SUSTAINING EMPLOYEE PARTICIPATION:
THE CHALLENGE OF TIPPING POINT DYNAMICS

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ABSTRACT

Widespread employee engagement is the cornerstone of success for many successful firms, but many others firms struggle in their efforts to engender it. This paper draws on extensive fieldwork at a manufacturer adopting practices of the Toyota Production System (TPS) to explore transient success in employee engagement and develop theoretical insights concerning the nature of the transition problem that arises as organizations attempt to migrate from current practices to new ones. Our analysis yields several critical insights into the process of fostering front line engagement. First, workers were actively involved in generating ideas, but the work of implementing those ideas strained key support personnel, such as plant engineers and maintenance workers at the field site, who were chronically time impoverished and thus challenged to do work while also learning how to work differently. Second, as they modified their work practices to address the mounting workload, they gained short-term benefits at the expense of delayed consequences. Third, the transition problem is rooted in the interaction of the need for learning by doing and the chronic time pressures on the support personnel. The paper develops a mathematical model and uses simulation analysis to explain the observed transient success and to identify a tipping point beyond which the organization transitions to a regime of lasting change. The simulations characterize the transition problem in organizational change: employee engagement can be self-sustaining if enough energy is invested in building their capability for problem solving.
Imitation is a central concept in many strands of organization theory. Imitation occurs when “a firm observes that some other firm is doing things that it would like to be able to do” (Nelson & Winter, 1982, p.123) and attempts to duplicate the target firm’s successful products, processes or strategies. Imitation is said to be a basic mechanism by which innovations spread throughout industries (Nelson et al., 1982; Rogers, 1995).

Institutional theory notes that pressures to conform to orthodoxy foster imitation and clearly identify mimetic processes in the path towards isomorphism (DiMaggio & Powell, 1983). Firms employ imitation as a response to uncertainty especially when organizational technologies are poorly understood (March & Olsen, 1976). Models emphasizing the socially embedded nature of organizational behavior find that inter-firm relationships influence the frequency of imitation of strategies, market entry, anti-takeover defenses, acquisition strategies, and organizational structures (Davis, 1991; Greve, 1995; Haunschild, 1993; Haveman, 1993; Palmer, Jennings, & Zhou, 1993).

Much strategic theory rests on the notion that imitation by other firms reduces overall profitability of an industry and whittles away the ability of successful firms to maintain competitive advantages (Nelson et al., 1982; Porter, 1980).

The centrality of imitation in these academic theories notwithstanding, imitation in practice is more challenging and less reliably successful than these theories seem to consider. Imitation is indeed a widely practiced approach to improving organizational performance. The study of best practices has become an almost standard technique in the managerial toolkit. One recent survey identified benchmarking as the most frequently used tool for process improvement (Dolan, 2003). Some authors herald the merits of the
search for exemplary practices: “Identifying and adopting what others do best is one method of meeting the growing need to find shortcuts to improvement. … Survival and growth depend on continuous learning regarding how to improve quality, reduce costs and time, and increase productivity. Any organization that has developed effective practices which contribute to these outcomes can be studied, and, where possible and suitable, their practices can be adopted” (Lake & Ulrich, 1993, p.2). Yet although firms often adopt innovations in work practices based on studying other firms, the results are often disappointing (Klein, Conn, & Sorra, 2001). Empirical studies document low rates of successful implementation of innovations ranging from process improvement technologies such as total quality management (TQM) (Easton & Jarell, 1999; Hackman & Wegeman, 1995) and business process reengineering (Champy, 1995; Hall, Rosenthal, & Wade, 1993), to high-performance work practices in manufacturing (Pfeffer, 1997; Pil & MacDuffie, 1996) and product development (Wheelwright & Clark, 1995) to the use of computerized technologies (Klein et al., 2001), including advanced manufacturing technologies (Zammuto & O'Connor, 1992).

Some research has explored reasons for difficulties in imitation. One class of explanations rests on attributes of the target innovation that make it difficult to imitate, such as compatibility with the adopting organization, observability, trialability, and complexity (Rogers, 1995). Explanations following the resource-based view of the firm similarly consider factors that make imitation difficult, such as impediments to factor accumulation, social complexity, causal ambiguity, tacit knowledge, economies of scale and scope, adjustment costs, and first-mover advantages (Barney, 1991; Dierickx & Cool,
A second class of explanations highlights steps firms take to make imitation less attractive to potential competitors, such as costly commitments and credible threats of retaliation. Offering yet another explanation, Rivkin (2000) proposes that “the sheer complexity of a strategy can raise a barrier to imitation” (p. 825). While each explanation offers some insight, all have as their main focus either the strategy and practice to be imitated or the characteristics of the target and imitating organizations. Such explanations do little to help us understand the fundamentally dynamic nature of intended, inter-organizational imitation. For example, consider an improvement initiative based on imitating another firm’s proven success such as in the adoption of TQM. The tendency for such imitation efforts to run out of momentum is widely recognized (Beer, Eisenstat, & Spector, 1990; Pettigrew, 1998; Pettigrew, Woodman, & Cameron, 2001; Repenning & Sterman, 2002), yet there is little research aimed at understanding the transient pattern of success so frequently observed. Theories that explain both why such an initiative first generates desirable results and then subsequently loses momentum remain largely unexplored.

The purpose of this paper is to explore transient success in imitation and thereby extend thinking beyond the traditional static view in which imitation is primarily seen as analogous to acquisition, importation, or transfer to one in which imitating is more akin to rediscovering, learning, or transitioning. In particular, we explore intended, inter-organizational imitation in the context of implementing widely accepted practices in process improvement.
The setting is a United States recreational vehicle manufacturer implementing practices identified with the Toyota Production System (TPS) and lean manufacturing (Monden, 1981; Womack, Jones, & Roos, 1990). TPS is a particularly compelling domain for this study because it is widely regarded as a superior production system, yet it has rarely if ever been successfully imitated. As Rivkin points out:

“Particularly striking is the ability of some firms to resist imitation despite extensive public scrutiny of their strategies. Firms such as Dell Computer, Southwest Airlines, and Toyota enjoy higher rates of return and faster growth than rivals even though journal articles, case studies, analyst reports, and books by founding executives reveal the ingredients of their successful recipes” (Rivkin, 2000, p. 824).

Moreover, TPS is a participative process improvement technology and thus similar in many regards to other widely studied managerial approaches such as total quality management (e.g., Easton et al., 1999; Hackman et al., 1995; Zbaracki, 1998). The focus of the research is implementation, “the process of gaining targeted employees’ appropriate and committed use of an innovation,” (Klein & Sorra, 1996, p. 1055) which follows the innovation adoption decision.

The research presented here follows the logic of grounded theory building, which begins with field-based case data and induces insights through analysis and theory building (Glaser & Strauss, 1967). The analysis is informed by causal loop diagramming and formal modeling in the system dynamics tradition, an approach that is achieving increasing prominence in organization studies (e.g., Perlow, Okhuysen, & Repenning, 2002; Repenning, 2002; Repenning et al., 2002; Sastry, 1997). We chose the combination of grounded theory building and system dynamics because of our interest in looking for connections between situated behavior and macro level outcomes (Weick,
Grounded theory brings the work of improvement activity into the foreground (Barley & Kunda, 2001), and system dynamics is an ideal complement because the phenomenon we are exploring unfolds over time.

The major results from the study were theoretical insights concerning the nature of the transition problem that arises as organizations attempt to migrate from current practices to new ones. The first insight concerns the importance of conceptualizing the development of new individual skills and organizational capabilities as a dynamic process of learning rather than as a static event such as an acquisition of knowledge or an endowment of skill. The need for sustained practice over time to learn by doing new skills renders inadequate a view that required skills can be gained through a mechanism that confers instant benefits. Second, from a close examination of how the work of improvement activity gets done I found that support personnel, such as plant engineers and maintenance workers at the field site, were chronically time impoverished and thus challenged to do work while also learning how to work differently. Mounting workloads placed significant pressures on these individuals that dissuaded them from attempting new ways of working. Third, by analyzing the implications of these first two points in combination, I learned that the transition problem is rooted in the interaction of the need for learning by doing and the chronic time pressures on the support personnel. By finding ways to meet the immediate need to accomplish the instrumental tasks of implementation, they undermined the longer-term learning processes that were needed to accomplish the transition to a sustained preference for new ways of working. As
pressures from mounting workloads favored current practices rather than new ones, the consequence over time was that the organization locked in to the old way of working.

A primary contribution of the paper is to take some steps toward characterizing the transition problem as an endogenously generated, dynamic pattern of behavior over time that arises from the need for learning by doing in the context of ongoing organizational activity. The paper develops a model that illuminates reasons for temporary success followed by loss of momentum, and model analysis shows that small changes can mean the difference between fleeting improvement and sustained success. This perspective contrasts with many in organizational and strategic thinking in which imitation is assumed to be static or nearly so. This dynamic perspective implies that much of the current practice of benchmarking is misdirected at the static, observable artifacts and well-honed (perhaps codified) practices of imitation targets rather than at the critical learning processes central to successfully navigating an organizational transition.

Similarly, the transition problem suggests a path toward bringing the implicit assumption throughout much of organization theory that imitation, although costly, is simple, automatic, straightforward, and static into better alignment with the experience of practitioners that imitation is difficult, uncertain, complicated, and dynamic.
METHODS

The site of the research is a plant that makes parts and assembles engines at a United States manufacturer of recreational vehicles. In the spring of 2000, the general manager of the plant became interested in “taking [the company] to a new level” of manufacturing performance. He began efforts in his plant to learn about and adopt new practices, drawing heavily on approaches identified as lean manufacturing (Womack et al., 1990) or the Toyota Production System (Monden, 1983). The field research began in June of 2000 in a pre-implementation stage as the general manager was beginning to think about how to introduce new production practices to the company, and continued for more than 20 months.

Data Collection

I collected data through on-site observations, in-depth interviews, and secondary sources. Early efforts focused on understanding the context, setting, and culture within which the focal change efforts were taking place. I spent several days shadowing the general manager and the production managers (direct reports of the general manager) of the facilities. I attended at least one of each of the various meetings that take place regularly at daily, weekly, monthly, quarterly, and yearly intervals as well as several dozen daily production meetings, known as "hot meetings," in which representatives of the various production units and support activities meet at the beginning of the morning and evening shifts to report daily status information and to coordinate activities. I attended many other meetings related both to ongoing plant activities and to the implementation initiative. Audio recordings of some sessions were made; detailed field notes were
recorded for others. I also participated in a group organized by the general manager comprising representatives from both salaried management and elected union leaders at each of the company's six production facilities. The group was chartered to lead efforts across the enterprise to adopt new and better production practices and met monthly for two-day sessions. I attended all of these monthly meetings. Later efforts brought me on to the shop floor observing and engaging in conversations with workers. In several production facilities, I followed the production of key component parts through a production cell, the assembly of an engine along the entire assembly line, and the assembly of a vehicle from start to finish, talking with workers at each step. I spent upwards of 120 days on site, observing managers and workers in their daily activities.

Over the course of this field research, I had many informal conversations or unstructured interviews with informants, recording these conversations in field notes. I gathered documents, electronic files, and emails generated during the course of the research, among other archival data. I also conducted a series of semi-structured interviews with management personnel, union leaders, and front-line workers. The data gathered includes more than 1200 pages of field notes and over 200 hours of audiotapes of meetings and interviews.

To supplement my observations, I interviewed selected individuals who were directly involved with the change initiative. Respondents included the plant general manager, the plant production managers, other members of the plant management team (direct reports of the general manager), both work group advisors for the production cell selected as the pilot area, elected union officials, hourly production workers, members of an
implementation team assigned to the change initiative, and other support personnel such as a plant engineer. The interviews lasted from 45 minutes to 2 hours, and some respondents were interviewed more than once. The interviews generally began by asking respondents to describe what they first remembered about the focal change initiative and then requesting them to construct a timeline of the course of events. They were asked to describe their own roles, the factors that helped or hindered the efforts, and their impressions about progress and the success of the initiative. They were asked for their opinion about the persistence of the problems that they identified, which in hindsight often seemed somewhat obvious. Finally, they were asked how the initiative had affected them personally, in particular what they may have learned through the experience. The interviews were audio taped, then transcribed.

Together, these methods draw on the strengths of the various methods and facilitate verification through an iterative process. In particular, the interviews provided opportunities for in-depth examination and the use of audio recording for accuracy, while the extensive direct observation allowed for comparisons between what people said in interviews and casual conversations and what they actually did (Pettigrew, 1990). These methods contribute to a rich database that I have developed comprising longitudinal data that includes both contemporary and retrospective reports from respondents.

Data Analysis

As Barley (1990, p. 234) notes, "the analysis of field data actually begins during a study's observational phase." The ongoing analysis of field data offers the possibility of
developing interim hypotheses and directs attention to relevant data (Glaser et al., 1967). My data analysis followed traditional qualitative methods for inductive field work (Eisenhardt, 1989; Miles & Huberman, 1984; Yin, 1994). I also made frequent use of causal loop diagramming, a graphical representation technique that is especially useful in the analysis of complex systems (Masuch, 1985; Sterman, 2000; Weick, 1979). The diagrams capture the feedback structure of a system of interacting elements and help to reveal the potential dynamic behavior of the posited relationships. During the course of the fieldwork, I made frequent sketches of such causal loop diagrams, often in the evenings during my trips to the research site. The diagrams were one explicit means of "always trying to make sense of one's data and thinking about what more one can find out" (Feldman, 2000, p. 615).

Data analysis included listening to the recorded interviews and reading the transcrips, coupled with a review of field notes. I identified patterns of interest and recurring themes in the data, bounding the analysis with a focus on efforts to implement change in the first production cell. As is typical in developing grounded theory, I organized the data into categories, which I represented with variables and causal relationships between them (Glaser et al., 1967). I combined variables and causal relationships to begin identifying causal loops as a description of the feedback processes gradually emerging from this analysis. During the data analysis, I occasionally translated portions of the emerging feedback structure into formal mathematical models and simulated their behavior in order to gain a richer understanding of the relationship between the feedback structure and the dynamic behavior. The iteration between the grounded data, causal loop diagrams, and
formal mathematical models led to additional insights and generated new questions that I
could explore in the available data or pursue with my respondents. On occasion, I
reviewed interim results of the analysis with members of the plant management team,
who often identified examples that were useful to fill in some gaps. The data analysis
approach follows methods used by other researchers applying a feedback lens to the
study of organizational phenomena (Perlow et al., 2002; Repenning et al., 2002). The
method assures the model that emerges from the analysis is tightly grounded in the field
data, with each casual link in the induced feedback structure matched to patterns in the
case studied.

OVERVIEW OF THE IMPLEMENTATION CHALLENGE

The Research Setting
The company I observed manufactures and markets a line of recreational motor vehicles
and related products targeted at enthusiasts. The company has a rich heritage and a well-
known brand. Market demand for its product continues to be strong. Despite this
success, management recognizes the need to stay competitive. It is commonly
acknowledged that the company's manufacturing costs are higher than those of their
competitors.

The engine plant, like the company's other manufacturing facilities, employs a unionized
workforce. Management and union leaders alike attest to a strong, cooperative
relationship between the union and the management. For several years, work practices
have been guided in part by the collective bargaining agreement, which details elements
of the organization structure and responsibilities of the union leaders and workers and the
salaried management. Elements of the agreement include work groups organized around
production units, “work group advisors” rather than supervisors, joint representation in
many decision processes, and a high degree of information sharing with employees, as
well as other practices typically characterized as high-involvement work practices (Pil et
al., 1996).

The workers were already organized in teams called work groups corresponding to
manufacturing cells that produced various engine parts. The plant managers and union
officials jointly selected one work group to be "a pilot area that we're going to try this on"
in the words of a production manager. The selected work group comprised
approximately 15 hourly production workers who run a machining and manufacturing
cell that produces several parts used in the engines assembled in this plant and at another
engine assembly facility in the company's production network. Due in part to quality and
cost problems, the company had recently considered discontinuing the in-house
manufacture of these parts and had begun purchasing a portion of their needs from a
supplier. Plant management and the union leaders had convinced the company to
continue internal production of these parts, but there was a clear sense that performance
improvement was needed or the company would indeed discontinue the operation.
Because some production volume had recently been shifted to outside suppliers, there
was a surplus of worker time that could be dedicated to improvement activity. Thus, this
cell was chosen because the need for improvement was clear and because resources for
improvement were available.
Learn a Little, Do A Little

The general manager and many other managers espoused their intent to follow an approach of learning and discovery rather than a top-down, directive approach to change. The general manager expressly articulated his belief that the workforce must be actively involved and that people learn by doing. One production manager described the strategy they chose to follow, recognizing that the managers themselves were not experts.

Let’s train [the production workers] and let’s encourage their intellectual curiosity and then let’s channel their thoughts and their ideas into things that are consistent with the tools of lean manufacturing and the process of lean manufacturing. … Well, what if we all learn this stuff together, you know? … Let’s get everybody on the same bus and let’s all agree where we are today and get some fuzzy idea about where we want to go. Then let’s see what we can learn along the way to bring clarity to where it is that we want to go. … That's where [someone] came up with the concept – learn a little, do a little.

To begin improvement activity on the shop floor, the managers formed a full-time implementation team, dedicating people to work with the pilot work group. Two of the team members were engineers from an internal consulting group in the company that works with the company's suppliers to implement lean manufacturing practices and who also had experience with lean manufacturing at previous employers. The manufacturing engineer already responsible for the selected area was assigned to the team. The work group advisor had significant experience with lean manufacturing from a previous employer and was quite enthusiastic. The team recruited two volunteers from the work group to work three-fourths to full time on the implementation. The union chose for the team a union analyst, an hourly worker who examines work processes and contributes to setting quantitative standards for work output in the various production jobs. The team
also had some support from an external consultant who conducted some training and provided expertise in lean manufacturing techniques.

Management authorized overtime expenditure and conducted weekend sessions to train the work group in basic principles of lean production, such as the central idea to continuously identify and eliminate waste of all kinds (Monden, 1983). The training invited the workers to suggest improvement ideas consistent with the principals of lean manufacturing. Lean manufacturing systems aim to reduce various forms of waste in the system, often by implementing processes such as just-in-time production, kanbans, production smoothing, improved process layouts, reduced set-up times, and standardization of operations (Monden, 1983; Womack & Jones, 1996; Womack et al., 1990). Early efforts focused on cleaning up the work space, better organizing the areas for raw materials and finished goods, and reconfiguring the machine layout to streamline the work process and reduce work in process. An hourly production worker described the prevailing approach of high employee involvement:

A lot of the stuff that we came up with came from the hourly employees. Roller racks was one of the things that we introduced. … The roller racks were designed by hourly people that actually worked on the jobs. … The company says you guys use it, you tell us what you want.

The hope was that as ideas got generated and implemented, workers would learn and improvements would accrue, setting in motion a process of continued improvement and learning propelled by the involvement and knowledge of the workers.

*Stalled Change: The Pattern of Start and Fizzle*
After several months of work in the pilot area, the management and shop personnel were proudly pointing to the initial success of the effort. A union official describing the early progress said, "It was going along pretty good there. The area was starting to really look uniform over there." Respondents testified in the early months to the enthusiasm and participation of the workforce. Yet several months later, some new work practices had been abandoned and performance had deteriorated. Specific performance data for the production unit are confidential but follow a similar pattern. Costs of scrap material, often due to quality problems in production, at first declined but then rose again later. Production output measures compared to standards for the work unit increased for a period of several months after the improvement effort started, peaked, and then began falling toward earlier levels. Several months after the successful start, even intangible measures such as worker enthusiasm were declining. One informant described the situation as “the wheels are coming off.” Another said, "If you go over there a couple of months later, after all this stuff, the [physical appearance] started to deteriorate." Several respondents reported a similar pattern for the improvement activity itself: an early phase of improved performance followed by a plateau and then decline. The pattern recalls one frequently observed in improvement programs and the implementation of new technology, a pattern I describe as start and fizzle. Similar patterns are well documented in the literature on organizational change.

THE WORK OF PROCESS IMPROVEMENT

*What Does It Take to Do a Little?*
A distinctive feature of the fieldwork in this study was the opportunity to closely observe shop floor workers as they undertook to do the activities of process improvement. Two empirical findings became quite clear from the data. The first key finding calls attention to how the technical content of improvements interacts with the process of implementation. Consistent with the notion of participative improvement, the vast majority of the improvement ideas originated as suggestions from the work group. However, the actual work of executing the tasks required to implement most improvement ideas fell upon the shoulders of others - that is, people outside the focal work group whom I will collectively call support personnel. Support personnel include the plant engineers, the maintenance department, the materials handling department, the tool room, the work group advisors, plant management, and even in some cases production workers in other work groups such as the assembly line that is the proximate customer of the subject work group. An important characteristic of many of the improvement suggestions was the varied nature of the tasks required to implement them, thus requiring the involvement of support personnel. One manager summed up the pattern regarding who gets assigned responsibility for doing the tasks: "Very rarely is it the person that came up with the idea."

Consider for example the idea to establish and organize a finished goods area they called the supermarket. Better organization of the finished goods supermarket would enable better signals about what parts the engine assembly lines needed, based on timely and accurate information about current inventories, and support a simple and effective process to replace what was used as parts are drawn from the supermarket. The work
group developed plans to organize the finished parts in an area specified for the 
supermarket. The work plan comprised several tasks. One task was to mark lines on the 
floor, clearly delineating the space for the supermarket and sections within it. The size of 
each section would be based on the capacity deemed necessary for each of the various 
parts they produced. Another task was to make and hang overhead signs that would 
identify the parts in each section and other information such as the desired stock level and 
the capacity of the section. These are tasks that are normally done by personnel from the 
maintenance department or other skilled trades. Thus, the ideas generated by the work 
group created demands for work by other people in the plant. As one work group 
member described, this was a common occurrence: "Like just for little things like 
hanging signs for a supermarket, we need signs for a supermarket. We need somebody 
who can do that." In this example, the critical support personnel were people from the 
maintenance department. As one manager observed, this was a common scenario: 
"Maintenance. [The workers] have got a great idea for maintenance to do. And then 
when it doesn't get done, maintenance is bad, right?"

The work group I studied frequently needed support from the plant's manufacturing 
engineers. Manufacturing engineers are typically responsible for tasks such as choosing, 
purchasing and installing new equipment and specifying the manufacturing processes 
required to use the equipment. In the supermarket example, a set of such tasks was to 
design, purchase, and install appropriate storage containers, such as rolling carts or flow 
racks. Another planned improvement was to redesign the layout of the manufacturing 
equipment, modifying the flow of work in process through the cell. The redesigned
layout included a new piece of equipment, which the manufacturing engineer would need to purchase. "Engineering" was one type of support personnel who were needed, and often not available, as noted by a member of the implementation team:

So we went up there and did the analysis, got some of the tools ordered, and did some of the basic things. Then we were starting to require more and more engineering. …

The process of matching tasks with various individual people to accomplish them was rarely given much explicit attention. Rather, the plant personnel drew upon their knowledge of the specialization and expertise of individuals, specific constraints in the union contracts, and socially understood role definitions to associate responsibility for a particular task with an individual or group. Tasks were "engineering jobs" or "maintenance jobs." The nature of the tasks combined with a taken-for-granted understanding of who does what in such a manner that a large number of tasks fell upon a limited number of people. For example, a manufacturing engineer described his role: "So I would be responsible for taking that, [this improvement], whoever came up with it, and putting it into the actual process." The norms about who did what were powerful, yet unspoken, as evident in this description from another manufacturing engineer:

When you are sitting in a group, … [with] some work group members and … work group advisors … and you are talking about how you are going to change this process and you are talking about moving machines around and talking about changing the manual work … You knew what your part of that job was.

The second key empirical finding concerns the support personnel as well. The support personnel were consistently overworked, facing time pressure from the various demands placed on them to do the improvement tasks. The work group and the implementation team were keenly aware that the things they wanted done by support personnel were not
getting done and complained about it often, as evidenced in the following statements from union representatives, implementation team members, and work group members:

If we had to have something from maintenance, they said you have to put in a [requisition]. It took a month to put lines on the floor. With this kind of thing that we're going through, you can't do that. (Union official).

But getting the people responsible to do the stuff we asked for … That’s one of the big things that’s always a stickler. We’d get promised, oh, by tomorrow that stuff will be out of there. A week later it will be sitting there. Who’s responsible? Whose stuff is this? … Our department never looked neat because we had just junk in there. (Production worker).

How do you [get something done by maintenance]? Send in a work order. Well, you send in a work order and it disappears. How do you get the priority? Because we are trying to show some speed and show some commitment, but we didn’t know who to plug into. (Implementation team member).

Any time there was a problem it fell back on the engineers. … Everything came down to the engineers. (Implementation team member).

It wasn’t really [anything] overt that we’re not going to do this and not going to do that, but it was just like [pause] you’re pulling an ox cart through a mud pit is basically what you felt like. (Implementation team member).

Thus, support personnel were the ones primarily responsible for the implementation of most improvement ideas, and the support personnel were chronically in short supply.

One interesting line of inquiry would be to question why the apparent imbalance between demand for and supply of support personnel time persists. Yet resource shortages such as this are commonplace in organizational life, so I turn here to a question that the close-in fieldwork in this study can greatly illuminate. That is, given constraints on the time of the support personnel, how do they cope with the challenge of continued demand for their services and what are the consequences for the improvement initiative? The inductive study of this question through building and analyzing a model tightly grounded in data
from the fieldwork led to important insights about the nature of participative improvement and learning by doing. In what follows, I develop a causal loop model, supported with additional field data, and then translate the qualitative model into a formal mathematical model that I use to simulate and analyze behavior. A more complete description of the field data for this analysis is found elsewhere.

A MODEL OF ORGANIZATIONAL CHANGE

A central construct in the model is *process improvements*, which are enhancements to the manufacturing *process capability* (i.e., the throughput of manufactured parts that the work cell can accomplish for each unit of production labor employed) that accrue from the implementation of improvement ideas. Process improvements are determined by the *task completion rate* and the *improvement value*, which is the amount of increase in process capability contributed by completion of each task. The task completion rate depends on the *support time available* that is spent working on improvement activity and the *productivity of support personnel*, defined as the number of tasks accomplished for each unit (e.g., hour) of support personnel time.

Figure 1 shows the way that improvement activity contributes to process capability. The rectangle icons represent stocks, which are integrations (accumulations) of inflows that increase the stocks less outflows that decrease the stocks. The pipe-and-valve icons represent the flows into and out of the stocks. Stocks give a system memory and inertia, create delays, and are critical to the dynamics of the system. As accumulations of past actions, stocks influence future actions which in turn influence the rates of flow that
change the stocks, thus closing the feedback loops (Repenning et al., 2002). Figure 1 represents process capability as a stock that is increased by process improvements and decreased by process degradation, a natural consequence of ongoing use and changes such as customer requirements and supplier factors. As the work proceeds, task completion generates process improvements that increase process capability. The diagram shows that ideas lead to improvement tasks, and the successful completion of improvement tasks results in the intended increase in the organization's capability.

Figure 1: Basic Stock and Flow Map of Lean Manufacturing Process Improvement Activity

Stocks are represented by rectangles, and flows are represented by "pipes with valves." A stock is the accumulation of the difference between its inflows and outflows (see Sterman, 2000). The arrows connecting the variables are labeled with "+" signs to signify that an increase (decrease) in the first variable leads to an increase (decrease) in the second variable, all else equal (see Sterman, 2000).

Workers contribute by idea generation, which fills the stock of tasks to do, which is in turn decreased by the task completion rate. When ideas are generated, they accumulate, so we can think of tasks to do as a backlog of tasks that need to be done but have yet to be executed. In the field site, representations of the backlog included flip charts of improvement ideas generated during workgroup meetings and training sessions, an action register filled out each week to track work assignments, a whiteboard chart identifying
tasks and responsibilities, and individual To Do lists such as might be found on an engineer's personal computer. Figure 1 helps explain why the support personnel were stretched. The backlog will grow as long as idea generation exceeds the task completion rate, which was the common circumstance. As one manager said, "The workers will always be able to generate ideas faster than we can implement them." Thus, the backlog of tasks continued to accumulate. An implementation team member discussed how the group continued generating ideas:

So we just kept on plodding on with our stuff. Had the people creating things. I think we got the work group so far ahead of engineering that – it was bad, but there was no way that I was going to wait for a support organization to give me resources while I got the people engaged. You can’t. It’s like – they have to catch up.

Moreover, in addition to ideas that were consistent with the premises of lean manufacturing, other ideas such as ideas that arose simply to satisfy individual wants and desires were included and became the responsibility of these support personnel. One of the support personnel, a manufacturing engineer, noted the continuing inflow of ideas and said, "You know some of the stuff might not have even been a part of the lean manufacturing plant. It is just [that] everything is labeled under [this program]." So, the support personnel fell further and further behind. The manufacturing engineer, for example, described the challenges he was facing as the work backlog grew:

I still saw us coming up with all these new ideas, new plans for improvements. You know we hadn’t finished the first new improvement. … You have all of these things but you didn’t get anything accomplished because you have so much you have to do. You are trying to do it all in one span of time. … You have to work with one thing at a time and that was the missing piece to the puzzle. … You kept pouring in more improvements. People kept coming in with more inputs and that was before you had one output.
The model thus far captures three basic relationships: 1) improvement activity leads to increases in process capability; 2) support personnel are required to complete improvement tasks, and 3) tasks accumulate in a backlog when the rate of idea generation exceeds the rate of task completion. Taken together, these relations imply that a key challenge in the implementation of an administrative technology for process improvement, such as lean manufacturing, is found in the manner in which the organization addresses the accumulated backlog of improvement tasks. Next, I turn to a discussion of the behavioral responses to this challenge.

Do A Little and Do A Little More: Responses to a Backlog of Work:
Support personnel have many demands on their time. As one union member describes, "A guy like [our engineer] and those guys, those guys are busy. They've got so many things on their platter that they can't devote the time that you need for that process." Similar challenges arose with support personnel from other areas. Support personnel, facing task demands from other sources as well, were frequently unable to respond quickly to the needs of the work group. Another respondent, noting the sluggish responses, said, "You couldn't get anything fixed. Do you hear what I am saying? I mean, simple things like putting lines on the floor and getting things moved, it just didn't happen." As described by a production manager:

    Maintenance then says, "OK, I have got this work group that has just asked me for some help, but I have a down machine over here. I've got to make a choice as to where I am going to work, because I am a scarce resource."
In the face of an accumulating backlog of tasks and in the absence of any slack time available, the options were limited. When asked what he could do about the many tasks that were piling up, one of the support personnel, a manufacturing engineer said:

> Nothing. You have to wait. That is pretty much it. You could have a meeting. Well, … we had this action item review every week … and we said, OK, here is the list of stuff that we want to get done. … Whatever resources involved will report how much time it is going to take. And every week, you know, things hadn't happened. So that was just a follow-up. What we'd do is try to push the pencil on some of the issues, and that's about all you can do.

Pressure to get work done under conditions of time, budgetary, and resource constraints is commonplace in organizational life. Yet, resourceful, dedicated individuals find ways to make do with what is available. As one team member described:

> You’re given a problem and you're told to solve it. Your training says solve it. So you analyze it. You put your heart and soul into it, and you’re going to work your butt off all the while getting hammered for things left and right. By God, I’m going to get this thing and its going to work. So you invest a lot.

So, the support personnel find other ways of getting things done. One option is to accept a lower rate of task completion, but this only leads to mounting pressure as ideas continue to accumulate. Another option is to increase the amount of time spent doing improvement tasks for this work group, but we have already seen that the support person (e.g., manufacturing engineer) is fully loaded with work to do. So under the prevailing condition of fixed resources, the only remaining options available to the overworked person facing this challenge must take the form of somehow increasing the productivity of support personnel, which implies finding a way to accomplish more tasks in the same amount of time.
One way for support personnel to do a task is to do most of the work collaboratively with production workers to gain the benefits of their input and to enlist their support in making the indicated changes, engaging the work group as a partner. Another way is for the support personnel to do the work alone and hand over the work product in the form of a mostly completed task. Both of these approaches are in the repertoire of how work gets done in the plant. Doing the work collaboratively is the prescribed process, consistent with the high involvement principles of lean manufacturing. But doing it alone is quicker. As a manufacturing engineer describes developing a new layout:

You'd kind of lay it out as an engineer yourself and come down and talk to the operators and they'd sign it and it's a done deal. [With] more input [from the work group], of course the process is going to be a lot longer. The process is longer to implement than actual layout moves.

The passage highlights the relative effects of the two approaches: collaborating takes longer. For another example, consider acquiring a new piece of equipment that will improve the flow of parts through the manufacturing cell. An engineer might accomplish tasks such as selecting, purchasing, installing, and setting up the machine without any worker involvement, a tactic that would take less of his time than a more drawn out approach that relies on active worker involvement in many of the decisions that need to be made. Consider the apparently simple question as to where on the floor to install a piece of equipment, as described by a manufacturing engineer:

You’ve got, in some cases, three to five operators across two or three shifts and every one of them has got their own idea of how they should do this. The machine needs to be three inches to the left. No, the machine needs to be 8 inches forward. No, this machine needs to be turned 90 degrees. No it doesn’t. Ok, and it just goes on and on and on and on and on and it’s never ending.
By reducing the amount of collaboration and focusing on executing the operational content of the improvement tasks, the support personnel can increase their productivity. An apparently subtle change in how the support personnel does the work, not what work he or she does, influences the rate at which the work gets done. A production manager summed up the tendency to shortchange the amount of collaboration: "People love to take shortcuts. [I've seen people say] screw it. I’m just going to tell the operator what to do."

Working in a less collaborative manner is one type of shortcut. Other researchers have documented the use of shortcuts in response to time pressure. For example in a commercial bank, lending officers facing work pressure from a backlog of orders cut corners to reduce the time they spend on each customer order (Oliva & Sterman, 2001).

Another shortcut is to do the easiest work first, as an engineer describes:

You keep adding to the action register list and you keep completing the first item. … We didn't put an actual priority that I can remember on any specific issue. The easiest thing always got completed first. The hardest thing got completed last. It didn't matter if the hardest thing was the first thing coming along. It was the easiest thing that got completed first.

Support personnel can increase the task completion rate by shortchanging collaboration. An increase in tasks to do translates to a higher indicated completion rate in Figure 2. In response, the support personnel conduct their work in a less collaborative manner, spending more of their time working alone and consequently less time spent collaborating. The character of how the support personnel do the improvement work changes. Because the less collaborative way of working is quicker, the productivity of support personnel is higher, boosting the task completion rate, which draws down some of the backlog of tasks to do. Increasing task completion by reducing collaboration forms a balancing feedback loop named the Go It Alone loop and designated Loop B1 in Figure
2. The accumulating backlog yields pressures that increase the likelihood of executing tasks through less collaborative means in order to complete them in a timely (or less tardy) manner. Equipment gets purchased, but workers may not have been involved in their selection. Layouts get designed, but the work group does not participate in the active discussions they would have with a high involvement approach. The instrumental character of the task is completed, but the social elements are given lower priority. The responsible individual is able to claim the task is completed. As a production manager said, "[You can tell your boss that you] got the machine." However, the benefits of engaging the workforce in the process have been circumvented. The production manager continues, "You believe that you'll be able to take the shortcut, but in the long run the shortcut is going to set you back." Indeed, it is the long run consequences of these shortcuts that are critical to the pattern of start and fizzle.
Reducing the time spent collaborating leads quickly to a reduction in the backlog of tasks, but this tactic has delayed costs due to circumventing the opportunity to collaborate. Collaborative work between support personnel and production workers is a source of experience in the practice of collaborating. As they accumulate experience doing work collaboratively, they build a resource available to them to facilitate future collaborative work, a form of social capital (Coleman, 1988). Collaborative work enables the development of trust, enhances social relations that can facilitate the flow of information, and may foster the formation of norms for how collaborative work is done (Coleman, 1988). Collaborating also facilitates the emergence of transactive memory systems (Wegner, 1986). Previous research has shown that team members who train together rather than separately trust each other's expertise more, coordinate task activity better, and develop more accurate perceptions of who knows what, with consequent improvements in performance (Liang, Moreland, & Argote, 1995; Mooreland, Argote, & Krishnan, 1996; Mooreland, Argote, & Krishnan, 1998). Performance may also be improved as individuals develop more skill with collaborative work in general, for example through learning to adjust their behavior to complement other team members (Reagans & Argote, 2002). The notion of learning by doing has a long tradition in research starting from Wright (1936) who documented learning curves that describe the link between cumulative experience and some measure of performance. Although there is wide variation in the rates at which organizations learn from experience (Dutton & Thomas, 1984), learning curves have been found in many industries (Argote, 1996;
Pisano, Bohmer, & Edmondson, 2001) and in a range of functions including manufacturing (Argote & Epple, 1990), services (Baum & Ingram, 1998), surgery (Pisano et al., 2001), product development, and process innovation (Hatch & Mowery, 1998).

Figure 3 adds a new construct to the model: Experience Collaborating. As the support personnel do work collaboratively, they learn by doing collaboration, and they build skill and social ties. The stock of experience collaborating is increased by learning from the time spent collaborating. The stock is also decreased by forgetting, representing the deterioration of experience in the absence of any collaborating activity. Modeling experience collaborating as a stock captures the fundamental notion of accumulation of experience central to learning curve theory (Argote, 1999).
Figure 3 shows two important benefits of experience collaborating. First, collaborating with support personnel in improvement activities provides production workers with an opportunity for learning by doing, developing experience with both the particular production process and the improvement activity. The resulting benefit is a boost in the quality of ideas for further improvements, shown as a link from experience collaborating to improvement value. In contrast, when workers are not involved in implementation activities, their understanding of the modified production processes may even decline.

For example, consider what happens when a newly acquired production machine experiences problems. A machine operator who has participated in the specification and selection of the new equipment is more likely to suggest effective solutions than an operator who has not been involved. A production manager described how the operator and manufacturing engineer collaborate to solve problems:

> If something’s wrong, all right, [the manufacturing engineer will] definitely tap into the operator’s knowledge to help try to understand, to help him understand what could possibly be going wrong with this piece of equipment.

Yet the ideas from the production workers vary in how much they contribute to improvement. In the following quote, a production manager explains how production workers use a new system to identify improvement ideas. A suggestion with adequate detail is actionable and useful, whereas a simple note, such as "winder down," is not.

> If I collect that data and I can turn that into usable information, in other words, … my number one downtime issue was fault code F9, low wire tension fault, right, on brass tag [so and so], I know that that’s what I need to fix, right? … "Winder down" doesn’t help us. "Winder down, fault code F9 low wire tension" is what we need.
A second benefit of experience collaborating is an increase in the productivity of the time spent collaborating, shown as a link from experience collaborating to productivity of support personnel. The new links close an important new feedback loop, named the *Learn by Doing* loop (Loop R1 in Figure 3). In contrast to the balancing loops described before, the Learn by Doing Loop is a reinforcing (deviation-amplifying) loop that tends to reinforce and amplify an initial disturbance (Masuch, 1985; Merton, 1948; Weick, 1979). Consider a reduction in time spent collaborating, which might result from the response of the support personnel to an increase in tasks to do. As the support personnel decrease their time spent collaborating, the level of experience collaborating declines, which in turn decreases the productivity of support personnel and lowers the task completion rate. Tasks to do decrease more slowly, maintaining a higher indicated completion rate and leading to an even further reduction in time spent collaborating. The reduction continues as support personnel further skimp on collaborative time, undercutting collaborating experience and reducing productivity still further, and the Learn by Doing Loop operates as a vicious cycle. Conversely, a reinforcing loop can operate in the favorable direction as well, as a virtuous cycle. As support personnel increase their time spent collaborating, they build more experience collaborating, increasing their productivity and boosting the task completion rate, which drains the stock of tasks to do more quickly, so the indicated completion rate drops fostering an even further increase in time spent collaborating.

Note in the following quote how the support personnel follow an approach that shortchanges collaboration, how the result compromises the workers' ability to get
involved, and how nevertheless the approach leads to a perceived outcome of task completion. A production manager describes how a group of support personnel, including himself, took an approach with a low degree of collaboration:

We didn’t do a good job of sharing what we were doing. The vision, the knowledge, the tools, so that they [the work group] could then apply their thinking and have input into this process.

Q. Who’s we?

You know, a few of us. [The work group advisor], the engineer, one operator, me, and [an outside consultant] actually did it. Okay? And, the intern. And so you know, we did it, right? We implemented this new layout and the work group seems to be working reasonably well with it.

The causal loop diagram in Figure 3 offers an explanation for the pattern of start and fizzle observed in the field data. At the outset of the improvement initiative, workers become engaged and generate many ideas for improvements in their production processes, found in the field data as flip charts replete with brainstormed ideas and action registers full of tasks for the support personnel to do. Managers temporarily allocate some additional support personnel time to assist in the implementation work, as in the field data. As support personnel respond to the increasing workload by "Going It Alone," the increase in productivity is almost immediate, so they are indeed able to boost their task completion rate. The resulting additional process improvements lead to enhanced performance, and the initiative appears to achieve early success. The negative consequences of shortchanging collaboration come only later, as experience collaborating deteriorates somewhat slowly over time. As experience collaborating drops, so too do both the productivity of time spent collaborating and the improvement value from new ideas, leading to a subsequent decline in the rate of process improvement, and process capability begins to wane. The initiative starts successfully precisely because the
shortcut is effective in boosting the task completion rate, and it fizzles because the delayed costs of the shortcut manifest over time. Start and fizzle is a special case of better before worse dynamics.

The preceding analysis follows an emerging stream of literature using causal loop diagrams to examine dynamic organizational phenomena (Perlow et al., 2002; Repenning et al., 2002; Weick, 1979). However, the human mind is poorly equipped to infer the dynamic behavior of systems with nonlinear feedback structure and significant time delays (Sterman, 1989; Sterman, 1994). By translating such feedback structures into formal mathematical models suitable for dynamic simulation and analysis, researchers have discovered important insights into important organizational phenomena such as the growth and decline of businesses, punctuated organizational change, side effects of successful quality improvement, and stress-induced disasters (Hall, 1976; Rudolph & Repenning, 2002; Sastry, 1997; Sterman, Repenning, & Kofman, 1997). In the next section, I simulate and analyze such a formal model.

**FORMALIZING THE MODEL**

The formal model is a system of nonlinear differential equations that describe in mathematical terms the same relationships depicted in the causal loop diagram. The three stocks in the model (i.e., Tasks to do, Experience collaborating, and Process capability) are defined as the integrals of their inflows less their outflows plus their initial values, which are chosen so that the simulations begin in equilibrium conditions. Each of the causal links in the diagram maps to an equation in the model, which are generally direct
translations of the verbal descriptions presented in the previous section. For example, when adequate tasks are available in the backlog the Task Completion Rate (TCR, units: tasks/week) is simply the product of Support Time Available (STA, units: hours/week) and the Productivity of Support Personnel (PSP, units: tasks/hour), written as:

\[
TCR = STA \times PSP
\]

The two other outflows (i.e., Process degradation and Forgetting) are modeled as first-order exponential decays, following standard practice (Repenning, 2002). The support personnel are assumed to allocate as much of their time to collaborating as is possible consistent with the need to accomplish the tasks to do in the Desired Time to Complete Tasks, a model parameter. For simplicity, the productivity of collaborating is modeled as an upward sloping linear function of experience collaborating with an appropriate minimum and maximum. Similarly, the improvement value is an upward sloping linear function of experience collaborating. The rate of idea generation is treated as an exogenous constant, which is varied in some of the tests below. The model parameters represent realistic managerial concepts, and their values were chosen based on managerial judgment and inference from the field data. The appendix presents full documentation of the model equations and parameters. A more complete description of the model along with additional sensitivity analyses can be found elsewhere.

**Temporary Success: Benefits of Early Collaboration**

The first test with the model is to introduce new ideas and allocate some additional support personnel time. In the field setting, managers allocated additional support personnel to assist in the work group, and then after a period of time the additional people
moved on to work on other projects. To simulate this scenario, I introduce at week 10 a burst of new ideas and also introduce additional support personnel time over 10 weeks. Figure 4 shows the pattern of the exogenous inputs in this test. Converted to similar units, the areas under these two rectangles are equal; that is, the extra resources are exactly the amount needed to accomplish the new tasks at the original productivity levels.

**Figure 4: Test Inputs to Introduce Ideas and Resources**

![Graph showing test inputs](image)

Figure 5 shows the results of a simulation with these test conditions. Process capability increases at first, then suffers a modest decrease, and begins to increase again. Process capability shows a prolonged period of superior performance relative to the initial levels but then eventually returns to the original level of process capability.
The early pressures cause support personnel to reduce the time spent collaborating, which increases task accomplishment, boosting process capability while drawing down the backlog of work. Thus, by about week 13 the backlog has become reasonable, and the support personnel begin increasing the time spent collaborating. Time spent collaborating climbs back above its initial levels by week 14 and stays higher for an extended period of time. By the time the additional resources are withdrawn in week 20, the collaborative work has led to accumulation of experience collaborating that pays off in both higher productivity and higher idea quality. Workers continue to generate better ideas after the additional resources have departed, and the increased effectiveness of process improvements contributes to higher levels of process capability. Process capability eventually peaks in week 31, as the rate of process degradation grows with increasing process capability and eventually overtakes the slowly declining rate of process improvements.

**Sustained Success: Engaging the Positive Loop**
The results of the previous section are encouraging. With a temporary introduction of additional resources deployed long enough to foster collaboration, there is a consequent increase in idea quality and productivity of collaborating, so the firm is able to achieve higher levels of process capability for an extended period of time. Yet, these results are still discouraging in that process capability eventually returns to its original levels. The firm enjoys an extended transient effect of its focused improvement activity but does not succeed in transforming to a sustained level of higher capability. In this section, I turn to a scenario that leads to such a transformation.

In this section, I introduce new ideas as before, but I vary the total quantity of resources introduced, still over a fixed duration of 10 weeks as before. For ease of interpretation, I vary the quantity of extra resources as a multiple of the indicated quantity, the amount used in the previous tests. Figure 6 shows the behavior over time of process capability for these tests using multiples of 1x (blue), 1.5x (gray) and 1.6x (green) the indicated quantity of resources.
The results now show two very different basic patterns of behavior over time. The first pattern (in blue and gray), is the one discussed in the previous section. It is characterized by an increase to a level of process capability well above the initial level that persists for an extended period until it eventually falls back to its original level. The first pattern results here not only when the quantity of resources is apparently adequate, but also when additional resources are as much as 1.5 times the indicated quantity. But when additional resources are just a bit higher (in green), at 1.6 times the indicated quantity, process capability continues to climb to a new level well above the initial process capability and is sustained at this higher final equilibrium. In other words, this second pattern is one in which the firm has achieved a lasting increase in capability, an enduring success. The organization has crossed a tipping point and has locked in a new mode of behavior. The support personnel are reaping the productivity benefits of a new higher level of experience collaborating that allows them to continue collaborating at the higher rate needed to sustain the additional experience level.
The key to understanding why a miniscule and only temporary difference in extra support personnel time leads to a dramatically different outcome lies in the dynamics of the stock of experience collaborating. One effect, perhaps the more salient, of adding ideas and resources is that tasks get done and generate improvements that increase process capability. But, a second more important effect is that doing the tasks collaboratively leads to building collaborative experience. Consider then the addition of ideas and resources as an infusion of some additional experience collaborating. The infusion adds to the existing stock of experience, which in turn determines the productivity of collaborating. At low experience levels, working alone is strongly favored over working collaboratively because there is a large productivity loss from collaborating. A little extra experience will not fundamentally change the balance. However, at very high experience levels, collaboration is almost as productive as working alone so each bit of extra experience encourages even more collaboration. Somewhere between these extremes, there is a threshold above which any increase in experience will set in motion the favorable reinforcing loop dynamics in which more time spent collaborating builds experience, increasing productivity and allowing still further increases in collaboration. Below the threshold, a small increase in time spent collaborating is overcome by the outflow of forgetting. Formally, the threshold, also called a tipping point, is an unstable equilibrium in which learning is exactly equal to forgetting in a regime where the system behavior is dominated by the Learning by Doing Loop R1. The test shown in the green line of Figure 6 adds just enough resources to get the stock of experience collaborating past the tipping point. Tipping behavior is observed in many systems, such as disease
epidemics, product development, and in collective behavior (Granovetter, 1978; Repenning, Goncalves, & Black, 2001; Sterman, 2000). (Elsewhere, I characterize the precise nature of the tipping point based on the model parameters.)

In the first pattern, the organization returns to the original conditions in which support personnel collaborate just enough to get tasks done at just the rate needed so that process improvements offset process degradation, maintaining process capability at a constant level, and experience collaborating stabilizes. In the second pattern, beyond the tipping point, experience collaborating has climbed to a higher level so the productivity of the time support personnel spend collaborating is also permanently higher. In addition, the improvement value is also sustained at a permanently higher level in the second case, since worker ideas for improvements are permanently better because support personnel collaborate with them on such a high proportion of tasks.

DISCUSSION

This paper develops a simple theory to help understand why imitation often fails. The theory explains an observed pattern of start and fizzle, drawing on observations from field research in which shop floor workers generate ideas faster than support personnel are able to implement them. The backlog of tasks influences the way in which the support personnel do their work either alone or in collaboration with the shop-floor workers. By shifting to spend more time working alone in the interest of greater productivity, the support personnel work off the backlog, and the implementation of these ideas improves process capability. The increased productivity in the short-term comes at
the expense of collaborating with workers, which has negative consequences later. When assigned resources move on to other projects, these consequences become apparent as less effective improvement ideas and lower productivity of future collaboration, which combine to cause a reduction in improvements and thus the observed fizzle. Conversely, if the support personnel build experience in collaborating, they become more productive in their collaborative activity, which can lead them to shift even more of their time to the collaborative approach. This sets in motion a positive feedback loop and leads to a sustainable increase in process capability even after the assigned resources are removed. Simulation of a system dynamics model shows the start and fizzle behavior, not only when resources are adequate to accomplish the ideas that workers generate but also when even more than adequate resources are allocated. However, when resource availability is large enough to allow support personnel to cross a threshold and set the positive loop working in the favorable direction, the firm achieves a lasting transformation to a higher level of process capability.

The notion that building organizational capability requires an investment of resources is not new, but the study here adds two points to suggest that managers may be unwittingly undermining their own futures. First, the self-reinforcing nature of alterations in how work means that initial changes in work practices to meet the challenges of constrained personnel can easily become locked in. Second, because managers are likely to be slow to recognize personnel shortages, the shortage conditions are likely to persist. Work does get done, and changes do get implemented, so managers see tangible evidence that things are not that bad. Negative consequences of personnel shortages are often less salient, less
certain, and result only after a significant delay compared to the vivid, certain, and immediate outcomes they notice. Researchers have documented the tendency of people to overweight salient and available information, to fail to recognize important delays, and to exhibit an aversion to risk (Dawes, 1988; Kahneman, Slovic, & Tversky, 1982; Sterman, 1994). Repenning and Sterman (2002) discuss how these effects yield a preference for work for which the outcomes are salient and are achieved with short delays and greater certainty. Taken together, these additional insights suggest that much of organizational life may take place in the aftermath of personnel shortages.

The analysis offers an important insight as to why imitating another organization's practices may be far more difficult than organizational theorists or practitioners often appreciate. First, imitating the current practices of a firm is not the same as mimicking the path through which the firm developed those practices. The milieu of today's organizational practices is an imperfect summary of the evolutionary trajectory that has brought the organization to the present. Popular techniques such as benchmarking and documenting best practices focus attention on a static view of current practice, at the risk of missing the importance of the learning by doing that has led to the present state. Even more insidiously, implementation activities focused on the instrumental tasks associated with copying proven practices may actually undercut the learning by doing that might otherwise occur.

Consider a firm attempting to copy the practices they observe at a firm that is successful as in Figure 6. When the focus of imitation is on the current practices, the imitating firm
will be copying the practices of the model firm after it has navigated the critical transition. But, these current practices do not reveal the key to the successful transition the firm has made previously. Indeed, the support personnel resources at the final time are identical in the simulations for firms on both sides of the transition point (e.g., green and gray in Figure 6). The difference between copying best practices and building capability for them through learning by doing has important implications for framing the challenge. The former suggests the approach is one of implementing or adopting a change. The latter suggests more attention to the importance of making a transition. The transition challenge is apparent in the present study. Although a production system with highly developed participatory work practices may indeed reduce the need for support personnel, in the short run developing the system requires more support personnel. This study suggests that a richer appreciation of this transition problem is needed, not only among managers of organization change but also among the scholarly community.

This work has important implications for managers embarking on a process of organizational change based on participative improvement. First, the reason for the fizzle is simple but maybe easily overlooked. The cause of the fizzle ultimately traces back to the reduction in the support personnel that are implementing improvement. It is not surprising that after resources are reduced, improvement activity wanes, but the situation is more complicated. Because of important delays in the system, improvement activity continues and process capability increases long after the reduction in resources. The observed decline comes much later than the departure of the additional resources. It is well established that people fail to appreciate the time delays between action and
response, and learning is compromised, especially when dealing with systems characterized by non-linear feedback and dynamic complexity (Diehl & Sterman, 1995; Paich & Sterman, 1993; Sterman, 1994). Managers experiencing a start and fizzle for the reasons described here are unlikely to attribute the decline to a simple explanation based on the departure of resources much earlier.

A second important implication concerns resource allocation policies. A resource allocation policy based simply on the work content of the implementation tasks and monitored by the rate of task accomplishment does not take into account the importance of the consequences of how work gets done. A traditional tool such as an implementation schedule to monitor progress may be misleading or perhaps even exacerbate the schedule pressure that leads to compromising ways of working that have future benefits but short-term costs. Task accomplishment is far more salient than intangibles such as the degree of collaboration in current work practices, the skill of the organization in doing work collaboratively, and the worker's understanding of the business processes they are executing. Yet, sustaining improvement in process capability depends heavily on these less salient factors.

This work also has implications for organizational theory in the area of organizational change. Several scholars have called for a greater attention to the interconnections between the content of change and the process of change. "Enough research has been conducted on organizational change to make it clear that, in most contexts, both content and process factors ought to be evaluated. Yet theories and analyses of organizational
change often tend to only one dimension." (Barnett & Carroll, 1995, p.219). "One particularly worthwhile domain in which process and content concerns converge is the translation of knowledge into action. There are many instances in which organizations know what to do (content) but have difficulty in actually implementing that knowledge (action). …The challenge for organization studies in the future is to find ways of understanding the connection between content and process, between knowledge and action, and between theory and practice to gain a better understanding of "why well-informed individuals and organizations within them pursue ineffective activities and promote dysfunctional policies and practices" (Pfeffer, 1997, p. 202). This paper identifies a critical interconnection between the content and the process of participative improvement. Moreover, the use of system dynamics to further explore such interconnections holds great promise.

The paper highlights the importance of "how" work gets done in addition to "what" gets done. The key to achieving a sustained transformation to higher levels of organizational performance is to engage a positive loop that can work to overcome the strong balancing loops that work to favor the status quo. Organizational researchers have frequently noted the strong tendency of organizations to favor the status quo, often referred to as organizational inertia (Leonard-Barton, 1992; Sastry, 1997; Tushman & Romanelli, 1985). The Learning by Doing loop provides a specific example of the means by which a reinforcing loop can work to overcome such inertial forces. Indeed, this work suggests a reconceptualization of participative improvement to incorporate a richer appreciation for the importance of building organizational capabilities to improve. The real challenge is
not one of improving our organizations' core business processes but of improving the way in which we improve. This notion echoes the thoughts of some researchers in the field of organizational learning (Levitt & March, 1988; March, 1991; Senge, 1990). The sustainable advantage is found not so much in improving the primary work processes but in improving the more general ability of the organization to continually improve itself (Senge, 1990). For example, in an empirical study of performance outcomes associated with TQM, Powell (1995) found that it was not the TQM tools and techniques but the tacit resources - such as an open culture, employee empowerment, and executive commitment - that can produce competitive advantage. Accomplishing tasks that lead to improvements in process capability can be considered a form of first-order change, whereas building experience so as to collaborate more effectively in the future can be considered second-order change (Bartunek & Moch, 1987). The way in which support personnel interact with shop floor workers is governed by organizational routines (Cyert & March, 1963; Nelson et al., 1982), and "engaging in organizational routines can be a process of learning" (Feldman, 2000, p. 625). Routines that are learning processes are examples of double-loop learning (Argyris & Schon, 1996). Attention to the importance of the reinforcing nature of improving the ability to improve holds the potential to improve both management theory and practice.

APPENDIX
This appendix presents the model equations and parameters. A complete description of the model including documentation of all equations and conditions used for the simulations shown in the main text is available from the author. Table 1 displays symbols used for the model variables, along with complete variable names and their units of measure.
Table 1: Model Variables

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<tr>
<th>Variable</th>
<th>Variable Name</th>
<th>Units of Measure</th>
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<td>PI</td>
<td>Process Improvement</td>
<td>Widgets/week/week</td>
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<tr>
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<td>Process Degradation</td>
<td>Widgets/week/week</td>
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<td>Task Completion Rate</td>
<td>Tasks/week</td>
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<tr>
<td>TSWA</td>
<td>Time Spent Working Alone</td>
<td>Hours/week</td>
</tr>
<tr>
<td>ICR</td>
<td>Indicated Completion Rate</td>
<td>Hours/week</td>
</tr>
<tr>
<td>IV</td>
<td>Idea Value</td>
<td>Widgets/week/task</td>
</tr>
</tbody>
</table>

The model is formulated as a system of non-linear differential equations as follows:

\[
PC = \int (PI - PD)dt + PC_0
\]

\[
PI = TCR \cdot IV
\]

\[
PD = \frac{PC}{\tau_d}
\]

\[
T = \int (IG - TCR)dt + T_0
\]

\[
TCR = \text{Min}[MCR, PDC \cdot TSC + \alpha \cdot TSWA]
\]

\[
MCR = \frac{T}{\tau_m}
\]

\[
TSC = \text{Max}\left[0, \text{Min}\left(\frac{\text{STA} \cdot \frac{\alpha \cdot \text{STA} - ICR}{\alpha - PDC}}{\alpha - PDC}\right)\right]
\]

\[
TSWA = \text{STA} - TSC
\]

\[
PDC = \alpha \cdot \text{Max}\left[0, \text{Min}\left(0.95, \left[\rho + \beta \cdot \left(1 - \frac{E}{E_0}\right)\right]\right)\right]
\]
\[ E = \int (L - F) dt + E_0 \]

\[ F = \frac{E}{\tau_f} \]

\[ L = TSC \]

\[ ICR = \frac{T}{\lambda} \]

\[ IV = \theta \cdot \frac{E}{E_0} \]

Model parameters are shown in Table 2. Parameter values are chosen based on discussions with managers. Extensive sensitivity tests, also available from the author, have been conducted and demonstrate that the qualitative patterns of behavior shown in the paper are robust across a wide range of parameter values.

### Table 2: Model Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter Name</th>
<th>Parameter Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \lambda )</td>
<td>Desired Time to Complete Tasks</td>
<td>2 weeks</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>Productivity of Working Alone</td>
<td>1 task/hour</td>
</tr>
<tr>
<td>( \beta )</td>
<td>Effect of Experience on Productivity</td>
<td>0.25 (dimensionless)</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Normal Relative Productivity</td>
<td>0.5 (dimensionless)</td>
</tr>
<tr>
<td>( \theta )</td>
<td>Effect of Experience on Idea Value</td>
<td>0.5 (dimensionless)</td>
</tr>
<tr>
<td>( \tau_f )</td>
<td>Time to Forget</td>
<td>12 weeks</td>
</tr>
<tr>
<td>( \tau_d )</td>
<td>Useful Life of Improvements</td>
<td>16 weeks</td>
</tr>
<tr>
<td>( \tau_m )</td>
<td>Minimum Time to Complete Task</td>
<td>2 weeks</td>
</tr>
<tr>
<td>( \text{IFC} )</td>
<td>Initial Fraction of Time Collaborating</td>
<td>0.3 (dimensionless)</td>
</tr>
<tr>
<td>( \text{IG} )</td>
<td>Idea Generation</td>
<td>30 tasks/week</td>
</tr>
</tbody>
</table>

Finally, the initial values of the three stock variables and Support Time Available (STA, hours/week) are chosen to start the model in dynamic equilibrium as follows:

\[ T_0 = \lambda \cdot \text{IG} \]

\[ E_0 = \tau_f \cdot L \]

\[ PC_0 = \tau_d \cdot PI \]

\[ \text{STA} = \frac{\text{IG}}{\alpha \cdot (1 - \text{IFC}) + \rho \cdot \alpha \cdot \text{IFC}} \]


