).

Organizations attempt to reconcile knowledge generated within epistemic communities with that generated by workgroups (Levina 2002). In many dynamic systems, we may observe a duality over time, with epistemic communities driving work group connections and vice versa. In some instances, however, knowledge derived through connections within workgroups may diverge from knowledge generated within epistemic communities.[3] How an organization addresses this divergence between these two bases of knowledge has an important bearing on its ability to generate and sustain a virtuous knowledge circle.

Collective level dynamics. The mindful application of knowledge by individuals and structural arrangements within work groups clearly shape behavior and learning within organizations. Yet, as March and Simon (1993, p. 8) highlighted, the "retrieval of experiences preserved in an organization's files or individuals' memories" is also important. Indeed, an organization can enhance the benefits accruing from knowledge processes unfolding at and across various levels if a repository exists for stocking knowledge flows.

Here, the metaphor of organizations as knowledge repositories (Walsh and Ungson 1991) comes to mind. Such a metaphor has become all the more important as information technologies enable the creation of digital assets and options (Markus 2001; Miller 2002; Sambamurthy et al. 2003). In this regard, corporate intranets and knowledge portals serve as digital repositories within which codified organizational knowledge accumulates. It is far easier for employees to retrieve and reuse knowledge from today's digital repositories than from the memory banks of yesteryear. Such ease of use enhances the options value of digital repositories (Miller 2002; Sambamurthy et al. 2003).

Despite these benefits, digital repositories can create information overload (Brown and Duguid 2002; Davenport and Prusak 1998). It has become all too easy to accumulate knowledge in digitized form. However, after a point, search and recontextualization costs outweigh the potential benefits from reusing the knowledge. Categorization of digitized knowledge in repositories may mitigate this problem of information overload (Bowker and Star 2000); however, categorization schemes themselves can create other problems. Specifically, as "layers of technology accrue and expand over space and time," these technology infrastructures inherit "the inertia of the installed base of systems that have come before" (Bowker and Star 2000, p. 33). Consequently, users' requirements may remain unmet (Markus 2001), thereby reducing knowledge reuse and the potential for a virtuous knowledge circle to emerge.

Interactive Dynamics Across Levels

Managing opposing forces at each organizational level is a difficult enough task (Alavi and Leidner 2001). To complicate matters, as Grover and Davenport (2001, p. 8) pointed out, knowledge processes are "recursive, expanding, and often discontinuous. Many cycles of generation, codification, and transfer are concurrently occurring in businesses." Therefore, coupling these knowledge processes, which are unfolding across levels to generate a virtuous circle, may give rise to new challenges.

To illustrate these challenges, we consider several initiatives that organizations undertake to couple knowledge processes within and across levels. For instance, consider the institutionalization of organizational routines as a response to complexity faced by employees and workgroups. Organizational routines help couple different knowledge processes unfolding at and across different levels (Nelson and Winter 1982). Indeed, they set the decision context that shapes individual

[3]Such divergence seems to have occurred as the Columbia space shuttle crisis unfolded. When the Columbia shuttle took off, a piece of foam struck one of the wings. In an analysis of the events that unfolded, a panel of experts concluded, "allegiance to hierarchy and procedure had replaced deference to NASA engineers' technical expertise" (Columbia Accident Investigation Board 2003, p. 200). These observations suggest that knowledge from work group connections appears to have prevailed over knowledge from the technical community.

and collective behavior. As March and Simon (1993, p. 8) observed, "actions are chosen by recognizing a situation as being of a familiar, frequently encountered type, and matching the recognized situation to a set of rules."

Yet, despite these benefits, routines can easily entrap an organization into a knowledge trajectory that is inconsistent with the demands of its changing environment. Organizational routines for harnessing knowledge may become so inflexible that they become the basis, not for dynamism, but for stagnation. At the extreme, core capabilities may become core rigidities (Leonard-Barton 1992).

Or, consider the recent attempts by many organizations to apply technology architectures to couple processes across levels. As Latour (1991) pointed out, "technology is society made durable." That is, fragile social processes are shaped by the presence of technological artifacts that enable and constrain social interactions in productive ways. Indeed, social rules are built into new information technologies, and these rules shape social processes (DeSanctis and Poole 1994; Orlikowski 1992). By facilitating the emergence of communities, these built-in rules can potentially alleviate problems generated by the interplay between tacit and explicit knowledge (Bowker and Star 2000).

Yet, the generation of communities through technology architectures can give rise to new problems. Specifically, social rules built into technologies can potentially overdetermine social processes (Brown and Duguid 2002; Davenport and Prusak 1998; Leidner 2000). Indeed, these rules can become so internalized and taken for granted that self-reflection gives way to mindless conformity (Berger and Luckman 1967; Schon 1983). Such mindless conformity can generate inappropriate actions, especially in complex, dynamic environments.

Finally, consider organizational initiatives to connect different levels by creating "markets for knowledge" (Davenport and Prusak 1998). Specifically, firms have been institutionalizing schemes that incentivize individuals to share and reuse knowledge. Such incentive schemes are mechanisms designed to overcome the challenges of inducing collective action from autonomous individuals (Oliver et al. 1985; Olsen 1965; Schelling 1978).

Despite the merits of such schemes, however, a market-for-knowledge perspective may end up destroying community dynamics critical to the free flow of rich tacit knowledge (Gold et al. 2001). Spontaneous social interactions become transformed into calculative social exchanges (Fukuyama 1995). As a result, an organization may have to incur higher transaction costs within such a market-for-knowledge than within communities (Callon 1998; Garud 1994).

Knowledge Management in Perspective

These interactive dynamics suggest that knowledge processes are inherently fragile (von Krogh et al. 2000). Such fragility implies that knowledge managers cannot just address issues at different organizational levels in a piece-meal manner. Rather, they need to embrace a systemic approach to knowledge management, dynamically balancing and trading off opposing forces at and across different organizational levels (Senge 1990). To appreciate the intricacies and challenges of such a role, we present a longitudinal study of knowledge management initiatives at a company acknowledged globally for its knowledge management practices. In describing these initiatives and their consequences, we offer insights into the generation and maintenance of a virtuous knowledge circle over time. However, first, we describe our research site and methodology.

Research Site and Methods

This research is an outcome of our continuing association with Infosys Technologies, a global software services company based in India. At the

end of its fiscal year 2004, Infosys was a U.S. $1 billion company with over 23,000 employees and globally distributed operations. Listed on the NASDAQ Stock Market and growing annually by at least 30 percent during the past decade, Infosys is among the companies consistently featured by *Business Week* in its annual Info Tech 100 list. It is also among a select group of companies to have received both the Asian and the Global Most Admired Knowledge Enterprise (MAKE) awards.

In exploring knowledge management (KM) practices at Infosys, we employed a naturalistic mode of inquiry wherein insights are induced through interpretive means (Lincoln and Guba 1985). This inquiry mode emphasizes procedural adequacy and credibility, which we established by employing the steps set out in Miles and Huberman's (1984) primer on qualitative research.

Our aim was to generalize from a case to a theory, rather than from a sample to a population. Typically, this is accomplished by iterating between data and theory until a stage of theoretical saturation is reached (Glaser and Strauss 1967). Lincoln and Guba (1985) outlined a systematic process for generalizing from a case to a theory. This process involves continually cycling through the following four steps: (1) purposive sampling, (2) inductive data analysis, (3) development of grounded theory, and (4) projection of next steps. Consistent with these steps, we began our purposive sampling within Infosys in the summer of 2000 by interviewing senior executives and mid-level managers. Over the next three years, we conducted multiple rounds of interviews with employees from different functions and levels. Overall, we conducted 56 interviews over a period of 3 years. We interviewed a few key people more than once in order to track how their perspectives evolved over time.

The interviews themselves were semi-structured and emergent. Participants discussed issues that they felt were most important for knowledge management and the growth of the company. Each interview, lasting between 1 hour and 1.5 hours, was taped and transcribed. Interviewed employees pointed us to documents such as strategic reports, analysts' reports, presentations, white papers, and employee surveys that further clarified knowledge management processes and outcomes at Infosys.

An analysis of the interview data and company documents enabled us to develop a more focused understanding of the company's accomplishments and challenges in the management of its knowledge. As part of our analysis, we read the interview transcripts and then listened to the taped interviews to check the transcripts for accuracy. We also read all company documents to which we had been referred by employees. We coded statements made during the interviews into a database using keywords, including the source for each statement and the type of documentary evidence that established the validity of claims made in the statements. Progressively, we combined these statements into broader themes.

The theorizing process was emergent. As we developed our database and continued to track the company, working hypotheses emerged. For instance, we concluded that knowledge management issues pervade the entire company. Accordingly, we decided that it would not suffice to study only one facet of knowledge management. We also realized that the outcomes of initiatives at Infosys would be manifest only over time as knowledge processes unfolded at and across different organizational levels. Therefore, we decided to conduct a longitudinal analysis of the company's knowledge management efforts.

As we completed the first round of interviews and analysis, we planned our next iteration. In the process, we perceived a need to gain a deeper understanding of the drivers and outcomes of the company's various knowledge initiatives. To do so, we decided to forge closer associations with the company's KM group and employees at various levels. Over the next three years, we held periodic interviews with members of the KM group and employees at all levels within Infosys. We also communicated periodically through e-mail with members of the KM group and a cross-section of employees as we sought further information or

clarification on specific initiatives. We coded these periodic interviews and responses to our e-mail communications. Again, we went about developing themes and coming up with working hypotheses to inform our subsequent steps.

By the end of 2002, we came to the conclusion that it was critical for us to gain an ethnographic feel for the dynamics at play within this company. Accordingly, a member of our research team spent 45 days at the company, becoming a part of the Infosys community to observe knowledge processes unfolding at various levels first-hand. Her detailed insider's accounts and final debriefing report were invaluable not only in strengthening our working hypotheses, but also in extending our insights.

Concurrent with these activities, we began writing a case on Infosys, placing special emphasis on its knowledge management initiatives and processes. In April 2002, we completed a first draft of this case, which we sent to the company for review and clearance. Several employees offered critical feedback and clarification, pointing us to additional benefits and problems that they perceived with the company's knowledge management initiatives. We made relevant additions and changes to the case based on this feedback and sent it back to the company for further review. After two such iterations, the company gave its final clearance (Garud et al. 2003).

By this time, we had developed a deep understanding of the practices and processes that Infosys employed to harness its distributed knowledge. We made periodic presentations to the KM group at Infosys, whose members commented on our presentations and offered additional insights. These interactions were invaluable to us in developing a greater appreciation of accomplishments Infosys had achieved and the challenges it faced in its efforts to manage knowledge as an organization-wide resource.

We were intrigued when, in April 2002, the KM group at Infosys decided to change the incentive scheme it had implemented to promote contributions to the company's central knowledge portal. Our discussions and subsequent analysis led us to a key insight that we develop in this paper: The very initiatives undertaken to initiate a virtuous knowledge circle may yield unintended consequences because of the mutually causal knowledge processes unfolding at and across different organizational levels.

Knowledge Management at Infosys Technologies

> An IT company like ours cannot survive if we don't have mechanisms to reuse the knowledge that we create...."Learn once, use anywhere" is our motto. The vision is that every instance of learning within Infosys should be available to every employee.

These sentiments, offered by a member of the KM group at Infosys, are reflective of the company's efforts to leverage knowledge created by its employees for corporate advantage. The adage "learn once, use anywhere" reinforces the continual learning and reflection required for knowledge accumulation and reuse. It also draws attention to a core belief that knowledge belongs not only to those employees who create it, but also to the entire company.

Infosys began efforts to transform its employees' knowledge into an organization-wide resource in the early 1990s (see Table 1 for an abbreviated chronology of initiatives; for complete details, see Kochikar et al. 2002). In 1992, Infosys encouraged its employees to offer written accounts of their on-the-job experiences on a variety of topics ranging from technology and software development to living and behaving in foreign cultures. These nuggets of experiential knowledge—called *bodies of knowledge* (BOKs)—were then shared in hard copy form among all employees. This initiative was an early effort on the part of Infosys to codify knowledge generated by its employees as a natural by-product of their daily work.

Table 1. Knowledge Management Initiatives at Infosys Technologies

Year	KM Initiatives
Since 1980s	• Employees hired for learnability, not just for technical knowledge.
1992	• Bodies of knowledge (BOKs) initiative launched.
1996-97	• Corporate intranet (Sparsh) launched. • Technical bulletin boards, BOKs and repositories offered through Sparsh. • CMM Level 4 certification attained.
1998	• People Knowledge Map implemented on Sparsh.
1999	• CMM Level 5 certification attained. • Central KM group chartered. • Company-wide KM program launched with emphasis on web/repository based approach.
2000-01	• Central knowledge portal (KShop) launched. • Customization tools for KShop entry pages offered; Local repositories integrated with KShop; corporate data made available on KShop. • Knowledge currency units (KCU) incentive scheme launched to jumpstart contributions to KShop. • Forms and project templates changed to enable knowledge extraction using automated tools.
2002	• Modified KCU incentive scheme implemented. • Project tracking tool implemented on KShop. • KM Prime and Knowledge Champion roles instituted. • Initiative to promote story telling and accounts of war games launched.

During the next few years, this initiative mushroomed into a full-fledged KM effort supported by tools such as e-mail, bulletin boards, and repositories for marketing, technical, and project-related information. In 1996, Infosys created Sparsh, the corporate intranet, to make BOKs (in HTML format), bulletin boards, and local repositories easily accessible to all employees. Soon, Sparsh became the central information portal for Infosys.

In late 1999, Infosys initiated a formal company-wide KM program to integrate all knowledge initiatives. One of the first decisions made under this initiative was to establish a central KM group to facilitate the company-wide KM program. A second key decision was to create a central knowledge portal called KShop. Consistent with its philosophy emphasizing central facilitation of distributed knowledge processes, the KM group created a technology infrastructure, but encouraged different practice communities within the company to maintain the content on KShop. A white paper published by the KM group (Kochikar 2001) clarified this philosophy which still drives KM at Infosys:

> A key success factor is to achieve the right balance between centralization and decentralization in KM initiatives. Centralization allows a greater ability to achieve organizational synergies and scale economies, but may be difficult from an implementation perspective. It may be easier to create smaller pockets to start with. Also, ownership and individual participation tends to be low as initiatives scale up. Niche groups within

> the organization may find that their relative cohesion facilitates such sharing better. Home pages, specific knowledge databases and utilities are best maintained at personal/group levels, while knowledge directories and bodies of knowledge are better maintained at the organization-wide level.

To reduce costs and to ensure easy scalability, the KM group implemented KShop on five PCs, which also acted as servers. Acting on feedback from employees, the KM group offered users tools to customize their respective KShop entry pages. The KM group also integrated access to corporate data and several locally managed repositories into KShop to provide a single entry point to much of the codified knowledge within Infosys.

The content on KShop was organized into different content types—for instance, BOKs, case studies, reusable artifacts, and downloadable software—with each content type having its own home page. Every knowledge asset under a content type was associated with one or more nodes (representing areas of discourse) in a *knowledge hierarchy* or taxonomy. Multiple paths were created through the hierarchy to facilitate easy categorization and retrieval of tagged knowledge assets. As the number of knowledge assets and nodes proliferated with time, information overload became a distinct possibility. To address this problem, the KM group initiated efforts to fine-tune its categorization scheme and make it more relevant to the different practice communities. A member of the KM group reflected on these efforts.

> For us, taxonomy is not just a framework for categorizing content; it is a strategy to unify multiple constituencies. Going forward, the search engine will be enhanced to leverage the taxonomy for delivering accurate search results. For this approach, we need a taxonomy that is more elaborate than the current one. The next version of KShop will support automatic classification tools. Even with the taxonomy being huge, this means easier classification for users.

Learnability

"Knowledge is the currency of the new millennium and we are building a company that will remain at the forefront of knowledge management." The CEO of Infosys offered this assessment in 2000 as he reflected on the role that knowledge has played in transforming a little known company into a global player within two decades. Operating in the highly dynamic software services market with clients distributed around the world, Infosys continues to place an emphasis on leveraging its employees' knowledge for corporate advantage. As the company's chairman and chief mentor frequently observes, "Our key assets walk out of the door every evening, and it is the management's responsibility to see that they return the next morning." Not surprisingly, Infosys is among the few companies in the world that values and reports its human capital on its balance sheet (for specific details, see Raghuram 2001).

How does Infosys build its human capital? As with other companies, Infosys recruits bright people and trains them regularly. Yet, given the speed and complexity of change that its employees confront, Infosys realized that formal training alone would not suffice for its employees to remain at the cutting edge of software development and deployment. Not only would the time lag between training and actual application compromise performance, but exclusive reliance on training also could detract from employees' ability to innovate at the point of knowledge deployment.

For these reasons, the company began recruiting employees for their "learnability." At Infosys, learnability refers to an "ability to derive generic conclusions from specific instances of learning." In this sense, learnability is much more than refining existing knowledge through a process of learning-by-doing. The director of human resources at Infosys clarified further:

> The only thing that is constant in this industry is change. If we want our people to address this change, it does not matter whether they know specific technologies like C++ or Java. That is something we

> can teach. More important is whether they are able to figure out how Java is similar to or different from C++ and make appropriate adjustments in applying it. Or, having solved a problem for one customer, can they apply that knowledge in a generic way to some other problem that they face later? This is why we recruit people who possess this generic learning capability that we call learnability.

Learnability is manifest in a noticeable tendency among Infosys employees across levels and functional areas to think and speak in terms of models. These models are bundles of assumptions, constructs, experiences, and working hypotheses ranging from the customer relationship model, which defines the way Infosys employees interact with customers, to an iterative model of software development, which encourages continual feedback and adjustments during project implementation (Jalote 2000, p. 74). Even the genesis of the company-wide KM program can be traced to a knowledge maturity model that evaluates the maturity level of knowledge processes (for more details, see Kochikar et al. 2002).

By no means are these models static templates whose only purpose is to transfer knowledge from one context to another. Rather, they are dynamic entities that coevolve with employees' experiences. Such coevolution is critical for employees to progress up the career ladder as they adapt from one job paradigm to another. At an organizational level too, learnability has played a vital role in the transition that Infosys employees have made from a predominantly Y2K-driven business model to one driven by e-commerce. The knowledge maturity model, which so far has guided KM efforts at Infosys, is itself being modified to incorporate new lessons gained during the implementation of the company-wide KM program.

Informal Communities and Formal Workgroups

To ensure that knowledge created by employees benefits their colleagues, Infosys encourages the formation of rich social networks among employees. Within these networks, knowledge sharing occurs informally with employees calling colleagues for help, thereby engendering an "asking culture" at Infosys. More recent manifestations of this asking culture include e-mail broadcasts for help on specific topics and the posting of queries on online bulletin boards or discussion groups. As an associate vice president who has climbed up the ranks explained,

> Information goes around informally. I can call up someone to get answers. Or, I can post a query or send an email and I will not be at all surprised to get several responses within five or ten minutes from colleagues located around the world. We still have a campus-like environment, though this may change as the company grows bigger.

To strengthen the firm's rich informal networks, the KM group developed a tool called the People Knowledge Map (PKM) in 1998. The PKM, deployed on the corporate intranet, catalogs the names and contact information of internal experts in specific areas, thereby enabling colleagues to locate them and benefit from their expertise easily. The PKM forges connections between communities and their respective knowledge bases. This tool is especially useful to the constant stream of newcomers who are not familiar with the pockets of expertise distributed within the knowledge network at Infosys.

Unfolding in parallel are formal processes within project teams. These project teams conceive, design, and complete software projects—the core of the value proposition offered by Infosys. Within each team, the creation and exchange of knowledge is governed by the strong bonds forged among team members as they work long hours together under intense time pressure. A core of experienced members always remains with the team even as other members are rotated to other project teams. These senior members mentor newcomers on idiosyncratic technologies, tools, and client requirements.

Each project team is organized into modules, with each module dealing with one aspect of a complex project. By 2000, most project teams had embraced an iterative model of software development. The iterative model is a fluid, adaptive process for the development of complex software in a rapidly changing environment. Rather than relying on sequential deployment of resources and activities, the iterative model employs parallel deployment. Rather than different modules within each team working in their own knowledge spaces, the iterative model forces overlap between modules reinforced by continual interaction and feedback. Such overlap enables members of a given module to specialize in particular tasks but, at the same time, have some general knowledge of the tasks performed by team members in other modules. In their attempts to explain this structure and development process, both a project manager and a senior developer offered the human brain as an analogy to describe how their project teams functioned.

Organizational Routines

To provide a template for routines for knowledge accumulation, Infosys adopted the capability maturity model (CMM). Developed by the Software Engineering Institute at Carnegie-Mellon University, the CMM gauges the maturity level of a software company's processes and methodologies on a scale of 1 to 5. Each of the five levels has built into it a series of steps that allow a software company to accumulate the knowledge and experience to move sequentially from one level to the next. As the company advances to the next level, additional steps force further reflection and improvement. At Level 5, the level at which Infosys operates, a company not only has mechanisms to prevent defects and manage technological change, but also the ability to quantify, measure, and continually modify its software development processes (for more details, see Jalote 2000).

For instance, implementation of CMM at Infosys includes a mechanism to enable its project teams to learn from completed projects. Through audits, members of a project team identify what went right or wrong during the course of a project. More importantly, a closure report written at the end of each project captures important lessons for the future. Typically, these closure reports include items such as the duration of the project, resources employed and other facts that allow a future reader to gauge the efficiency and effectiveness with which the project was implemented. These reports also contain a section on causal analysis that records major deviations in process performance and lists possible causes for these deviations. At the end of this report, a conclusion summarizes the major points learned from the project for future reference. Closure reports serve as a key mechanism linking knowledge creation and deployment at the work group level with the rest of the organization.

The flexibility embodied in the CMM framework enables Infosys to try new initiatives, learn from them, assimilate the outcomes, and, in the process, change its very processes and routines. In this sense, Infosys' CMM Level 5 induced organizational routines are analogous to learnability, which drives knowledge creation and deployment at the individual level. Over time, Infosys has adopted the CMM framework not just for software development, but also for all other organizational initiatives. For instance, an Infosys regional director offered a specific instance of how the company has applied the CMM-inspired iterative implementation process to an initiative other than the fine-tuning of software methodologies.

> When we started the first off-campus Development Center within India, it was a revolutionary step for us. We started out on a very small scale....We went through several issues and problems, and we committed mistakes....At the end, after several experiments over a full year, we came out with a very scalable

and repeatable process to set up development centers. We went through the same piloting process when we started our first Development Center outside India. Today, we have the capability to set up development centers anywhere in the world just like that.

Catalyzing the Knowledge Spiral

By the beginning of 2000, Infosys appeared to have put together the necessary elements of a knowledge system at each organizational level. It had recruited employees for learnability and developed informal processes and formal structures to enhance knowledge creation and sharing. It had leveraged CMM Level 5 routines as the framework for organization-wide learning and change. Furthermore, in implementing the central knowledge portal KShop, it had created a digital platform for the accumulation and reuse of organizational knowledge.

These initiatives were not sufficient by themselves to jump-start a virtuous knowledge circle. Patronage of KShop by employees remained low. Employees within various project teams and practice communities continued to use their informal networks to access knowledge in times of need. Local repositories of specialized knowledge continued to proliferate within project teams and practice communities. In other words, processes at different levels of the knowledge system were not coupling and reinforcing one another.

In response, during the first quarter of 2001, the KM group implemented a major initiative—the knowledge currency unit (KCU) incentive scheme—to jumpstart contributions to KShop. Under the scheme, Infosys employees who contributed or reviewed contributions to KShop would be awarded KCUs, which they could accumulate and exchange for monetary rewards or prizes. Additionally, employees' cumulative KCU scores would be displayed on a scoreboard on KShop, thereby increasing the visibility and standing of prolific contributors.

Intended and Unintended Consequences

These initiatives began yielding results, especially after the KCU incentive scheme was introduced. For instance, within a year of introduction of the KCU scheme, over 2,400 new knowledge assets—project proposals, case studies, and reusable software code—were contributed to KShop, with nearly 20 percent of Infosys employees contributing at least one knowledge asset. Over 130,000 KCUs were generated by the KM group and distributed among contributing and reviewing employees.

Even as these events unfolded, the KM group began wondering if the KCU incentive scheme had become *too* successful. One concern had to do with employees experiencing information overload and, consequently, higher search costs for reusable knowledge. As a member of the KM team commented,

> If the repository becomes too heavy, the chances of getting useful information reduce with time. So, there is a trade-off that people have to make, especially because we are looking at increasingly short life-cycle projects—nowadays, 6 weeks to 3 months. Suppose someone searches the repository, gets three documents, takes 2 or 3 days to read these documents and finds out that they are not useful. Then, he might question the very point of searching the repository, considering it a waste of time....Some people have told us informally that they are finding it faster to do things on their own or to ask someone they know instead of searching the repository for reusable content.

Complicating matters, the explosive growth in the number of contributions began placing a heavy burden on the limited number of volunteer reviewers. A shortage of reviewers made it difficult for the KM group to ensure that contributions were reviewed for quality and relevance before being published on KShop. With review processes still

struggling to keep pace with the accelerating pace of contributions, assets of uncertain quality began appearing on KShop. When even contributions of questionable quality began receiving high quality ratings from colleagues, the rating scheme itself came under scrutiny. A manager commented,

> Our experience is showing that relying solely on incentives may not be the right way to increase knowledge sharing. Incentives increase awareness and the number of contributions. But, the quality of these contributions is in question because some people are gaming the system....Then, there are groups within the company that have a sharing culture and don't care about incentives. The number of contributions generated by these groups is as much or more than the rest of the company put together.

Concerns also began emerging about the possible impacts of the KCU scheme on knowledge processes at the other levels of the organization. One such concern was the potential for the KCU incentive scheme to destroy the spirit of community and the asking culture within the company. What employees would have given freely to each other earlier was now being monetized through the KCU incentive scheme. "Why not gain some rewards and recognition for my knowledge contributions, especially when others are doing so?" was the question being asked by employees who had shared their knowledge earlier for free for the "joy of sharing."

An additional concern was the real possibility that some project teams and practice groups, disappointed with KShop, could revert to building and relying on their own local repositories instead of contributing to the central portal. A project manager explained that this trend could result in the fragmentation of the knowledge commons.

> Nowadays, there are many useful knowledge assets being retained at the team or practice unit levels that never make it to KShop. There is a growing impression that many units are holding their assets close to their people in local repositories. With time, this may become a barrier to true knowledge sharing or reuse.

Taken together, these concerns and unanticipated emergent processes had the potential to compromise the key objective of the company-wide KM program: to make every instance of learning within Infosys available to every employee. A manager who had been associated with the KM initiative from the beginning reflected on these challenges.

> We are coming to realize that knowledge management requires much more than just technology. We have to pay attention to the cultural and social facets of knowledge management as well. We have to continually campaign and evangelize besides investing the time and resources to manage the content. Knowledge management initially appears to be a deceptively simple task. But, make just one wrong move and it is difficult to convince people to come back.

Process Interventions

Sensing the potential of the KCU incentive scheme to compromise the company-wide KM program, the KM group took prompt action. First, they intervened to decouple knowledge sharing from the economic incentives that threatened the spirit of community and the perceived utility of KShop. Specifically, in April 2002, the KM group modified the KCU incentive scheme to emphasize recognition and personal visibility for knowledge sharing contributions more than monetary rewards. It formulated a new composite KCU score that emphasized the usefulness and benefit of contributions to Infosys as rated not just by volunteer reviewers or colleagues, but also by actual users. Moreover, to increase the accountability of reviewers and users who rated contributions to KShop, the KM group began demanding tangible proof to justify any high ratings. Finally, the KM group significantly reduced the number of KCUs

awarded for reviewing contributions to KShop and raised the bar for cashing in the KCU incentive points for monetary rewards. The KM group hoped that these steps would shift the motivation to share knowledge away from monetary rewards.

A second set of initiatives focused on improving KM practices within project teams and practice communities. Intense time pressure in completing projects within stringent deadlines reduced knowledge codification efforts within teams. To address this issue, the KM group modified forms and project templates to facilitate extraction of knowledge using automated tools. The group also implemented a project-tracking tool on KShop to log details and deliverables pertaining to every project within Infosys. The objective of these initiatives was to enable the codification and extraction of knowledge even as teams carried out their routine project-related tasks.

Despite these attempts, knowledge codification continued to vary across project teams. To address this shortcoming, the KM group introduced a hierarchy of roles to broker knowledge sharing between project teams, practice communities, and the wider organization. Within each project team, one volunteer member would be designated as the KM prime. The KM prime would be responsible for identifying and facilitating the fulfillment of the team's knowledge needs for each project. The KM prime would also ensure that, after the completion of each project, the team codified and shared critical knowledge gained during the project with the rest of the company. At the practice community and wider organizational levels, the KM group also created the role of knowledge champions to spearhead and facilitate knowledge sharing and reuse in critical or emerging technologies and methodologies. Furthermore, the KM group encouraged employees to swap stories on KShop with the view of promoting widespread sharing of tacit individual and team-level knowledge and experiences.

These initiatives certainly had an impact. After the modified KCU scheme was introduced, those who had contributed to KShop just to secure monetary rewards reduced their participation. For instance, in the two quarters immediately following the introduction of the modified KCU scheme, the number of new contributors per quarter declined by nearly 37 percent, whereas the number of new knowledge assets contributed to KShop per quarter declined by approximately 26 percent during the same period. After this significant initial decline, however, the number of new knowledge assets contributed to KShop slowly stabilized and then increased at a more manageable pace. Users of KShop reported lower search costs and significant increases in the quality and utility of knowledge assets available through the portal. Looking into the future, there was also much optimism that the KM prime and knowledge champion roles would yield positive outcomes.

These initiatives underscore the continual nature of change at Infosys. The KM program at Infosys continues to evolve based on feedback from Infosys employees and the KM group's continual efforts to gauge the effectiveness of their various initiatives. As Infosys continues to grow in terms of its work force, geographical reach, and value proposition, new challenges will surely emerge. Reflecting on the transformative nature of change that shapes the company and its KM program, a company director pointed out,

> Many years ago, people would ask, "Are you sure where you are going? Do you know what issues you will get into?" Our answer to these questions is still the same: "No, but we have the processes in place to address these issues as and when they arise. And, as we address these issues, we will transform ourselves."

Virtuous Circles, Vicious Circles and Steering

A systems way of thinking (Maruyama 1963; Masuch 1985; Perrow 1984; Senge 1990; Weick 1969) provides us with a theoretical perspective to understand these dynamics. First, it enables a

deeper understanding of how an organization might attempt to generate a virtuous knowledge circle through initiatives at and across levels to achieve a dynamic balance between forces for continuity and change. Next, it explains how and why the very initiatives taken to generate a virtuous circle may also end up generating a vicious circle. Finally, it also offers insights into process interventions that knowledge managers might use to steer their organization's knowledge system around or out of vicious circles and to enhance the potential for virtuous circles to emerge (see Figure 2 for a summary).

Virtuous Circles

The Infosys case suggests how an organization can accomplish a dynamic balance by institutionalizing practices at and across different organizational levels. At the individual level, recruiting employees for their ability to reflect-in-action balances the tendency to engage only in knowledge refinement through learning-by-doing. At Infosys, employees endowed with learnability encapsulate their experiences in models. Such models serve both as models *of* and also *for* knowledge experiences (Geertz 1973). In addition to channeling learning efforts, these models, when applied to new contexts, enable employees to engage in both single-loop and double-loop learning and generate new knowledge.

At the group level, interlaced structures provide the benefits of knowledge from communities as well as from workgroups. These interlaced structures force epistemic overlap between members of different communities—what Nonaka and Takeuchi (1995) label as *shared division of labor*. Rich connections between different workgroup modules, each subscribing to different epistemologies, allow knowledge from across these communities to recombine, thereby generating innovative solutions to emergent problems. At the same time, such arrangements afford mutual control which produces an ongoing mediated consensus (Polanyi 1966, p. 72).

Key to the balancing act at the collective level is the recognition that volume can overwhelm value within digital repositories (Brown and Duguid 2002, p. xiii). In this regard, Infosys developed categorization schemes to enable easy search and retrieval of knowledge assets from digital repositories. As these categorization schemes are customizable by different user communities to better reflect their respective thought-worlds, the potential for inconsistencies between induced and emergent categories is minimized. At a process level, these initiatives are reflective of adaptive structuration, wherein rules inscribed in technologies and rules constitutive of social processes coevolve (DeSanctis and Poole 1994; Giddens 1986; Orlikowski 1992).

Organization-wide routines—in the case of Infosys, the capability maturity model—forge a dynamic balance between the sustenance of core competencies and the onset of core rigidities. CMM offers a template to pilot initiatives, learn from experience, and iteratively scale up only those initiatives that prove successful. Accordingly, Infosys' implementation of CMM illustrates how organizations might leverage routines as sources of both continuity and change (Feldman and Pentland 2003) to develop dynamic capabilities over time (Eisenhardt and Martin 2000; Teece et al. 1997).

These institutionalized practices are all necessary but by themselves not yet sufficient to generate a virtuous knowledge circle. An additional requirement is the coupling of knowledge processes across different levels to jumpstart the establishment of a knowledge commons. In this regard, models of collective action (Schelling 1978; Gladwell 2000) demonstrate that a critical threshold has to be crossed for a bandwagon to emerge. Recognizing that socio-psychological processes may prevent this critical threshold from being reached, Oliver et al. (1985) have highlighted the need for incentives to create a bandwagon.

Infosys instituted several initiatives to couple knowledge processes unfolding across the different levels. For instance, the People Knowledge

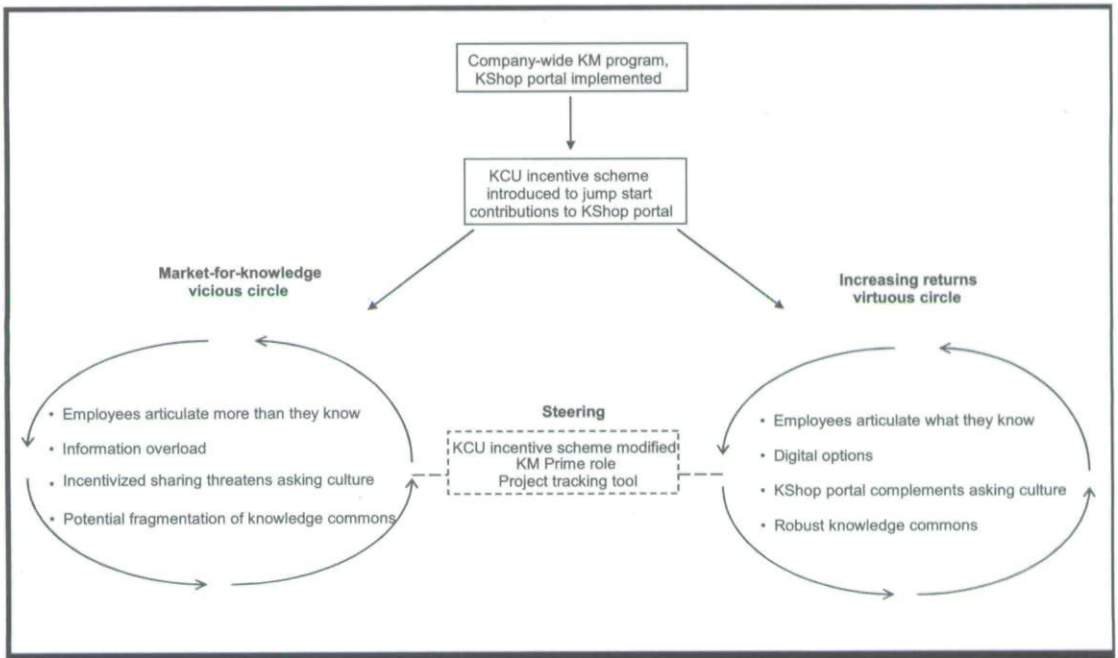

Figure 2. Vicious and Virtuous Circles at Infosys

Map was implemented to couple processes across the individual and group levels. The project closure report initiative is illustrative of initiatives to couple processes across the group and collective levels. In addition, the KCU scheme was an important initiative to couple processes across the individual and collective levels of the organization.

The catalyzing effect of incentives in generating a bandwagon was all too evident at Infosys, with contributions to KShop increasing significantly after the introduction of the KCU scheme. Indeed, it seemed as though Infosys had successfully initiated a virtuous knowledge circle. Why then did potentially negative consequences arise for Infosys' knowledge system? To address this question, it is useful to look at the darker side of mutually causal processes. The very same mutually causal processes that have the potential to generate a virtuous circle can just as easily generate a vicious one.

Vicious Circles

Vicious circles are triggered when feedback generated at a particular system level is amplified across the entire system, setting in motion events that generate unintended negative consequences (Maruyama 1963; Masuch 1985; Senge 1990; Weick 1969). Especially in systems with tightly coupled components (Orton and Weick 1990), as in the case of an organization's knowledge system, mutually causal feedback loops can easily be amplified across the system, thereby rendering it more susceptible to pathologies (Perrow 1984).

Market-for-knowledge vicious circle. This was the case with Infosys' intervention to jumpstart contributions to KShop through the KCU incentive scheme. The incentives worked in that contributions to KShop increased significantly. Unfortunately, however, contributions began increasing faster than the system's ability to review them for

quality. Moreover, some employees were so incentivized that they began articulating "more than they knew." The resulting information overload, together with the decreasing quality of knowledge assets available on KShop, increased search costs for users and affected reuse adversely.

This sequence of events bears out observations made by Hansen and Haas (2001) that attention—not information—is a scarce resource. Employees were incentivized to articulate their knowledge, and articulate they did. Ensuing dynamics led to information overload on KShop threatening to disrupt the very virtuous circle that Infosys had generated with considerable effort.

Senge (1990) conceptualized such situations as exhibiting dynamic complexity. Dynamic complexity is inherent in

> situations where cause and effect are subtle, and where the effects over time of interventions are not obvious....When the same action has dramatically different effects in the short run and the long, there is dynamic complexity. When an action has one set of consequences locally and a very different set of consequences in another part of the system, there is dynamic complexity. When obvious interventions produce non-obvious consequences, there is dynamic complexity (Senge 1990, p. 71).

These observations were certainly true of the pattern of relationships at and across the different organizational levels within Infosys. Local actions at each organizational level had global consequences. Short-term results were different from long-term results. Indeed, in real time, interventions such as the KCU scheme appeared to be the obvious ways to proceed, but the non-obvious outcomes, such as information overload, could only be understood over time.

Other potential vicious circles. It is not difficult to think of other vicious circles an organization may confront as it attempts to keep its knowledge system in dynamic balance. For instance, consider the connections between tacit and explicit knowledge. Excessive emphasis on explicating and codifying knowledge can create several pathologies. We have already alluded to the information overload that may emerge when tacit knowledge is first explicated and then stored in digital repositories. In addition, the very articulation of tacit knowledge can end up trivializing it (Polanyi 1966, p. 20). As Tsoukas (1996, p. 14) noted, "individual knowledge is possible precisely because of the social practices within which individuals engage—the two are mutually defined." As a result, efforts to codify knowledge in an abstract form to enable wider reuse may make it more difficult for colleagues to apply such knowledge across contexts. In other words, codification may paradoxically reduce knowledge reuse instead of increasing it.

Consider another vicious circle. Organizations would surely like to recruit employees for their ability to be reflective practitioners. However, such employees may prefer to create knowledge anew as they deal with problems, instead of reusing the knowledge created by others and stored in digital repositories. In other words, hiring bright individuals who can generate new knowledge might paradoxically reduce knowledge reuse from digital repositories and the potential for increasing returns accruing from such reuse.

Although these vicious circles are only illustrative, they highlight certain properties of the knowledge system. First, the effects of initiatives taken at one level of the system can be felt across different levels. Second, these effects feed back into the system and may get amplified due to the mutually causal nature of processes unfolding at and across levels. Third, effects of specific initiatives are not immediately obvious because of time lags between causes and consequences. As a result, the resolution of a particular problem at a given level or time may create a different problem at another level or time.

These observations highlight a key paradox of knowledge management: that an organization's knowledge system contains seeds of its own

destruction. Leave it alone, and virtuous knowledge circles may never materialize. Intervene to couple processes at and across different levels, and vicious circles are bound to emerge.

Steering the Knowledge System

Given these dynamics, what role should knowledge managers play in supporting their organization's knowledge system? An answer to this question requires an appreciation of the mutually causal processes that constitute an organization's knowledge system. Despite the almost axiomatic nature of this statement, many knowledge managers continue to think in terms of straight lines when "reality is made up of circles" (Senge 1990, p. 70). Consequently, many of their interventions are based on a linear view of relationships between variables wherein changes in one element of a system are expected to lead to a proportionate change in another (Mohr 1982). According to Weick (1969, p. 81), "managers continue to believe that there are such things as unilateral causation, independent and dependent variables, origins, and terminations."

In situations characterized by dynamic complexity, as is the case with an organization's knowledge system, solutions based on a linear way of thinking can often exacerbate the problem instead of solving it. Specifically, a change in one part of a system can have a disproportionate impact on a different part of the system in a subsequent time period and the interactions between the parts can generate negative outcomes. By the time such outcomes are understood, the system has often already locked itself into a vicious circle.

To handle mutually causal processes, therefore, organizational interventions need to be *processual* (Massey et al. 2002, p. 287). In other words, interventions need to address process drivers and the ways in which these drivers interact with one another over time (Drazin and Sandelands 1992; Pettigrew 1992; Tsoukas 1989). As Senge (1990) pointed out, this mindfulness entails seeing beyond local *detail complexity* to identify *dynamic complexity* in the broader knowledge system.

We offer steering[4] as a processual way for knowledge managers to address these dynamics. Just as experienced drivers switch from cruise control to active steering at busy intersections or congested roadways, knowledge managers need to proactively anticipate emerging pathologies within the knowledge system and steer around them. Steering also implies an ability to extricate an organization that inadvertently finds itself mired in a vicious circle.

Steering around vicious circles. To steer, knowledge managers must first develop sensitivity to the dynamic complexity inherent in their organization's knowledge system and to the onset of vicious circles (Senge 1990). This requires an epistemology that recognizes the web of mutually causal processes constituting the knowledge system. It also means forsaking the traditional linear view of understanding phenomena in terms of necessary and sufficient causation (Mohr 1982).

Such a shift in mindset redirects attention to the inherently distributed and diverse nature of knowledge processes across different levels of an organization (Hutchins 1995). An implication is that knowledge management cannot be centralized in one person. No one person can possess the diversity of perspectives and the cognitive ability to interface with the many distributed and mutually causal knowledge processes constituting the knowledge system. Instead, consistent with the principle of requisite variety (Ashby 1965; Morgan 1986; Shannon and Weaver 1949), management of knowledge within an organization is best left distributed among a team of individuals with diverse epistemic leanings.

Steering out of vicious circles. An organization may find itself trapped in a vicious knowledge circle despite steering. As Masuch (1985, pp. 22-23) noted,

[4]In using the term *steering*, we have been influenced by the work of Kemp et al. (2001) on strategic niche management and policymaking as a process of socio-technical change.

> Vicious circles lead an absurd existence since everyone should avoid "deviation-amplifying"[5] feedback. Yet, once caught in a vicious circle, human actors continue on a path of action that leads further and further away from the desired state of affairs.

Likewise, with regard to such vicious circles, Kanter (1977, p. 249) observed that "it is hard for a person to break out of the cycle once begun."

How, then, might knowledge managers steer the knowledge system out of a vicious circle? One way would be for them to identify and decouple system processes that may have triggered the vicious circle (Starbuck 1996; Weick 1969). Actions by Infosys to decouple the association between monetary incentives—its KCU incentive scheme—and its employees' knowledge behaviors is an illustration of decoupling. Such decoupling breaks the deviation amplifying feedback loops driving the vicious circle, thereby affording knowledge managers an opportunity to steer out of it.

Knowledge managers could also introduce deviation counteracting feedback loops through interventions in other parts of the system. Deviation counter-acting feedback loops arrest the tendency of the system to drift further and further away from the desired outcome (Masuch 1985; Senge 1990). In the case of Infosys, the institution of the KM prime and knowledge champion roles and automated tools for extracting knowledge from redesigned forms and project templates constitute efforts to counteract the negative impact of time pressure on the extent of knowledge codification.

In summary, a systems view of knowledge management sensitizes knowledge managers to the fact that vicious circles may emerge despite and even because of their best efforts. At the same time, it affords them the potential to dynamically steer around or out of vicious circles when they arise. In doing so, it offers an epistemology that departs from approaches that either grant knowledge managers primacy over organization-wide processes or afford them no such agency.

[5]Deviation amplifying feedback progressively leads a system further and further away from intended outcomes. Therefore, it increases the deviation between intended outcomes and realized outcomes over time.

Implications and Conclusion

Knowledge is key to the continued vitality of organizations, but managing knowledge as an organization-wide resource is not easy. What is it about knowledge that entices yet entraps those who try to manage it for increasing returns? Our in-depth analysis of events and experiences at Infosys offers several insights into the nature of the challenges that organizations confront in harnessing knowledge. First, an organization's knowledge system comprises mutually causal processes that unfold at and across different organizational levels. Second, these mutually causal processes generate opposing forces that need to be balanced dynamically to generate a virtuous circle. Third, an organization's knowledge system contains seeds of its own destruction, as the very initiatives that the organization undertakes to generate a virtuous circle have the potential to generate vicious circles as well. Fourth, knowledge managers must intervene processually to steer their organization's knowledge system around and out of vicious circles that are bound to emerge.

Underlying these insights is a systems view of organizational knowledge. Such a systems view opens up new avenues of research on knowledge management. For instance, consider studies that explore specific approaches to building an organization's knowledge system. Among others, these include (1) an approach to knowledge creation that stresses the role of individuals, (2) a communities of practice approach that emphasizes informal relationships based on shared language and thought-worlds, and (3) a repositories-based approach that emphasizes codification and central storage of organizational knowledge. From a systems perspective these different approaches are constituent pieces of an organization's knowl-

edge system rather than stand-alone pieces. From such a perspective, it would be instructive to explore how these constituent pieces interact with one another to enable or impede the generation of virtuous circles. More specifically, it would be interesting to explore the differential conditions that create complementarities or substitutive effects among knowledge derived from repositories, communities, and creative individuals.

Indeed, a systems perspective offers a wealth of opportunities to explore and mitigate specific tensions that may arise within and across organizational levels. For instance, consider the impact of knowledge codification on reuse. Explication through codification has the potential to divorce the codified knowledge from its context, thereby inhibiting the propensity of employees to reuse knowledge from organizational digital repositories. How might knowledge be represented to enhance the propensity of employees to reuse codified knowledge from digital repositories? Or, consider the effect of time and work pressures on knowledge management processes and outcomes. Such pressures may reduce employees' propensity to share information with one another. In such a case, how may technological tools, work practices, and social mechanisms be integrated to alleviate the tensions that time and work pressures generate?

At its core, a systems perspective offers a certain epistemology for conducting research on knowledge management. First, by focusing our attention on mutually causal processes and dynamic complexity, a systems perspective shifts the emphasis of research to an exploration of processes and their drivers. In doing so, it underscores the importance of employing longitudinal approaches to research. Second, a systems perspective raises the possibility that, despite management's best efforts, vicious circles are just as likely to emerge as virtuous circles. Accordingly, it sensitizes researchers to the possibility of unanticipated negative outcomes in the context of knowledge management. Only if we pay attention to these facets can we fully appreciate the challenges and potential of managing knowledge as an organization-wide resource.

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