OFFICE AUTOMATION: A MANAGEMENT BY CONSTRAINTS APPROACH

by

Barry D. Floyd
Leonard N. Stern School of Business
New York University
624 Tisch Hall, 40 West 4th St.
New York, NY 10003

and

Boaz Ronen
Recanati Graduate School of Business
Tel Aviv University
Tel Aviv, 69978 Israel

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Center for Research on Information Systems
Information Systems Department
Leonard N. Stern School of Business
New York University

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Barry D. Floyd
Stern School of Business
New York University

Boaz Ronen
Recanati Graduate School of Business
Tel Aviv University

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1 Introduction

A medium sized manufacturing firm recently invested three million dollars in technology to improve operations in its offices. The company had experienced substantial productivity gains on the shop floor and had hoped for a similar experience in the office. Current office technology seemed capable of meeting their needs and after analyzing the company's various office operations, management decided on a set of goals they wished to accomplish. The company's goals in the project were to reduce clerical manpower by 10%, shorten the response time to customer complaints and to managers' request for information, and to improve communication among senior staff.

However, after a year of struggling with the technology they had purchased and installed, they found that manpower had actually increased due to the need for more technical staff to keep the equipment operating and that the response time to customer complaints remained about the same as did the response time for managers' information requests. The communication performance among senior management was only moderately improved.

However, worst of all, they found that half of the installed equipment was not being used.

Their goals were not unreasonable. Experts in office automation have predicted increased productivity, more capabilities, higher satisfaction among the workers, managers, and clients as well as the prestige of having a technologically advanced work environment among the benefits of placing computer and communications technology into the office. Managers wishing to improve the office have subsequently sought these goals.

But the result of office automation for this company has too often been the result for many - the expectations of Office Automation have not been realized. Typically, improvements in word processing productivity have been the best that have been achieved for most organizations.

Why have these failures occurred? Many reasons have been proposed for the failure of office automation. Some suggest the implementation difficulties of imposing change in a 'stable' setting. Others propose that technology is not yet capable of meeting the real goals of the organization and that overall costs will always be higher than anticipated and expected use lower.

In this article we propose that a major reason for many of the failures of office automation is a breakdown in the analysis process which determines where office technology should be applied and how office performance should be measured. Technology which improves efficiency while not improving the bottom-line of the organization is inappropriate. For example, improving a typist's efficiency when the typist is used only 75% of the time is money ill-spent. Office analysis must focus on the *overall* performance of the system. Techniques which are currently being developed in the domain of production management provide this focus and are applicable to the domain of office analysis.

In moving attention from the production floor to the office floor, typically the organization changes it analysts and its analytical techniques. The premise of this strategy is that the two work environments should be viewed as essentially different. We disagree with this premise.

Originally, many office analysts had production system backgrounds and used those techniques and representations to analyze business information systems. However, with the current separation in the training of the business analyst and the production system analyst, the new techniques and methods in the production system environment are not transferred to the business setting. We find that there has been significant progress in analyz-

ing production systems and that these techniques and conceptual frameworks are importance for office analysis. For example, technology has been introduced to support a 'just-in-time' approach to inventory management leading to better quality and higher profits.

The shop floor techniques have also suggested different measures for evaluating system performance. Efficiency, utilization, and ouptut are viewed as less valuable than measures such as throughput, operating expenses, and inventory. Furthermore, these measures are considered on a global basis rather than focusing on one component of the system in isolation. A transfer of these measures to the office will improve our direction in the implementation of office technologies.

Finally, our discussion does not preclude the important progress which has been made in the socio-political domains of office analysis. These factors are extremely important in designing, developing and implementing office systems. Although these factors provide significant differences between the shop floor and the office floor, we believe that the newer conceptual frameworks found in production management can work in conjunction with the important emphasis on the interpersonal and political issues of successful office automation.

Thus, given our belief that there are many analogies between the production floor and the office floor - and the techniques which are applied successfully on the shop floor can be applied successfully to the office floor, we present a discussion of one production floor technique, Management By Constraints (MBC) and show how it applies to the identifying focal points on providing technology to automate office functions.

2 Managing an Office by Managing Constraints

Management By Constraints as developed by Goldratt, (see 'Suggestions for Further Readings') is a method for improving the performance of a process by focusing on *system* constraints. A premise of this method is that it is unreasonable to increase production capacity for resources which are not constraining resources. Doing so simply leads to excess inventory. Furthermore, this approach suggests that anticipated benefits, such as decreased operating

STEP	ACTIVITY
1	Identify goal of the system
2	Identify appropriate measures for the goal
3	Identify system constraint(s)
4	Decide how to exploit system constraint(s)
5	Subordinate all the system to the above decision
6	Elevate the constraint
7	If in a previous step a constraint was broken go back to step three (don't let inertia be the system's constraint).

Table 1: Steps in Management by Constraints process.

expenses, received from improvements to non-constraining resources should be contrasted against anticipated benefits received for similar expenditure levels made on the constraining resource for *all monies* spent on system improvements.

A system constraint is defined as anything that restricts system performance, preventing the system from reaching its stated goals. For example, in processing orders from customers, the order taking process may be efficient, but it may be a constraint on the system throughput by not possessing enough capacity to process all requested orders. Hence, resources which are to be expended on improving system throughput should be first applied to this order taking process.

In analyzing systems, a major philosophical objective of the MBC approach is to optimize performance at the *global* or *system* level rather than at the local level. To accomplish this goal, Goldratt has defined a *series* of *steps* which focus, in a recursive fashion, on the constraints which inhibit gains in performance (see Table 1). In the following discussion we review each of these steps and present examples illustrating how the process works in an office setting. We then illustrate the steps in the analysis of a dentist's office.

STEP 1: Identify the goal of the system.

Within an organization, many *system components* are put into place to design, produce and sell products and services. Other components are put into place to manage this production process. While each component has its own goal, it must be *consonant* with the goal of the organization or the *system goal.* For most organizations, the system goal should be to be profitable and to remain so in the future. This translates into getting the goods and services out the front door at a price higher than it takes to produce the goods or services.

The choice of a profit goal and the choice of product or service of the company help define the activities which must occur to meet the goal. These choices also set the stage for defining the measures (which we will discuss in the next step) to be taken to track and evaluate progress. Often analysts focus on improving a particular component's performance while losing sight of the organization's overall goal of profitability. Improvements which do not help get goods and services out the front door will take attention and resources away from the organization's real needs and create a negative impact on the bottom line.

For example, if a subgroup of the organization works on building up inventory, creating information systems to help this process, it could fail. It must have customers for the products. It is not simply the creation of the product which produces profits, but the transfer of the ownership of those products to a customer. The goal of the component must be consonant with the goal of the organization.

Furthermore, if a subgroup of the organization focuses on system utilization, trying to push utilization of resources and creating information systems to help track this measure, it could fail also. Utilization is an accounting concept which is often at odds with the more important concept of throughput - getting the product to market. Note that if an office focused only on utilization, there would be few, if any, personal computers to be found. When subgoals or incorrect goals are optimized, the proper functioning of the total system may be in jeopardy.

STEP 2: Identify appropriate measures for the goal

Human behavior is strongly influenced by the measures set up to evaluate that behavior. If speed is measured in a contest then the contestants

ITEM	MEASURE
1	Throughput
2	Operating expenses
3	Inventory
4	Lead time
5	Quality

Table 2: Measures in Management by Constraints process.

go faster. If accuracy is the measure, contestants slow down and work more accurately. Therefore, the choice of the measures used to evaluate performance within the process must be consonant with the goal of the system. As such it is imperative that the measures be global in nature rather than local. A global measure is one which measures progress towards the system goal by determining the status of factors which directly affect system goal achievement. The importance of setting global measure vs. local ones is to provide incentive for coordinating among each of the subunits in the system. The only way to score high on the global measure is through coordination. Local measures circumvent this.

For example, if the hubcap division of an auto company has a goal of maximum production and its production capacity is greater than the rest of the production lines, then excess hubcaps are produced. Output with no customer is expensive waste. Another example concerns the scheduling patients in a doctor's office. Although there may be enough chairs to seat 15 people, actually scheduling 15 people to meet with one doctor at the same time would be disasterous for the doctor's reputation.

There are three global measures suggested in an MBC approach (items 1-3 in Table 2.) and two more as suggested by Eden and Ronen. We discuss these measures in the following paragraphs.

Throughput refers to the goods and services sold to a customer or consumed by the organization. Output differs from throughput in that output includes all of the unsold goods and services. The greater the throughput for a system, the more profitable it will be. Many managers mistake output for throughput. They believe that by creating the product, they have created profits for the organization. This is not the case. If the product does not

have a customer, the manager has created an item for inventory with all the inherent costs associated with keeping something in storage.

Consider a situation where an organization wishes to improve its purchasing department by introducing technology to support electronic data interchange (EDI) for the purchasing process. In analyzing such a situation, often the manager reviews system efficiencies, selecting the system which is most efficient. However, a different approach is to focus on throughput, contrasting system throughput before the change was made with throughput subsequent to change and selecting the system which has the greater throughput. If efficiency is considered, it should only be considered in relation to its effect on operating expenses.

The second measure, *operating expenses*, is important in realizing the actual costs of production. Often managers are fooled through analyses which illustrate imaginary savings when implementing office systems. For example, a common analysis determines the amount of a person's time which may be saved through the implementation of some new technology. However, if no one is released and the person's new found time doesn't modify the throughput in a positive way, the savings are not real. There is no decrease in operating expenses! In fact, the costs could be higher due to personnel or maintenance agreements on the new technology used to save time.

The third measure, *inventory*, represents money invested in raw materials, work in process and finished goods. While some inventory is necessary, lower inventory reduces expenses and improves profits. The dangers of inventory are well known: damage, theft, perishing, obsolesence, etc.

In an office setting, inventory can occur in unwanted ways. Consider a purchasing department, orders can be thought of as work in process. If the purchasing department is unable to keep up with the organization's requests for goods, paperwork (purchase orders) builds up. The department may misplace orders, errors will occur as workers attempt to speed up an overloaded process, people in the organization will constantly interrupt the purchasing department requesting information on their order, and throughput will deteriorate.

Note, if we introduce technology in the purchasing department to reduce the inventory of orders, we may simply be moving the inventory buildup to the finance department which has to approve and finance the purchases. This might suggest that Office Automation technology should also be used to assist the finance department; for example, developing a decision support

system (DSS) to aid them in the decision making aspects of their work. Again, the *overall* organization and organizational goal must be considered.

As another example, consider the photocopy department in an organization. If a presentation is to be given twice, once this month and once the following month, and handouts are required, often all copies of the handouts are made at one time. This requires the storage of the excess handouts until the second presentation (note that these extras copies are NOT considered throughput at this time, they are output!). As is usually the case, the presentation is changed slightly and the handouts must be modified, or the presentation is cancelled or the handouts can't be found.

One production system technique which can be used in the office setting to reduce inventory is the 'just-in-time' method. In such a method, inventory is held to a minimum through scheduling the arrival of raw materials at the time of use. This approach typically leads to lower costs and higher profits.

The fourth measure, *lead time*, is important in evaluating the overall performance of the system. Lead time refers to the response delay between the time when a customer requests a product or service and the time when the product or service is provided. Short lead times provide a competitive advantage for the company.

The last measure, *quality*, is also a determinant in providing a competitive advantage to the organization and therefore in measuring progress towards the goal of profitability. Quality, a multi-dimensional concept, depends on the process used in creating the product or service. Management can manipulate the quality of its products (e.g., the number of errors in an order) by focusing attention on these dimensions making appropriate changes to the process. An article by Garvin, 1987, presents a list of eight dimensions of quality (see further readings).

STEP 3: Identify the system constraint(s)

As mentioned earlier, a system constraint is anything that restricts the system from achieving its stated goal. There are many ways to identify constraints in a system. Perhaps the simplest but most effective is to ask the people involved in the work process. For the office, it means asking the office worker, the secretary, clerk, or other knowledge worker about the aspects of the work environment which restrict their work flow. For example, asking the

purchasing department where orders are most often held up provides insight into a constraint in the order processing system.

A second technique is a visit to the work site. Such a visit allows the analyst to see where any mountains of inventory are building up. When a buildup of inventory occurs, a constraint on the system usually exists (e.g., consider the purchasing department and its backload of orders to process).

Another set of techniques is analytical. Work load analysis falls into this category, where the objective is to identify the most utilized resource. This resource will utimately be one of the constraints on the system. Also in the analytical class of techniques is to analyze the resources used by the jobs that pass through the process. In doing so, a contrast of those jobs that are overdue with those jobs that are on time (or early) identifies potential resource constraints. The resources that participated in late jobs and did not participate in the on-time jobs are candidates for bottlenecks.

These system constraints can be either internal or external. An example external constraint is the market - it may simply not want all the products the organization produces. An internal constraint can be a department such as finance or purchasing, or it can be an individual within a department such as a secretary or a manager (who must approve all orders). It can also be a machine such as a copier or a fax machine.

STEP 4: Decide how to exploit the system constraint.

Given that we have determined what the constraint of the system is, the next step is to exploit the constraint by determining how to make the best use of the constraint. This can be done in two ways. The first way is to assure that the constraining resource is used 100% of its available time. For example if a typist in an office setting is the constraining resource, the goal is to assure that the word processing equipment is continually in working order so that the typist can work 100% of the allocated working hours.

The second way is to evaluate the mix of products which flow through that resource. This evaluation should lead to a mix which increases the overall profitability of the organization. For example, if the office is a doctor's office, he could choose to restrict his practice to patients which provide higher profit margins. Finding a mix which is acceptable to the organization may be difficult for many offices. Often, the products which pass through an office

vary widely in mix with each requiring attention by the constraining resource for reasons outside of profitability.

STEP 5: Subordinate other system decisions to the above decision.

In this step, the goal is to make other system decisions congruent with the constraint. The perspective of the system as defined by MBC is to envision the constraining resource as the 'drum' of the system with the other system components 'marching in step' to that beat. For example, if the typist is a constraint, then the rate at which documents are given to the typist to type, should match the rate at which the typist works. In addition, to assure that the typist always has some material to work on, the creation of a buffer (i.e., an in-box), which can hold some material (but not an exceptional amount) can be created.

STEP 6: Elevate the system constraint

After having made the system work as effectively as possible with the current constraint, the goal is to discover how to overcome that constraint to improve the system's performance. Again there are two ways in which we can improve the system. One way is to purchase additional resources of the same nature to improve capacity. For example, if the typist were the constraint in the office system, adding an additional typist to the work force may relieve the constraint.

A second way is to make organizational or technological changes to the system. For example, we may be able to improve the typist's speed through training or through providing her with greater control over the work flow. We may also improve performance through purchasing better word processing equipment.

For each improvement, we would perform a cost/benefit analysis to determine if the expenditures led to higher profits before making the investment. As mentioned earlier, by focusing on the constraining resource, we have a better opportunity for increasing throughput and, therefore, increasing profits.

STEP 7: Go back to STEP 3

Finally, if the constraint has been broken in one of these steps, the next step is to go back to STEP 3 and identify the new system constraint. In this analysis, the overall goal is to end with the constraint at a desired location. Thus, in evaluating the system, the process repeats until the goal is at this chosen place, not stopping with just the first constraint being broken and letting inertia get in the way. Often the location of the constraint is at the most expensive resource. For example, in a dentist's office, the most expensive resource is the dentist and, therefore, the constraint should be placed with him. We explore this a bit more in the following example.

3 The Dentist Office

To illustrate the approach of managing by constraints we discuss a dentist's office and point to where the results of the analysis suggest attention could be focused when automating such an office. A dentist's office contains numerous opportunities for automation: mailing lists, patient data storage and retrieval, reminder systems, communication system among the office members, accounting functions, and so forth. A consideration for both the Dentist and the office analyst is 'Which office component, if any, should be selected for automation?'.

Let us consider an office which has one dentist, a dental assistant, and an office manager. The dentist performs standard dental activities of examining patients, tooth repair, and cleaning. The dental assistant aids in these activities, helping the doctor as needed, preparing necessary equipment and compounds, and by taking X-rays. The office manager schedules patients, tracks accounts, sends forms to insurance companies and answers the telephone.

The physical setting of the office itself is a waiting room large enough to hold 5 to 6 patients comfortably, though rarely are there more than 2 or 3 patients in the waiting room at any given time. There is a reception desk where the office manager sits and, inside, there are three 'work stations', two of which are comparable in the amount and type of equipment while the third is geared towards minor work and for the cleaning of the patient's teeth.

Identify system goal

The goal of the dentist is to be profitable while providing excellent quality dental care for his patients. He prides himself by knowing most of his patients and in having serviced some patients and their children for years. He measures his success by being able to live comfortably, provide meaningful employment to his two employees, and by having a clientele who are pleased with his work.

In spite of the calm which surrounds his office, he realizes that dentists are beginning to have a difficult time finding patients. The number of clients with dental decay is decreasing due to the use of floride, and so, some of his high-skill tasks are decreasing in frequency. Though he is still busy, he is unwary about the future and wonders if the use of computer technology will help him remain profitable.

The dentist has heard about new computer technology which is supposed to make his office more productive at reduced cost. While intrigued, he is still suspicious of any improvements which can be made to his currently, well-run situation. He is uncertain about which functions in the office would be 'candidates for automation'.

Identify system measures

We can apply the five measures discussed earlier to our dentist office. Any technological advance should impact one of these measures favorably for us to consider implementing new technology. The first measure, throughput, corresponds most directly to the number of patients the doctor sees during a day. Because of the type of service provided, the dentist's output is typically equivalent to his throughput. The office does, however, produce other outputs in the form of bills and reminder notices. These items would be considered throughput when the bills are paid and when the reminders are responded to by the clients.

The second measure, operating expenses, consists of all of the monies expended to service the clients, including salaries, phone bills, mail expenses, and dental supplies.

The third measure, inventory, occurs primary as the number of clients waiting for service in the office seating area. This value should neither be zero nor so large that customers who wait too long decide to leave. Inventory also occurs in the inside work areas allowing patients to be prepared so that

the dentist can work efficiently.

The fourth measure, lead time, is the difference between the time that a person calls for service and the time at which he is scheduled for an appointment to have that service provided. An objective is to get the lead time close to zero.

Finally, quality, is reflected in a number of ways, such as the number of complaints a patient makes about the work, the appearance of the work, as well as the type of interaction between the dentist and the patient.

Identify the system constraint

Given the dentist's goals and the measures which he uses to evaluate his office, what is the constraint in the office? If we could place the constraint anywhere in the system, we should place the constraint with the dentist. Why? The dentist should be allowed to work at the rate he desires without having to waste time waiting for patients to be seated or for his dental assistant to complete a task (these are other possible constraints). It is mainly the dentist who creates profit for the office, *and*, he is the high cost resource in the system.

It is possible that the dental assistant or the office manager may in fact be constraining the system throughput. If they are, these constraints could be removed (i.e., elevate the constraint) so that the constraint becomes the dentist. Both the office manager and dental assistant are much less costly resources. As mentioned earlier, if a resource is to remain idle, in most cases it should be the lower cost resource.

Exploiting the system constraint

The notion behind exploiting the system constraint is to improve the performance measures while not making any improvements to the existing system. For example, assuming the dentist were the constraint, we could increase revenues by servicing patients who require work of a more costly nature but which take the same amount of dentist time as the less costly work (e.g., work which requires a greater degree of dental skill). This could improve the profitability measure while not really altering the constraining resource (the dentist). If the dental assistant were the constraint, we could decide on a mix of patients which could increase throughput by selecting patients who require less preparation time. In both of these instances a cost/benefit analysis would be performed to select the optimal mix of patients.

Subordinate other system decisions

In this step the goal is to make other decisions about the system be coordinated with the work schedule of the dentist. For example, the inflow of patients should be at a rate which the dentist can easily handle. In a sense, he is the 'drum' of the system, creating a beat which other system components must be insynch with. Hence, the other two workers in this system, the office manager and the dental assistant, must work according to the dentist's rate. This implies that the utilization of these two workers depends on the dentist and not on their own potential. For example, the office manager doesn't schedule as many patients as he can receive, he schedules as many patients as the doctor can service. Similarly, the dental assistant doesn't prepare as many compounds for patching teeth as he can make, the dental assistant makes compounds at the rate required by the dentist. The office manager and the dental assistant may not be busy 100% of the time and should not be evaluated on this criteria.

Note that if the dental assistant is the constraining resource, patients should be scheduled so that the assistant is able to service each of them adequately. This could imply that the dentist is idle for periods of time during the day. If this constraint is unacceptable, we then elevate the constraint as discussed in the next section.

Elevate the system constraint

After identifying the system constraint and optimizing the performance of the current system, the last option is to consider modifying the system to elevate the system constraint. It is at this point that we consider providing automation for the office.

If the dentist were the constraint, we could purchase computer equipment which would support his retrieving and recording details concerning patient visits. The equipment could reduce his time spent with patients, therefore improving throughput, and/or it could improve the quality of his service by enhancing his interaction with the patients through better information.

Non-technical solutions could entail letting the dental assistant perform some dental functions which require less skill, such as cleaning. It may be possible that the dental assistant who takes on this task may not do it as quickly, but a cost/benefit analysis may show that it is not important - efficiency is not the main concern.

In cost accounting, typically we assign overhead on hours worked. Therefore, the idea of transferring a task from an efficient resource to one which is less efficient would be going in the wrong direction. But in a management by constraint approach it becomes clear that in the global scheme of system performance, it may be exactly what is necessary.

When either the dental assistant or the office manager is the constraint, and we wish the constraint to be elsewhere, we can modify the system to elevate the constraining resource. For example, if the office manager is unable to schedule sufficient patients due to clients who don't arrive for scheduled appointments, we could implement a scheduling system to assist in this function. An analysis of the cost of the system and the resulting benefits would have to precede the actual acquisition of the system. And, if the dental assistant is unable to prepare compounds and perform his work quickly enough, we could hire another assistant to support this function or provide technological support to improve the performance of the dental assistant. The goal in these two instances is to elevate the constraint sufficiently so that the dentist becomes the constraining resource in the system.

Finally, if the dentist already is the constraint, we do not want to apply office technology to the office manager or to the dental assistant unless it improves the measures we have previously discussed. Purchasing a computer system to reduce the time it takes to send out bills is not fruitful if the office manager already has slack time. The monies would be better spent on improving the dentist's performance.

Once we make changes to a system to elevate a constraint, we need to re-evaluate the system to determine which resource has become the new constraint. If this is not where we wish the constraint to be, we must procede through the steps again, until we end with the constraint at the desired location.

4 Investment in OA

How does improved performance on our five measures translate into an evaluation of the return on our investment into office technology? Because our goal was to be profitable and to remain so, the impact of office automation technology must have a positive impact on our financial position. We discussed five measures for evaluating system performance. The first three of

these measures can be translated directly into a monetary evaluation of the system changes.

Increases in throughput, and decreases in operating expenses and inventory are reflected immediately in the cash flow position of the organization and find their way to the balance sheet of the company statement.

The two other measurements are more difficult to directly apply to the financial health of the company. Both decreases in lead time and improvements in quality generate changes in the overall system which impact the financial statement indirectly through changes in sales and market share over a longer time frame. It may also be difficult to separate these improvements from other environmental variables. However, a method for determining the financial impact of changes in these two measurements is to review the financial statements prior to any changes and to review them subsequent to the changes.

5 Summary and Conclusions

Management By Constraints works in production systems and we believe it has enormous potential for evaluating office systems. We have proposed that a major cause in the failure of office automation is a breakdown in the analysis process. In this analysis, the focus of attention has been misdirected towards components of the system whose improvements matter little to the overall performance of the system. The focus should, more appropriately, be on the constraints of the system. We believe that that is why technology such as word processing has succeeded where electronic mail is still unsuccessful in many organizations.

Furthermore, in evaluating the results of implementing office technology, the focus should be on measures such as throughput rather than output. We must do away with the standard cost accounting techniques with its inappropriate emphasis on efficiency and utilization for all system components (they are most useful in evaluating the system constraint in order to exploit it). The measurement standards most appropriate for today's systems are throughput, operating expenses, inventory, leadtime and quality. Emphasis on these measures will assure progress towards improved profitability and continued organizational existence.

While it may occur that the constraint moves with changes to the sys-

tem, the focus of the analysis should be on ongoing improvement until the constraint has been put into a desired place. This also suggests that every system may have a different constraint, and hence, a different technology to improve the system's performance. For example, if the constraint is communication, use communication technology, if the constraint is in manager decision making, apply DSS technology, if the constraint is in expertise, apply expert systems technology.

In conclusion, there is danger in applying IS technology where it is not a constraint. The implementation of any technology into an organization is a difficult process and if it is not needed (which the workers quickly discover), the technology will not be used.

SUGGESTIONS FOR FURTHER READINGS

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