Modeling the Sustainability of Knowledge Management Programs

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Abstract

In this paper we explore the processes that create sustainable Knowledge Management (KM) programs. Much of the extant KM literature is advocacy or case description. There have been few attempts to look at success or failure as *the result of the combination of endogenous forces that place KM in the context of the firm, and affect outcomes over time.*

This paper starts by describing a causal model that links a firm's staff and resources to the firm's ability to develop a knowledge repository, and the effects of this repository on the knowledge available to members of the firm. This model was developed through literature review combined with case study and 26 intensive interviews conducted at two international IT consulting firms.

This model is formalized through the use of system dynamics simulation. It produces behaviors characteristic of successful knowledge management programs. Under alternative conditions, the model illustrates unsustainable outcomes. These outcomes are characterized by decay and marginalization of the knowledge management program.

Knowledge management experts at one of the case study firms reviewed the results of the model through a set of structured interviews. Analysis of the interviews demonstrated that the model depicted plausible behavior for both the sustainable and unsustainable scenarios.

This work contributes to the knowledge management literature by identifying and simulating the interaction between the knowledge-generating processes of the firm and its own dynamics. This simulation may be used to understand *how knowledge management programs are embedded in the larger environment of the firm, and how that environment is in turn affected by the ability to manage knowledge successfully.*

I. Introduction

Knowledge management (KM) is growing up. Advocacy has begun to give way to more comprehensive perspectives on what constitutes useful theory and effective process, and how to preserve the advantages gained through its use. Early authors helped us understand the organization of tacit and explicit knowledge, its value in knowledge-intensive industries, and how knowledge influences our ability to maintain and develop our organizations [1-3]. They told of the untapped knowledge leverage within our firms if we could properly evaluate it, organize it, and apply it [4, 5]. Senior managers were convinced; In 2001, Bain & Co.'s annual survey of management tools found that 32% of their survey respondents were using KM, up from 28.5% the previous year [6].

As more firms experimented with KM techniques, anecdotal evidence about the difficulty of launching and maintaining a KM program emerged. In the same survey, Bain & Co. reported that 12% of firms defected from their previous KM program, and that managers were less sanguine about the results of KM than other management tools (*ibid*). What might be causing this result? If we look at the hypothesized reasons for KM failure in the case study literature, we might think of attributing it to the challenge of developing a sharing culture, the presence of rewards for participating in knowledge sharing, issues of leadership, oversold technology, uncertain quality of information captured, or even shifts in management fashion [7-10]. It has also been argued that KM has been subsumed into the culture of organizations, and no longer detectable as an independent activity. These insights have merit and contribute to our understanding of KM success and failure [11].

In contrast, some authors discuss a more systemic perspective on KM. Holsapple and Joshi [12] noted the need to "investigate linkages between resource, managerial and environment influences… and the outcome of KM conduct". We agree that the observations on the influences behind success need to be linked through a common perspective. KM does not exist in a vacuum; it is linked to the operations and dynamics of the firm [13-15]. Such a model of KM should be linked to how the firm uses and generates knowledge over time. It should reflect the re-use of knowledge, in a highly leveraged but not inexhaustible way. Finally, how individuals and the firm react to the availability and efficacy of collected knowledge on their own work needs to be considered. Without

understanding the processes in which KM is embedded, it is difficult to account for its behavior or results.

This paper provides a framework for linking the knowledge-generating processes of the firm and its own dynamics into its knowledge management program. The framework was developed through intensive case study at two multi-national information technology (IT) consulting firms. It is operationalized through a simulation model that formalizes the structure of KM in a hypothetical knowledge-intensive firm. Later in the paper we show how under different conditions the simulation demonstrates either sustainable or unsustainable KM outcomes. We conclude with a discussion of the implications of this work for KM managers.

II. Why Sustainability Matters

Getting a KM program started in an organization requires several parallel activities. From the literature we understand that there are enabling architectures and infrastructures that must be in place. Reward structures need to be established to encourage participation. A common epistemology that allows for the linkage of diverse sources is useful. Screening contributions for quality and vetting proprietary and confidential content is required. These activities move KM towards acceptance and integration into business operations.

Yet for all these challenges, launching a KM program is just the first part of a longer process. Continued funding and participation depends on what the program achieves over time. Quantification of these results is notoriously difficult to establish. In some cases, direct effects to productivity and outcomes can be measured [16]; in other cases, non-financial measures have been proposed [4].

Whatever the measurement technique, sustainable KM programs must provide value to users over time. Managers paying for these programs weigh these results in the face of the economic constraints of the firm, and they must choose to continue or de-emphasize the KM efforts as the fortunes of the firm shift. Successful KM programs may start well, achieving highly leveraged knowledge transfer. As the programs grow, however, concerns about the incremental value of the knowledge, its timeliness, and changes in individual motivations, among others, start to cloud the perceptions of effectiveness. The ongoing success of these programs depends balancing all of these expectations over time.

Endogenous dynamics exist in the environment of knowledge, and its inherent structures affect KM's influence on the firm. Knowledge and knowledge artifacts are continuously generated as part of the firm's operations [13]. As with other assets, though, their value accumulates from investment, or decays from neglect [4, 17]. In addition, the firm faces challenges to its accumulated tacit knowledge from staff turnover, as departing individuals take their experience and collected wisdom with them [15].

There is a life cycle to collected knowledge. Cutting edge techniques become commonplace and market data becomes stale. The knowledge program may move towards specific topics, rather than general concerns. After the initial identification of widely useful knowledge, less universally valuable information is often captured and disseminated. The incremental effect of new knowledge can be less than early "blockbuster" ideas. Recognition of these changes shifts efforts away from collection and facilitation and towards cleanup and refreshing the content of information. Changes in customer demand require new perspectives that render older concepts out of date. [18]. Firms that engage in knowledge management have the opportunity to support its accumulation and diminish the effects of decay.

Even with an active program of knowledge refinement and refreshment, the accumulated knowledge often becomes less useful over time. Let us illustrate the effects of this idea with a hypothetical example (Figure 1). While there are always timeless nuggets of wisdom within a firm, many deliverables, reports, and techniques have a limited lifetime. In our work, we have been told that some market information has a useful lifetime of months, and technical information of a year or less. We might expect, therefore, that rather than creating unconstrained benefit, a KM system might start with increasing changes to staff knowledge. Initial enthusiasm and benefits to staff knowledge can peak and level off as a balance between the positive effects of KM and costs of maintenance grow. Alternatively, if the firm is unable to keep pace with the changing quality and value of its knowledge assets, the KM program stumbles. In the absence of corrective measures, these changes can cause user disillusionment, cascading into a loss of financial support, and ultimately failure.

Resting on a body of collected wisdom is not sufficient in knowledge-intensive industries. Instead,

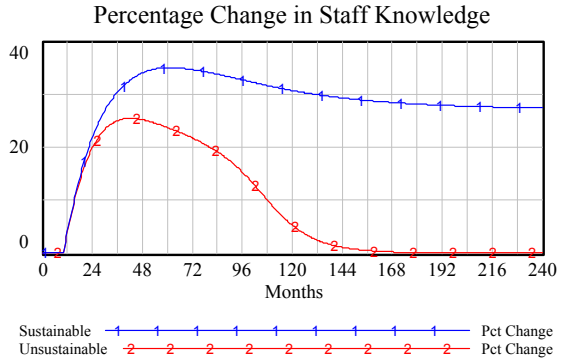

Figure 1: Hypothesized Sustainable and Unsustainable Effects of Knowledge Management

firms must somehow identify the attrition rate of collected knowledge, the demand for its replacement, and a technique for satisfying its knowledge users and the managers who allocate funds for KM support. In the next section we discuss our approach to identifying the dynamics underlying sustainable KM.

III. Investigating Sustainability

In order to investigate the dynamics of KM programs we were fortunate to obtain the confidential assistance of two very large IT consulting firms. We interviewed 26 managers and KM professionals at these firms over a period of years, attempting to discern how their operations and their perceptions about knowledge management changed. IT consulting firms were chosen as the focus for our theory building because of the critical importance of KM to their operations and their early adoption of the idea. Their internal IT skills allowed them to overcome the technology hurdles that discouraged many other attempts. They also recognized the organizational and social issues that came with information sharing, with strong leadership from the highest levels of the organization that included explicit and implicit incentives for staff participation. In addition, the firms believed that their cultures supported information sharing, at least to some extent, within co-located or cooperating workgroups. This combination of sophisticated infrastructure support and growing recognition of the social dimension of KM made these firms particularly good sites for this research.

Out of these interviews emerged an understanding of the forces that underlie KM sustainability. At the start of this fieldwork, these two firms were at the peak of the Internet boom, facing the happy problem of too much work for their existing staff[1]. At the same time, those individuals in the firm who had the most marketable skills were being tempted to leave. The KM business problem was to extract and retain as much of the rapidly emerging tacit knowledge as possible, and transferring it to newly hired junior staff. Later, with the precipitous burst of the IT market, the KM programs were struggling to maintain their presence and effectiveness in the face of severe internal cost cutting.

This swing in KM fortunes helped illuminate how successful programs respond to challenges from within the firm and its environment. In these firms, much of the KM activity worked within two common implementation models: managing knowledge as an asset through explication and distribution, and managing knowledge as a facilitated social network, using communities of practice, skill directories and other communications tools [19]. At first, efforts to collect deliverables and project materials were dominant. Over time, one firm became overwhelmed with the volume of materials being submitted, and had to cut back severely on the scope of its formal knowledge capture program. The other, with a slower rollout, managed growth somewhat more elegantly, even though many staff were eager to be recognized as participants.

The growth of contributions to the knowledge system did not directly correspond to a growth in its effectiveness. Knowledge managers found that many contributions were redundant. Project deliverables submitted for inclusion in the knowledge management systems were found to duplicate previous submissions from other projects, or required severe redaction before they could be shared. Individuals searching knowledge bases often limited their search to the most readily available materials, further reducing the effect of size on knowledge.

Both firms used panels of experienced staff to help screen the content for accuracy and widest applicability. There was some uncertainty about the number of topics to be covered, and how deeply each should be investigated. Searches were often constrained by the time available to act on information, rather than complete satisfaction of the information request. KM managers, learning of this behavior, shifted their knowledge organizational techniques to meet this "grab and go" modality by improving indexing and keyword tags, further increasing the maintenance burden. The KM managers were trying to adapt their content and organization to the search behavior of the users.

Interestingly, in these two companies, there was much regret that the KM management was unable to establish convincing links between the use of the knowledge management system and financial productivity, in terms of revenue per staff hour. Such a link would have been quite desirable, as it more readily translates soft benefits to hard dollars. In several of the interviews, the perception of knowledge usefulness was based on improved quality of output, not quantity.

In both firms few resources were solely dedicated to KM. Most project teams had a designated staff role that coordinated knowledge reporting, along with other responsibilities. Many of the knowledge contributions were artifacts developed during project work. A few experts in the various subject areas did review of project contributions and managed discussion fora. During the early years, staff were taken off billable tasks to perform these efforts. When the firms became more sensitive to costs, these paid positions disappeared, and more content work was done by volunteer efforts by senior executives, rather than mid-level managers.

[1] Interviews with KM managers, HR executives and line staff were conducted at the first firm from 1998-2000, and from 2000-2002 at the second firm.

Moving responsibility for KM to senior managers had several secondary benefits that contributed to sustainability. First, it changed the focus of the KM efforts. Partners exerted more control over content than before, with more resources going away from task fulfillment and more towards market intelligence and project control topics. Second, it brought direct benefit to the people who made funding decisions about KM activities. When turnover and knowledge transfer were the driving forces behind KM, junior staff were the primary beneficiaries, and managers and partners made decisions about funding based on the secondary perceptions of benefits. Now, as the partners received more direct benefit, they could apply the newly limited resources to the areas that had most direct interest for them.

The success of the KM programs at both firms increased the demand for more KM activities. The rapid uptake of the technology was followed by requests for increased topical coverage, as well as a large increase in requests for informal knowledge sharing. At the same time, the increasing demand for KM increased costs. The problems of organizing and classifying contributions emerged as the volume of contributions accelerated. Staff were eager to submit their work for inclusion when incentives were provided, and this put additional pressure on the knowledge managers to review and edit contributed materials, reducing the time available to develop new materials.

IV. A Feedback Model of KM Sustainability

Both the literature and our own fieldwork provided ample evidence that KM programs are part of a complex system that linked the knowledge activities of staff, the firm's efforts to leverage its collected knowledge. Within these programs are endogenous forces that change the value of the collected knowledge to the firm over time, which contribute to KM program success or failure.

This perspective of KM effects is summarized in a causal loop diagram (Figure 2). It shows the relationships between three interacting feedback processes: staff knowledge development through work experience, the effects of a KM system, and the influence of satisfaction on KM resource availability. Later in the paper we discuss how this model can be simulated and the results of that simulation.

Staff knowledge development. Assume for the moment that a firm has a stable staff level. They apply their time and collective knowledge towards the completion of tasks. Staff and staff knowledge are linked, as individual knowledge is retained tacitly. As staff complete tasks, they gain additional experience and knowledge, which in turn helps them complete future

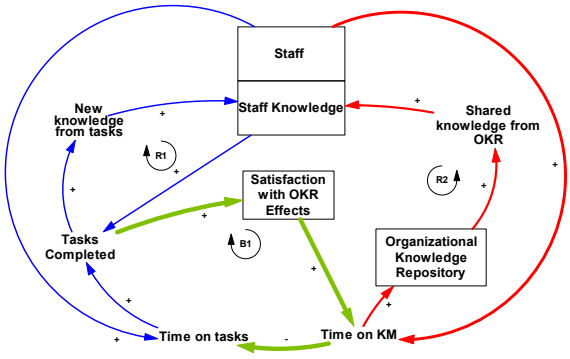

Figure 2: Causal Loop Diagram of KM effects of Staff Knowledge

tasks, improve the quality of their work, or in other ways advance their individual skills. This task completion loop (R1), is reinforcing, in that the more time spent on tasks the more new knowledge accumulates. Not all agree that experience always contributes to knowledge; it is possible to repetitively perform rote tasks, without gaining incremental knowledge. It has also been argued that experience does not become knowledge until it has been fit into a framework of understanding. Nevertheless, within firms where knowledge tasks are preeminent, it is fair to assume that there is some basic positive association between accumulated experience and the knowledge asset. See [20, 21] for a discussion of various non-linear learning curve formulations.

KM effects. The introduction of a knowledge management system requires the diversion of staff from their regular work activities and redirecting them towards KM work. Staff time spent on knowledge development contributes to a repository of documents (referred to as an OKR, for Organizational Knowledge Repository), though it is not a stretch to think of tacit knowledge and interpersonal connections in a similar context. Shared experience is captured, codified, and available to staff as organizational knowledge. Its use supplements personal experience, which in turn reinforces task completions, and generates additional knowledge (R2).

Satisfaction with OKR effects and Resource Allocation. In our simple model, the loops R1 and R2 represent forces in competition for a scarce resource, the staff time available to the firm. Both task completion and organizational knowledge development rely on staff time, with an increase in one necessarily causing a decrease in the other in our fixed staff environment. If satisfied with the effects of KM on their work, staff will encourage sustaining or increasing its use.

In a sustainable KM environment, the use of KM produces a positive effect on the rate of task completion. This would produce an increase in satisfaction with the

KM program, which would create pressure to shift additional resources towards KM, and away from work on tasks. At some point, however, shifting staff off tasks drops the dropping level of task completion will reduce the satisfaction on the knowledge program, and the time on knowledge management will be limited. This loop (B1) has a balancing effect on the resource allocation between task and knowledge work.

There is also an inkling of how the same structure applies to a failed KM effort: a change in the KM program or environment that reduces user satisfaction can cause KM efforts to decrease. A decrease in KM efforts might further reduce KM effects on the firm, which sets off a reinforcing cycle of where reduced KM effects further reduce efforts until they reach a marginal level.

In the two firms we studied, and in discussions with senior executives of other consulting firms, KM was not seen as a vehicle to reduce staff; rather, staff levels were determined by the current and pending backlog of business contracts, and KM was used to improve the rate of task completion and the quality of results in an increasingly competitive climate. Few, if any, staff were hired specifically for KM work; rather, individuals between projects, on part-time status, or on special assignment worked in KM management. This led to some inconsistencies in KM content and effectiveness, and the KM management would have preferred dedicated staff, or at least more general exposure across the firm to the maintenance aspects of their programs.

V. A Formal Model of KM Sustainability

The feedback model shows how sustainability might be achieved, but it is insufficient to understand when and how this occurs. We use the discipline and notation of System Dynamics [21] to describe more specific structures that flesh out how the effects of staff turnover, experience and learning, the development and use of KM, and the factors that affect satisfaction and staff allocation.

Staff and Staff Knowledge. In the simulation, we distinguish between two types of staff within our hypothetical firm. Staff join the firm as juniors; after a few years, some staff are promoted to senior staff; most leave the firm. Over time, these senior staff also leave the firm. Departing staff, whether junior or senior, are replaced by new hires (Figure 3). This maintains the stable level of staff over time needed to isolate knowledge effects from firm growth. For the purposes of this simulation, we continue to hold staff at a constant level.

Staff knowledge, possessed tacitly by these individuals, is modeled as a co-flow of staff. Knowledge accrues to both juniors and seniors based on their work experience. When staff leave the firm, their contribution to the stock of staff knowledge they carry with them leaves as well, so that there is a continual drain of knowledge. Knowledge also decays over time, whether through forgetting, obsolescence or other factors. This creates a "leaky" co-flow, where knowledge is not conserved as staff move through the aging chain. The particular formulation for knowledge decay is a first-order exponential smooth; in the presence of a constant flow of knowledge, this creates the desirable and realistic behavior of diminishing returns of experience to knowledge.

KM and OKR development. In the simulation model, only senior staff can be removed from task work and placed on knowledge management work. This time is spent on developing new materials, synthesizing contributions of others, sanitizing confidential information for wide distribution, modifying existing materials, or removing information that is no longer relevant. It is assumed that as senior staff work on KM, they do not add to their experience-based knowledge.

Once in place, these materials enter wide circulation and become established knowledge. Over time, the materials age and become obsolete. These obsolete documents may be discarded, or staff effort may be spent revising them to the current state of knowledge (Figure 4). The age of the average document is also tracked as a surrogate for the timeliness of the OKR contents, with relevance diminishing over time. When a document is reviewed, its relevance is refreshed.

The simulation also includes structures that support the concept of topicality. A quality repository provides information on topical issues. Concentration on a small number of topics limits the usefulness of the materials when there are many knowledge gaps to be filled. Shallow coverage of topics may not provide enough flexibility and insight into a problem. It takes time to

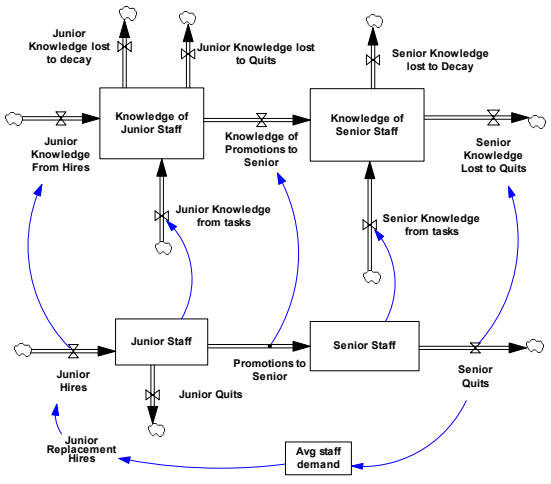

Figure 3: Staff and Staff Knowledge Aging Chain / Co-Flow

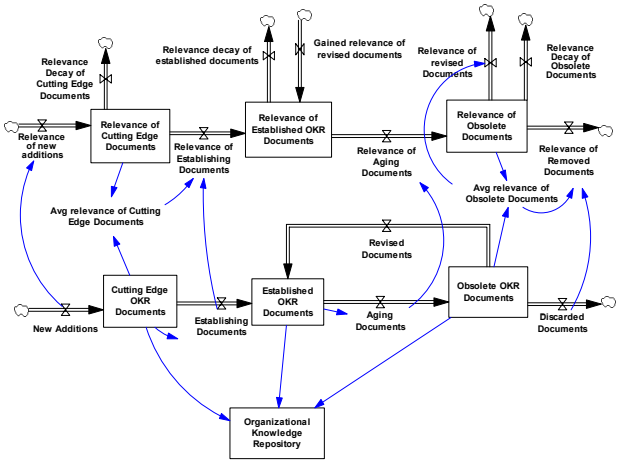

Figure 4: Organizational Knowledge Repository Aging Chain / Co-flow

develop a rich repertoire of topics. We have modeled coverage as a function of repository size, relative to a desired number of topics. The desired number of topics grows over a period of time to a maximum, reflecting the growth in expectations for coverage that occurs after the program is launched.

Learning from the knowledge repository. Our model specifies that the effects of the KM program accrue only to junior staff. Reading a document, re-using a deliverable as a model for current work, or combining presentations provides them incremental experience beyond their actual work efforts. Successful KM is the equivalent of gaining vicarious experience, obtaining the benefit without spending the time needed to learn first-hand. This is the crucial discrete leverage point, where junior staff can be almost as successful as senior staff by obtaining guidance and concrete examples. The dynamic leverage to the firm comes as the same guidance and examples are re-used over time.

This perspective allowed us to operationalize the learning effects of a KM system. First, use of the knowledge repository by junior staff transfers experience. This new experience combines with the user's own first-hand experience to produce elevated knowledge. The diminishing returns constraint still applies: Users gain experience faster than without KM, reaching their knowledge potential sooner, but they end up with as much knowledge as they might have achieved from experience alone.

User and managerial satisfaction. The final element in the simulation is the evaluation of satisfaction and its effects on resource allocations. In the simulation we identify two types of satisfaction. The first, user satisfaction, arises from the response of junior staff to the availability of KM, its timeliness, and its topical coverage. The second type, managerial satisfaction, compares perceptions of user satisfaction against the cost of diverting staff from their normal workload. We have chosen to model this cost as forgone knowledge, rather than as a financial measure, so that benefits and costs may be directly compared.

The two components interact to create the feedback that established how resources are applied. For example, increased user satisfaction increases perceived benefits, and increases demands on the KM system. This creates pressure to add resources to its development. In turn, this pressure adds additional costs to KM by diverting staff from their normal, knowledge-generating tasks, which reduces managerial satisfaction. Managerial satisfaction in turn determines the allocation of resources to KM, which affects its quality, and in turn user satisfaction.

VI. Simulation of knowledge dynamics

Our goal for the simulation was to develop and illustrate scenarios for KM programs that linked knowledge activities and the environment of the firm, using the feedback model and concepts described earlier. Through these scenarios we hoped to explore and confirm the mental models of KM manages about how these factors interact. In the absence of live data, we used hypothetical data to parameterize the model. The parameters support representative scenarios that show sustainable and unsustainable knowledge management programs, with the hope of obtaining more insights through extended discussion. Through these simulations we found that while sustainability may be achieved, the dynamics of the system can send a program from an apparently successful start into one that falls into failure. We present below an example of sustainability and two other examples where changes in the expectations of users, and the decay rate of knowledge alter the outcome.

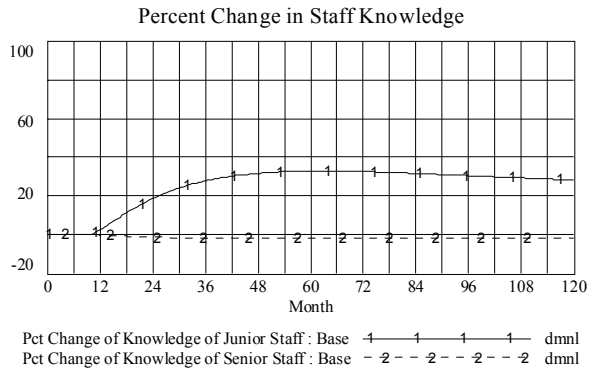

Figure 5: Simulation of effect of KM Program: Base Run

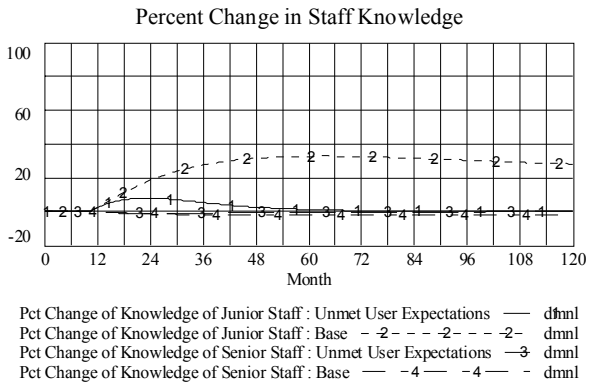

Figure 6: Simulation of effect of KM Program: Unmet User Expectations vs. Base Run

The simplest evidence of sustainability is the long-term effect of the KM system on staff knowledge. Our model runs are calibrated so that there is no net staff gain and the knowledge lost to turnover is equal to the knowledge gained from task work[2]. When KM is introduced, any changes in staff knowledge are therefore attributable to the KM program itself. Our initial run, labeled "Base," shows the effect of KM on both junior and senior staff knowledge. The KM program is introduced at time 10 with a small repository. Once in place, the percentage change in junior staff knowledge grows for several years (Figure 5, item 1). This change is accompanies by an acceleration of interest in KM by the organization, which further boosts its use and funding. At time 60, about 4 years into the simulation, the KM effects peak, and slowly fall off to a point where the average junior person is about 35% more knowledgeable than before the KM program was introduced. Senior staff, on the other hand, lose some small fraction of the knowledge that they might have attained from new work (Figure 5, item 2).

The KM system continues to exert a positive influence on junior staff knowledge throughout the simulation. This influence is sufficient to generate user satisfaction, and a stable level of KM resources, even as the repository ages and efforts shift towards maintenance. In the terms of the model presented in Section IV, a balance between Loops R1 and R2 is achieved that allows the firm to continue its task work and maintain its KM system, with a higher level of knowledge than before.

A change in user expectations can upset this balance and shift the system from sustainability to failure. In the "Unmet User Expectations" scenario we increased the user expectations for the knowledge effects of the KM system. These effects come from the relevance and timeliness of the available materials as well as the number of topics in place. The result was a KM system that produced positive effects at first, and then fell into disuse, as the Percentage Change in Junior Staff knowledge fell back to 0 (Figure 6, item 1). In this case, Junior Staff knowledge increased about 10%; while users were learning from the materials in the repository, there was a smaller acceleration of user interest in KM than in the Base scenario, and fewer resources were shifted to develop topics and materials (Figure 6, item 3). Once the materials started to age, user interest continued to fall off, and resources started shifting away from KM activities. This in turn further reduces the firm's ability to maintain the collected knowledge, further reducing the benefits received. Referring back to Section IV again, the shift of resources away from KM and back to tasks reinforces the pressure to do task work and abandon the KM activities. Eventually, both the junior and senior staff perceive little benefit from the program, and the program is shut down.

In another scenario, "Fast Decay Knowledge" we assumed that the firm was collecting a mix of materials that, while valuable at first, lost its usefulness more quickly than the base parameters. In this case, the initial reaction to the KM program was positive and similar to that in the Base, with junior staff knowledge rising about 22% over what experience alone provided. After a few years, however, the drop in repository quality shifts resources away from creating materials and towards maintenance (Figure 7, item 1). Without materials on emerging concepts, the knowledge effects start to fall. Towards the end of the simulation, the user satisfaction also drops, which begins a shift away from KM use, and ultimately causes the demise of the program.

Expert Scenario Review. After the simulations were formulated, we again contacted our KM experts to discuss the scenarios and the implications of the systems approach. These discussions, conducted individually through a structured interview format, largely confirmed

[2] The detailed simulation, named KNOWLEDGE1, is available from the authors upon request.

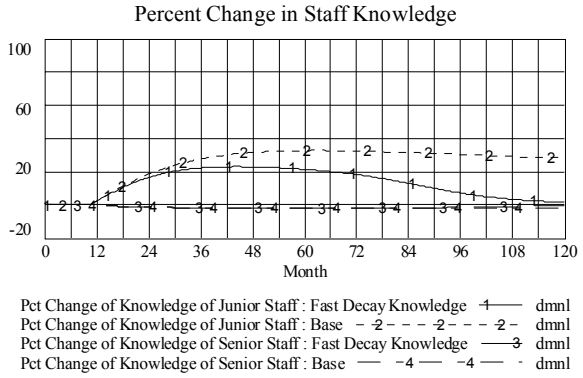

Figure 7: Simulation of effect of KM Program: Fast Decay Knowledge vs. Base Run

our causal assumptions. There was mixed support for the synthetic outcomes of the Base scenario. Comments included the observation that much of the knowledge growth occurred in the first few years, and then stabilized. Our informants would have thought 3-5 years would be necessary to establish a successful program. There was wide agreement about the alternative scenarios, and the process by which they can fall into a "death spiral". A final major concern was the (intentional) absence of corrections by KM managers when there were indications of dropping user expectations. Our interviewees indicated that firms might be able to act more speedily to correct falling quality or expectations.

VII. Limitations of the Study

This study has several weaknesses that constrain what was achieved, and what inferences can be made from its findings. While the use of the combination of interview and simulation gather and analyze data helped mitigate these problems, some important concerns remain.

Limitations of case study analysis. The case study is based on voluntary interviews with staff at two firms. Executives from both firms endorsed the research work, but participation in interviews was voluntary, and access was limited. The potential informants were selected through recommendation, and most were conducted by telephone. As many of the interviewees were active in the knowledge management programs of their firms, there may be some group of skeptical users or managers who were not reached. In addition, the number of informants at each firm was somewhat small (15 at one firm, 11 at the other), raising concerns about the generalizability of their perspectives.

Limitations of causal and formal modeling. The causal model developed in this project has several weaknesses. As an abstraction from the complexities of the real world of knowledge-intensive firms, a certain amount of uncertainty exists around the adequacy of the researcher's synthesis and elicitation of the underlying mental models. In other recent system dynamics studies, group facilitation and modeling techniques have been used to improve the accuracy of the causal models (see Vennix, 1996, for examples). The informants in this study were not able to meet to discuss the model, so the synthesis of their comments fell to the researcher. The use of secondary interviews to review the causal model mitigates this bias somewhat.

The system dynamics modeling process itself introduces limitations and assumptions that must be understood. Some of the structures used in the model, such as diminishing returns of experience to knowledge, are arguably over-simplifications. Without these simplifications, however, models quickly get overly complex, and lose their exploratory value. Alternative formulations may generate different numerical values, if not different behaviors. Some care must be taken to understand the difference between predicting behaviors and predicting values. The important findings from this work are not the percentage differences between scenarios. Rather, the importance comes from the behaviors demonstrated over time, where successful programs boom and recede, and unsuccessful ones boom and fail.

Other knowledge management techniques. A final limitation of the research is the focus on one type of knowledge collectivity, a document repository. It has been argued that informal knowledge networks provide important contributions to sharing and trust. In some environments, these networks may be more important than formal codified knowledge. It may be argued that the model constructs of knowledge timeliness and relevance and satisfaction may be applied to communities of practice and other knowledge management approaches. Until this is further considered, its absence must be considered a further limitation.

VIII. Contributions of this work

This work adds to the KM literature by creating a framework for understanding how the endogenous dynamics of knowledge combine with user expectations and allocation decisions to produce sustainable or unsustainable results. The simple causal model presented in Section IV shows the role of feedback in this process. The simulation model, described in Section V and reported on in Section VI, puts these feedback elements into place for consideration by KM experts. The importance of the interrelationships between the KM program and the firm should not be overlooked, and parallels the insights of the importance of corporate culture in understanding KM outcomes.

Developing the simulation environment is a second important result from this work. While others (notably [22] and [23]) have developed feedback-based simulations of the effects of knowledge on the strategic planning of firms, this model may be used to provide insights for mangers of knowledge programs about the effects of changes in their environment on their programs. This is of particular interest in the consulting arena, where the rapid switch from high market growth to a rather sustained period of market doldrums has played havoc with KM programs.

This type of model may be used to investigate questions of KM approach and strategy once recovery begins, and help managers anticipate the outcomes. It may be used to show the effects of shifts in staff levels on knowledge leverage, and support changes in KM staffing and emphasis. It also depicts the importance of focusing on user satisfaction in KM, and how that satisfaction must be continually med and monitored to ensure success in the face of changing requirements that are difficult, if not impossible to identify ahead of time.

IX. References

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