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Evaluating MIS Effectiveness by Means of the Measure of Flexibility

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Abstract
The growth of MIS investment and its influence is making MIS evaluation ever more indispensable. MIS effectiveness should be measured in the context of an organizational use process. MIS implementation is a planned organizational change. This change requires time and cost as penalty of change (POC), a concept to be used as an index to measure the flexibility that an organizational MIS should acquire at the time of its implementation to accommodate changes in the future. MIS planning should not only meet immediate needs of an organization, but also provide such future-oriented flexibility. To enable this, MIS planning should include measurement of flexibility as an integral part of it. This paper aims at presenting a practical evaluation procedure for MIS flexibility enhancement. After looking at three cases of MIS implementation, we will define and categorize MIS flexibility. We will then discuss the meanings of POC and end by illustrating our MIS evaluation procedure.

1. Introduction

All excellent businesses worldwide are struggling with information technology (IT) investment so that they will gain a competitive edge in the rapidly changing management environment. This trend is making the evaluation of MIS effectiveness increasingly more crucial and indispensable. What they expect from IT investment is "early" acquisition of value or effectiveness that MIS will bring. In the business world, speed and agility are perceived to be the most important key words. These are realized by the value of strategic information infrastructure, one of the five values that Information Economics (Buzacott, 1982) proposes, and the other values proposed are realized in the use process of application systems on the strategic information infrastructure.

As for evaluation of MIS effectiveness, methods traditionally utilized have been "Total Quantification with Qualitative analysis" (Barad and Sipper, 1988), "Information Economics" and "Contribution to Corporate Performance" (Brown et al., 1988; Chryssolouris, 1996) in the classification of cost/benefit methodology. But perception and use of a particular information system can be heavily conditioned by personal and situational variables (Chryssolouris, 1992). This fact in particular makes it difficult to evaluate MIS effectiveness quantitatively. Deemed relatively reliable for this purpose, however, are the following five measures: "High levels of system use", "User satisfaction with the system", "Favorable attitudes about MIS function", "Achievement of objectives", "Financial payoff" (Delone and Ephraim, 1992).

All the same, the benefits accruing from an information system may not be totally quantifiable. Moreover, as regards the more advanced decision-support system applications, tangible benefits cannot be easily determined in the first place. And even though cost/benefit methodology has been rigorously pursued, the failure-riddled history of many systems development projects has shown that realistic estimates of the benefits have always been difficult to formulate. In fact, many MIS researchers have shifted their focus to the human and organizational measures of system success such as information quality, system quality, and the impact of systems on organizational performance (Falkner, 1986).

With all this taken into account, let us define our final goal as formulation of a realistic method for estimating MIS effectiveness in the planning stage as opposed to "after the fact". An MIS consists of several subsystems, each with its multiple functions, and each of the subsystems is so constructed as to meet the demand of a particular organization. The effectiveness of an MIS is actualized through its practical use by an organization. Furthermore speed and agility that an enterprise is anxious to secure can only be derived from a well-structured information infrastructure. Therefore, as a measure of the property of an MIS that can absorb the demand of an organization with agility, let us focus our attention on "the flexibility of the information infrastructure (MIS flexibility)" and assume:

- that if an MIS has developed highly flexible infrastructure now, it will be better able to meet the changing demands of an organization in the future,
- that in an organization's effort to enhance MIS flexibility, there is a level of investment that will maximize MIS effectiveness despite a time lag.

We might substitute these two assumptions with the following questions.

1) How flexible an MIS should we acquire now in order to accommodate changes in the future?
2) On the time axis, what is the nature of the relationship between resources invested in an MIS and its effectiveness expected? And under what kind of condition do they match?

The aim of this paper is to focus on the first question and seek for its solution. We will first analyze and discuss the evaluation of MIS effectiveness from the resource/efficiency-oriented viewpoint (Hamilton and Chervany, 1981) and follow up the discussion with a goal/effectiveness-oriented analysis (Hamilton and Chervany, 1981). Here let us add that throughout this paper we will use the term MIS in the limited sense of computer-based information system.

2. Business Speed and Agile Management Depend on MIS Flexibility

In the last quarter of this century, we have seen many wondrous rapid innovation in the field of IT e.g. end-user spreadsheet computing, data base management system (DBMS) with the function for data description and handling, data processing and communication with cheap but high-performance personal/mobile computer and telecommunication, user-friendly human interface with pointing device and multimedia, internet, etc. Due to all these innovations, managerial decision-making, which depends on the information handling by IT engineers, have certainly gained a great deal in speed and agility. It is also true that speedy and agile management has been giving many businesses a competitive edge and businesses with little IT investment are more likely to decline. But does IT investment guarantee business success? Actually we have seen many difficulties standing in the way of IT innovation as the following cases amply demonstrate.

Case 1: Change of Standard Operating Procedures

Building a new information system is a form of planned organizational change involving many different people. Since this sort of socio-technological change involves changes in work, management and structuring of the organization, we should take good account of the following as many authors of MIS literature have been suggesting (Falkner, 1986; Kumar, 1986; Laudon and Laudon, 1994; Lucas, 1974):

1) difficulties involved in management change,
2) fitting technology to the organization (or vice versa),
3) and understanding the limits of IT

Kanban-system is well known worldwide as a typical Japanese production control system. But actually many Japanese corporations had traditionally adopted MBPN (management by production number), and some of them attempted to implement an MRP without success. The Robot system section of the company A tried business process re-design in 1984 and 1988.

The quantity of robot order sprang from one or two to more than 10 per month between 1982 and 1983, and a further order expansion was predicted. They prefabricated common units and parts of a robot system for which the order was virtually settled. After final specification decision, these and other customer options were assembled into a finished product before its shipment. The order expansion, however, generated backlogs of unused parts, which led to a rise in production costs. It was this predicament that faced them with the need to change the management process.

There was a marked difference in system effectiveness between the first and the second redesign. It was brought about by the following managerial considerations in the second attempt.

a) Implementation of a Customized MRP System Package

- step-by-step implementation of the new method (a mild change in the organization)
- dispatch of an IT engineer (operative support)
- thoroughness of education and training (understanding of the computer output)

b) The Application of Kanban-system to Common Units and Parts Production Line

- rearranging orders in the production line
- thoroughness of visual control (the practice of putting materials in proper order)

This bring home to us the following:

- Human beings are far more flexible than an MIS,
- If the changes do not exceed the tolerance of the organization, they may be accepted.

In order to attain a goal for administrative change, an organization may have to go through several steps successively. We have seen that the length of a step (change) must not exceed the tolerance of an organization. The MRP system package did not have enough flexibility for a planned change not to overload the tolerance. On this account the package required extra costs for the addition of the MBPN function (since after this re-design project, all Japanese computer manufacturers have developed MRP systems that include the MBPN function). MBPN-MRP has become a standard production control system in Japan. An MBPN-MRP system permits an organization to carry out a step-by-step system implementation, and is more flexible than a standard MRP system. When an organization plans to implement a step-by-step change, the MIS should have enough flexibility to fit in with the change process.

Case 2: Downsizing as an Implementation of New Technology

The printing paper container manufacturer B had used on a mainframe a fairly sophisticated system for scheduling and production control targeted at printing and subsequent processes. In 1994, with its stocks due to go public the next year, the manufacturer decided to build a sales management system. In those days downsizing was the fashion of the day in Japan. Jumping on the bandwagon, this company decided to build the system on client/server architecture. The development, accompanied by a purchase of PCs for development, was outsourced to a vendor. The development of this system on this basis took far less time than on a mainframe. By adopting a prototyping-like development approach and using a relational DBMS, a user-friendly application system was completed one year later

However, the capacity of the one-year-old PCs was less than sufficient to let this system work and replacing them with the latest high-end PCs required extra cost. Furthermore, upgrading to a new OS for the PCs required a great deal more extra cost for lack of upper compatibility. For several years after that, the company found to their great disappointment that with the PC-based system they had to cope with far more system failures and their recoveries than with the mainframe-based system.

Several years later, they undertook another change, this time in the system for in the system for data communication with customers, but the change took far more time and labor than they had expected due to deficiency in documentation. Their choice of technology was the trend of the times. But the heterogeneous new technology that they had adopted continued to make fun of the engineers. Now the heterogeneous monster has been tamed and become relatively obedient. In other words, the new technology has become more flexible.

Generally implementation of new technology entails the high risk of system failures (i.e. an information system that either does not perform as expected, is not operational at a specified time, or cannot be used in the way it is intended to be). Successful implementation does not mean the immediate realization of effectiveness because it takes time for the users to acquire proficiency in the use of the new system. System trouble obstructs flexible use of an MIS. A project like this whose due date is critical requires a high degree of MIS flexibility.

Case 3: Preparation for the New Millennium

System designers could have foreseen the occurrence of the year 2000(Y2K) problem at the stage when the data was being designed. This implies that they programmed Y2K problem intentionally.

The company C was one of the first corporations in Japan that introduced computers. They also very early undertook a change in their application system from batch to on-line real time processing. The change was executed by adding DAM files (direct access method) and programs written in Assembler for real-time processing to the existing batch processing system. The new system was only used during the daytime. The old batch system took over data from the new system after regular office hours for processing during the night. A scrap-and-build approach to the system development had been dismissed in order to meet the demand of the executives who were anxious to start using the new system as soon as possible.

In 1988, the MIS Division of the firm was very busily occupied with maintenance of the system that had been built 20 years before, and was swamped with a huge backlog. After racking their brains about how to overcome their predicament, they decided to replace an old DB with a relational database (RDB).

The procedure that they worked out for the change consisted of:

1) building a new RDB normalized with a data dictionary (DD), with all data from the existing MIS integrated into it,
2) creating an interface between the existing MIS and the new RDB,
3) and finally switching over from the existing MIS to the new system, which would access the new RDB directly.

This renovation cost far more than expected and required serious efforts of the engineers. But both the running cost and the backlog decreased as the changeover progressed. In the fall of 1999, most information IT personnel in the world were in great fear of the arrival of the Y2K. At this time, the changeover of the firm's MIS had already been completed. Because of the superior flexibility of the MIS infrastructure, the expansion of the date-fields to accommodate the change of millenniums was completed by the next day by a mere modification of the definition of the date-fields in the DD.

Remarks

- In order to carry out a planned change successfully, MIS needs flexibility conformable to the tolerance of an organization.
- Experience and proficiency are important factor in the utilization of IT. This suggests that flexibility brought about by a planned change needs to be considered on the time axis.
- Moderate renovation of the infrastructure may improve MIS flexibility. Contrariwise neglect of the infrastructure is likely to cause troubles and renders MIS less flexible.

MIS flexibility is a critical factor affecting system success. Let us consider the meaning MIS flexibility as well as the evaluation method for it.

3. Definition and Measurement Concept of the MIS Flexibility

Flexibility is an index of a system's capacity to absorb risks of potential change, so that a flexible system is bound to be one with a well-structured infrastructure. In other words, the evaluation of MIS flexibility is a matter of decision-making on infrastructure development strategies for the enhancement of the flexibility of the information system.

3.1. Measures of MIS Flexibility

There are two other definitions of flexibility in the literature (McFarlan, 1981; Myyer and Boone1989; Parker and Benson, 1988; Pnuell and Zussman, 1997; Primrose and Leonard, 1984; Richardson and Gordon, 1980; Son and Chan, 1990). One defining it as the ability of a system to cope with external change (e.g. tasks to be disposed of) and the other as the ability to cope with internal change (e.g. system breakdowns). The proposed measure for the first definition is the probability of the occurrence of tasks and their disposal. The proposed measure for the second definition is the ratio of the expected rate of production with disturbances hindering it (e.g. breakdowns) to the expected production rate under conditions free of disturbances. The measures of flexibility reviewed here reflect two distinct viewpoints about flexibility. The second definition suggests that flexibility is an intrinsic attribute of an MIS. The measure of flexibility ascribed to this viewpoint seems to presuppose that flexibility is computable as a function solely of the properties of an MIS. The first definition on the other hand suggests that flexibility is a relative attribute that depends not only on the properties of an MIS itself, but also on the external demands placed upon it.

The quantification of flexibility has been the focus of academic work, but there have been few MIS applications. A classification of flexibility (Srinivasan and Millen, 1986) includes:

Internal flexibility:

- *machine flexibility:* the easiness of exchanging or modifying hardware e.g. computer, network, basic software),
- *process flexibility:* the ability to make new application functions using diverse combinations of hardware, software and network,
- *routing flexibility:* the ability to handle system breakdowns, software bugs and hardware troubles and continue giving services, utilizing application functions,
- *expansion flexibility:* the ability to expand application system functions easily and in a modular fashion,
- *production flexibility:* the universe of service types that a system can support.

External flexibility:

- *product flexibility:* the ability to produce application functions economically and quickly,
- *volume flexibility:* the ability to operate profitably while dealing with different volumes of data processing and system development,
- *operation flexibility:* the ability to reorder several operations in order that both system development and daily data processing can be executed concurrently (it includes a change to other kinds of machines).

Machine flexibility, process flexibility, routing flexibility, expansion flexibility, and *production flexibility* are classified as "internal" factors, and *product flexibility, volume flexibility, operation flexibility* as "external" factors.

3.2. Relationship between Internal and External Factors

When internal flexibility is low, disturbances cause inconveniences such as system breakdowns, performance degradation, and service delays, which obstruct goal achievement of an organization. Figure 1 illustrates the origins of internal changes and their risks, i.e. troublesome situations where planned changes will not be achieved smoothly.

Demands for MIS development and/or modification made by an organization originate in business planning, user needs and IT innovation by MIS division. In MIS development, experience with technology and project size, structure and urgency are known as risk factors that can lead to project failure (Japan Information Processing Development Center, 1981). The relationship between project risks and the external factors of flexibility is as follows:

- Degree of experience with MIS development directly affects *product flexibility*. *Production flexibility* as internal factor mainly constrains the effectiveness of *product flexibility* (i.e. If an objective of a project involves an unfamiliar area or new technology, the effort to accomplish it will overburden the project team).
- *Volume flexibility* as external factor determines the success and failure of an MIS project of a given size. *Machine and process flexibility* as internal factor mainly affect facility of handling system volumes estimated (i.e. If the scale of the demanded system exceeds the reserved resources, the hardware might have to be up-graded and/or the development method changed).
- Urgency of a project imposes a heavy constraint on the whole development schedule. Facileness of schedule change is explained by the external factor of *operation flexibility*. Working sequence change is mainly constrained by *expansion flexibility* (i.e. segmentation of the whole system into modules) and *process flexibility* (i.e. combination of modules). When the development is interrupted, the system consisting of modules must be able to continue supplying service even if it is limited.

In brief, external flexibility increases when internal flexibility improves, and the risks of change are absorbed accordingly. That is, internal factors provide the constraints on external factors.

Flexibility Type	Change	Trigger and [Risk]	Risk Evasion Strategy
Machine flexibility	Exchange	Failure in machine replacement [System unusable]	Enhancement of Connection interchangeability
		Upgrading of basic software [System unusable, System breakdown]	Enhancement of Upper compatibility
		Failure in Application function expansion [System unusable, System failure]	Standardization (e.g. Structuring, Normalization)
Process flexibility	Development	Implementation of new technology and/or method (e.g. skill deficiency in resource utilization) [System uncontrollable, System breakdown]	R&D, Standardization, Education & Training, Outsourcing
		Excessive demand for development (e.g. overload on skilled engineers) [Increase of back log and/or bugs]	Scheduling, Use of CASE, Outsourcing
Routing flexibility	Service continuation	Defects in hardware [System uncontrollable]	Multiplexing, Back up & Recovery, Outsourcing, Insurance / Maintenance contract
		Bugs in basic software [System uncontrollable, System breakdown]	Back up & Recovery, Outsourcing, Preventive maintenance
		Bugs in application programs [System unusable, System failure]	Thoroughness of testing, Standardization, Education & Training, Back up & Recovery
		Mistake in operation [System failure]	Education & Training, Job enrichment, Outsourcing
Expansion flexibility	Change of function	Change of standard operating procedures [System failure]	Standardization (e.g. structuring, normalization), Use of CASE/DBMS, Education & training, Outsourcing
		Expansion of business affairs (e.g. new function by M&A) [System failure]	Standardization (e.g. structuring, normalization), Use of CASE/DBMS, Education & Training, Outsourcing, R&D
Production flexibility	New service area or function	Demand in an unfamiliar area (or experience deficiency) [System failure]	Standardization (e.g. structuring, normalization), ER administration, R&D, Use of consultant, Outsourcing, Education & Training

Figure 1. Risk Evasion Strategy for the Risks of Internal Factors

3.3. Flexibility Enhancement Strategies

Figure 1 furthermore illustrates the strategies for enhancement of MIS flexibility involving each of the internal change factors. The risk evasions for internal factors are realized by flexibility enhancement strategies, which constitute the MIS infrastructure development strategies. These last in turn are comprised of technological and organizational countermeasures. Technological countermeasures include: research and development (R&D), system multiplexing, back up / recovery, upper compatibility, standardization of MIS development and data (e.g. structuring, normalization), CASE/DBMS (computer assisted software engineering / database management systems), preventive maintenance, insurance, and so on. Organizational countermeasures include education / training, outsourcing, administration of entity relationship (ER), practical use of exterior consultants, job enrichment, etc. In short, the problem of flexibility enhancement is a decision problem of selecting MIS infrastructure development strategies.

A different way of defining infrastructure development is that its objective is to reduce disharmony that is apt to occur between an MIS and an organization. Implementation of planned change in an organization often generates this disharmony, which constrains the MIS effectiveness. When a change is planned, a project team will be organized. But its success or failure depends on the reduction of this sort of project risk, in the absorption of which external flexibility will play a crucial role. Enhancement of the external factors of *product flexibility, volume flexibility, and operation flexibility* is another key to the solution of decision problems on infrastructure development. If change demands require neither time nor costs, the disharmony will not occur. The degree of potential change demands must be predicted before a change is undertaken.

On the other hand, internal flexibility involves the following:

- system analysis and design takes a long time if the target service area is unfamiliar;
- use of new hardware and/or development technology will necessitate spending an unexpected amount of time mastering technological skills (proficiency).

The procedure for evaluating system flexibility is required to put both internal and external factors of flexibility in a proper perspective (see section 5).

4. Model for the Measurement of Flexibility

4.1. Penalty of Change

The development or the modification of an MIS requires costs, which means the penalty of change (POC [Japan Information Processing Development Center, 1981; Utunomiya et al., 1993]). A generic measure that is nevertheless relatively easy to apply to actual management situations may be one based on the hypothesis that the flexibility of an MIS is a function of its sensitivity to change. The lower the sensitivity, the higher the flexibility. Since flexibility is thus inversely related to the sensitivity to change, a measure of flexibility must be capable of quantifying the POC. If a change can be implemented without cost, then the system has a maximum flexibility, and the POC is 0. If, on the other hand, a change incurs a large cost, then the system is very inflexible, and the POC should be high. Demand for a change, as a possible future entity, to be stated in probabilistic terms to deal with prediction uncertainty, should be appropriately accounted for in the POC. This consideration leads to the conclusion that a measure of flexibility (POC) should account for the cost for change and the probability of change. A definition of POC must then take the general form of:

POC *(penalty of change)* **=** ***COST*** *(of change)* × ***PROBABILITY*** *(of change)*

The lower the POC, the higher the flexibility. If the cost for a change is low, then the POC will be low, indicating high flexibility. If the probability of change is low, then POC will again be low, even if the cost for change is relatively high. This means that a system should not be considered inflexible even if it could incur a high cost for a possible change that, however, has little probability of occurrence. Neither should a system be considered very flexible even if it could only incur a low cost for a possible change that, however, has little probability of occurrence.

4.2. Meanings of the Flexibility Evaluation in Terms of the POC

This value of POC is based on two inputs: the cost for potential change and probability of potential change, where change is a transition from one "state" to another. The nature of a state depends on the type of flexibility in question: for product flexibility, a state may be the type of product manufactured by the system; for operational flexibility, it may be the operational status of the system (e.g. "fully operational" or "partially operational"); for volume flexibility, it may be the demanded production rate. Both cost and probability can be viewed as a function of a discrete variable X that represents a potential change. X_i denotes the *i*th value of X.

The Penalty of Change (POC) can be defined as follows:

$POC = Co(X_i)\ Pr(X_i)$,

where

n = the number of potential changes

X_i = the *i*th potential change

$Co(X_i)$ = the cost of the *i*th potential change

$Pr(X_i)$ = the probability of the *i*th potential change

and it can be interpreted as the "expected" value of the penalty to be incurred for a potential change.

Potential Changes	$X_0 \rightarrow X_1$	…	$X_0 \rightarrow X_i$	…	$X_0 \rightarrow X_n$
Cost	$Co(X_1)$	…	$Co(X_i)$	…	$Co(X_n)$
Probability	$Pr(X_1)$	…	$Pr(X_i)$	…	$Pr(X_n)$

Figure 2. Penalty and Probability as Discrete Function of Potential Change

The calculation of POC can be viewed as an application of single-attribute decision-making under uncertainty; i.e. a decision problem of selecting MIS infrastructure development strategies for the enhancement of MIS flexibility. X_i ($i = 1, 2, \ldots, n$) is a possible future scenario, which means the state after the *i*th system change; $Co(X_i)$ is the attribute value for the future scenario, which means the indispensable management resources for the *i*th change; and $Pr(X_i)$ is the probability of occurrence of the future scenario.

Decision-making in actuality is nevertheless based on many kinds of indeterminacy, and it is impossible to provide all reliable calculation elements beforehand. But the measurement of flexibility in terms of POC is conceptually easily acceptable. By utilizing the concept of POC, therefore, we might be able to formulate a practical evaluation procedure for enhancing flexibility in an MIS, which in turn will contribute to the increase of managerial agility.

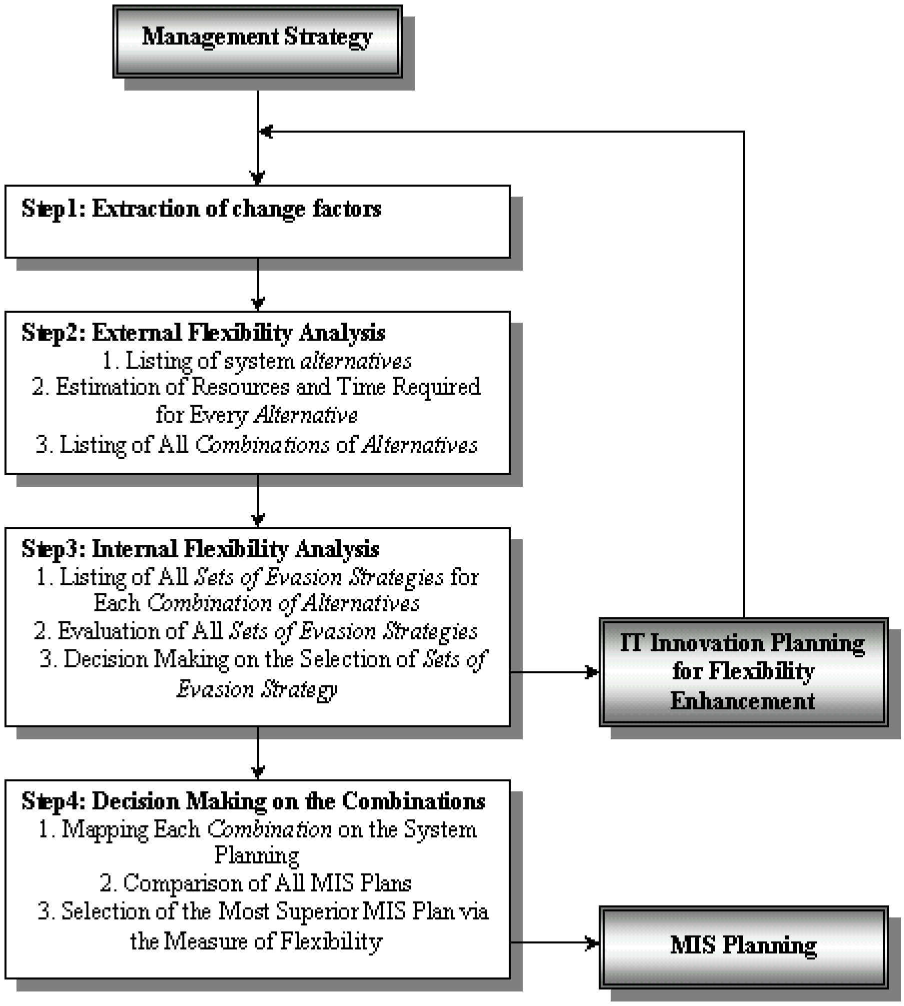

Figure 3. **Procedure for Flexibility Evaluation**

5. Practical Procedure for Flexibility Evaluation

The calculation of POC, if possible at all, cannot but be carried out by using indeterminate elements derived from intuitive prediction. Today IT innovation is bringing about dizzy changes in management environment. When it comes to predicting potential future changes, the actual world we find ourselves in is a far cry from a vantage ground. It would therefore be futile if we were to attempt to grasp the entire probability distribution of both internal and external factors that would be required for a theoretically perfect POC calculation. In order to pursue the present aim of working out a practical evaluation procedure, a better idea would be to focus on the structure of MIS flexibility. The result of the examination of flexibility in Section 3 allows us to represent the nature of MIS flexibility as a functional, i.e. a function of a function:

MIS flexibility = f (external flexibility), and external flexibility = g (internal flexibility)

Let us go on with our discussion of flexibility evaluation in light of this functional structure. In strategic management, in the first place managerial goals are adopted, and then strategies are planned for their realization. The external flexibility of the MIS needs to be provided in amounts sufficient to accommodate the implementation of these strategies and the internal flexibility in turn should be satisfactory enough to back up the required external flexibility. This suggests that we should start with external flexibility analysis and follow it up with internal flexibility analysis in light of the result of the former analysis (see Figure 3).

The mission of an MIS division is to meet the demand for development/modification of an MIS required for implementing management strategies. This means that in order to provide enough external flexibility to absorb the change demand, they need to secure the capacity to expand internal flexibility and work out and efficiently implement several sets of strategies for that purpose. That is to say, they need to develop well-structured infrastructure in advance to accommodate future changes and to plan IT innovation for this purpose. We must note here that this innovation itself may be the cause of another kind of potential change factors.

Let us go back to our starting point. An important practical question concerning MIS flexibility is "*how flexible an MIS we should acquire at the time of its implementation in order to accommodate possible changes in the future.*" This question has to do with future demands for changes, which cannot be predicted with certainty. If it were to be applied to an actual planned MIS implementation, the theory of POC we have presented would seem to require more detailed research. However, the above considerations suggest that for the present purpose a framework comprised of the following steps might be a reasonable procedure for evaluation of MIS flexibility with a view to its enhancement.

Step 1: Extraction of External Change Factors

External change factors originate in management planning, user needs and IT innovation by the MIS division. The aim of this step is to extract every potential change. For simplicity's sake, we assume only the following three items as external change factors: implementation of environment accounting, creation of a recycling plant and the need to cope with the Year 2000(Y2K)(see Figure 4).

Planning Item	Due Date
Environment Accounting	April, 2000
Recycling Plant	Autumn, 2000
Y2K	The end of 1999

Figure 4. Extraction of External Change Factors

Step 2: External Flexibility Analysis along with Project Risk Analyses

In this step, we will consider the following in order to enumerate all *combinations* of development *alternatives* for the planned change factors (i.e. possible options for developing the systems) to absorb all external change factors;

- product flexibility: for the strategy realization, what kinds of development method are possible?
- volume flexibility: how much development resource will each *combination* of *alternatives* require?
- operation flexibility: if a sudden external disturbance occurs during the development of alternatives, will the existing

MIS infrastructure have enough allowance for order change?

Figure 5 illustrates the *alternatives* that can be adopted for each change factor, and the estimates of the monetary value of management resources required and of the length of time that each *alternative* would require. For environment accounting we assume the *alternatives* of "new development" and "expansion of the existing systems" and for recycling plant "new development" and "customization of similar systems". For Y2K we assume "early preparation" and "emergent preparation". The first *al-*

ternative means the renovation of the system infrastructure including the normalization of data. The second means limiting the preparation to coping with the trouble in question immediately before it takes place. Let us assume that all *alternatives* have enough resources available for their execution, with the exception of the *alternative* of the early preparation for Y2K.

This step should also address the question of the tolerance of an organization for a change we referred to in Case 1, because excessive change is one of the essential causes for system failure. When a change is judged to be likely to exceed the tolerance of the organization concerned, the situation should be fed back to the management strategy so that the strategy itself may be reconsidered. The implementation of environment accounting may require a step-by-step process because it entails the necessity of changing the standard operating procedures.

(a) Listing of System Alternatives

Change Factor	Function	Alternatives
Environment Accounting	Financial accounting system	New development
		Expansion of existing systems
Recycling Plant	Factory management system	New development
		Customization of similar systems
Y2K	Modification of programs & data	Early Preparation with Standardization, CASE, DBMS, etc.
		Emergent Preparation as correction of data & programs

(b) Estimate of Resource and Period for the Alternatives

Change Factor	Alternative	Resource Requirement			Each Cost1 (1000$)	Required Time (month)
		Manpower (man month)	Storage (G byte)	Others		
Environment Accounting	New	600	100	…	350	12
	Expand	400	80	…	250	8
Recycling Plant	New	…	…	…	650	15
	Custom	…	…	…	450	10
Y2K	Early	…	…	…	1,000	18
	Emergent	…	…	…	600	12

Figure 5. External Flexibility Analysis

Step 3: Internal Flexibility Analysis

The objective of this step is to consider how to enhance the internal flexibility with a view to an efficient absorption of external change demand. Expansion of internal flexibility (i.e. machine, process, routing, expansion, and production flexibility) to evade operational mistakes or system breakdowns is a fundamental mission of the MIS division, and it is supposed to be carried out continuously based on IT innovation planning. What we should examine here is:

1) possible *sets of evasion strategies* for internal flexibility enhancement that can be applied to a *combination* of development *alternatives*,
2) their implementation cost and their running cost (Cost2), and their utility for external flexibility expansion i.e. cost1 reduction.

Cost1 represents the amount of potential cost that might have been incurred by damage caused by internal risks, which, however, will be deterred by the application of a *set of evasion strategies*. POC in this connection is represented by the formula below:

POC = Cost for Internal Risk ×Occurrence Probability of Internal Risk
Cost1 Reduction = – POC

The probability of the occurrence of some internal risks could be estimated by daily MIS monitoring. However, the number of possible *sets of strategies* for evading internal risks and the degrees of their application can be infinite and most of them probably have never before been known. Therefore, just as in the case of new technology implementation, in order to estimate the probability of the occurrence of these risks, the cost for the implementation of the strategies and their utility (which depends on the users' technical proficiency), we cannot help relying on extrapolation from past experience. All the same, there is no doubt that the application of *evasion strategies* will reduce the probability of troubles and the damage they may cause should become lower. For Y2K, most MIS divisions will regard early preparation as more desirable because they are placed in a management situation similar to that shown in Case 3. In this example the challenge for the MIS division is to find how to manage to raise internal flexibility for the implementation of early preparation.

Combination of Alternatives			**Sum of Cost1**	**Cost1 Reduction** ($1,000)	**Set for Internal Risk Evasion**	**Cost2 for the Set** ($1,000)	**Prob-ability** (%)	**Required Time** (month)
Envi-ron.	**Recy-cle**	**Y2K**						
New	New	Early	2,000	-3,500	1) ST, OT, CD, … *	2,500	30	16
					…	…	…	
					n) ST, OT, …	2,000	25	18
New	New	Emergent	1,600	-700	…	2,100	…	…
New	Custom	Early	1,800	-3,000	…	2,000	…	…
New	Custom	Emergent	1,400	-600	…	1,800	…	…
Expand	New	Early	1,900	-2,500	…	1,900	…	…
Expand	New	Emergent	1,500	-300	…	1,600	…	…
Expand	Custom	Early	1,700	-2,300	…	1,700	…	…
Expand	Custom	Emergent	1,300	0	…	1,000	…	…

*) ST: Standardization, OT: Outsourcing, CD: CASE/DBMS, PC: Practical use of consultants, ET: Education / Training, TT: Thoroughness of testing (see Fig. 1)

Figure 6. Internal Flexibility Analysis in Terms of POC

Step 4: Decision Making on MIS Planning

The above three procedural steps will give us several *combinations* of *alternatives* to absorb all potential change factors. Despite the uncertainty still to be solved, we are now in a position to map each *combination* onto MIS planning, taking into account time and resources required for it. Since all the *combinations of alternatives* share the same function, final decision-making on the selection of a *combination* will be a matter of pay-off maximization. This means that we will select a *combination* that ranks highest in terms of MIS flexibility.

Combination of Alternatives			**Total Cost*** ($1,000)
Environ.	**Recycle**	**Y2K**	
New	New	Early	1,000
New	New	Emergent	3,000
New	Custom	Early	800
New	Custom	Emergent	2,600
Expand	New	Early	1,300
Expand	New	Emergent	2,800
Expand	Custom	Early	1,100
Expand	Custom	Emergent	2,300

*) Total Cost =Sum of Cost1 - Cost1 Reduction + Cost2

Figure 7. Comparison of the Combinations

5. Conclusion

This paper has presented a scheme for evaluating MIS effectiveness by means of the measure of flexibility. The methodology presented above as the MIS evaluation procedure is based on the assumption that MIS flexibility can be defined as an ability to absorb the potential change factors from inside and outside the MIS environment. The procedure involves the POC-based evaluation of the *combinations* of development *alternatives* in terms of their economical efficiency in the absorption of potential changes.

The challenge facing us is to find how to apply the methodology presented here to actual business practice, and to address the second question we posed in the Introduction to this paper.

References

Buzacott, J. A. "The Fundamental Principles of Flexibility in Flexible Manufacturing Systems," *Proceedings of the First International Conference on Flexible Manufacturing Systems, Amsterdam*, N. Holland, 1982, pp.13-22.

Barad, M., and Sipper, D. "Flexibility in Manufacturing Systems: Definitions and Petri Net Modeling," *International Journal of Production Research*, 1988, pp.237-248.

Brown, J., K. Rathmill, Sethi, S. P., and Stecke, K. E. "Classification of Flexible Manufacturing Systems," *The FMS Magazine*, 1984, pp114-117.

Chryssolouris, G. "Flexibility and Its Measurement," *Annals of the CIRP,* (45:2), 1996, pp.581-587.

Chryssolouris, G., and Lee M. "An Assessment of Flexibility in Manufacturing Systems," *Manufacturing Review*, (5:2), 1992, pp.105-116.

DeLone, William H, and Ephraim R. McLean "Information System Success: The Quest for the Dependent Variable," *Information Systems Research*, (3:1), 1992, pp.60-95.

Falkner, C. H. "Flexibility in Manufacturing Plants," *Proceedings of the second ORSA/TIMS Conference of Flexible Manufacturing Systems: Operations Research Models and Applications*, K.E. Stecke and R. Suri, Editors, 1986, pp.95-106.

Hamilton, S., and Chervany, N. C. "Evaluating Information System Effectiveness - Part l: Comparing Evaluation Approaches," *MIS Quarterly*, 1981, pp.55-69.

Kumar, V. "On Measurement of Flexibility in Flexible Manufacturing Systems: An Information-Theoretic Approach," *Proceedings of the second ORSN/TIMS Conference of Flexible Manufacturing Systems: Operations Research Models and Applications*, K.E. Stecke and R. Suri, Editors, 1986, pp.131-43.

Laudon, K. C., and Laudon J. P. *Management Information Systems: Organization and Technology*, 3rd Ed., Macmillan College Publishing Company Inc., 1994.

Lucas, Henry C., Jr. *Toward Creative Systems Design*, New York: Columbia University Press, 1974.

McFarlan, F. Warren "Portfolio Approach to Information Systems," *Harvard Business Review*, September-October 1981, pp.142-150.

Myyer, N. Dean, and Boone, Mary E. *The Information Edge*, The Carswell Company, 1989.

Parker, M. M., and Benson, R.J. *Information Economics: Linking Business Performance to Information Technology*, Prentice Hall, Inc., 1988.

Pnuell, Y., and Zussman, E. "Evaluating the end-of-life value of a product and improving it by redesign," *International Journal of Production Research*, 1997, pp.921-942.

Primrose, P. L., and Leonard, R. "Conditions Under Which Flexible Manufacturing is Financially Viable," *Proceedings of the third International Conference on Flexible Manufacturing Systems*, 1984, pp.121-132.

Richardson, P. R., and Gordon, J. R. M. "Measuring Total Manufacturing Performance," *Sloan Management Review*, (9:2), 1980, pp.47-58.

Son, Y. K., and Chan, S. P. "Quantifying Opportunity Costs Associated With Adding Manufacturing Flexibility," *International Journal of Production Research*, (28:7), 1990, pp.1183-1194.

Srinivasan, V., and R. A. Millen "Evaluating Flexible Manufacturing Systems as a Strategic Investment," *Proceedings of the second ORSN/TIMS Conference of Flexible Manufacturing Systems: Operations Research Models and Applications*, K.E. Stecke and R. Suri, Editors, 1986, pp.83-93.

Users Guide for information System (I), Japan Information Processing Development Center, 1981.

Utunomiya H., Ohashi H., Takahashi I., and Miyagawa Y. "The Evaluation of Information Systems," *Journal of Information Processing Society of Japan*, Information Processing Society of Japan, 93-IS-46, 1993, (96:90), pp.1-40.