Evaluation of New Technology Implementation via *POC* Analysis

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Abstract

In recent years the evolution of highly developed and complicated computerization has boosted the importance to business of IT infrastructure. Enhancement of business agility is not possible unless greater flexibility is built into IT infrastructure. More often than not, MIS's today are not flexible enough in this sense to agilely accommodate demands for system change incessantly confronting them.

We have been focusing our research on MIS flexibility, its evaluation and the development of methodology for its enhancement. This paper aims to present a comparative evaluation via *POC* (penalty of change) analysis of system alternatives involving a case of new technology implementation. To start with, we will define the concept of MIS flexibility. We will then describe an actual case of technology implementation and define the problem it involved and go on to illustrate the evaluation of MIS flexibility via *POC* analysis.

Keyword: Management information systems, MIS evaluation, MIS flexibility, IT infrastructure, penalty of change

Introduction

In recent years the evolution of highly developed and complicated computerization has boosted the importance to business of IT infrastructure. Enhancement of business agility is not possible unless greater flexibility is built into IT infrastructure. More often than not, MIS's today are not flexible enough in this sense to agilely accommodate demands for system change incessantly confronting them.

We have been focusing our research on MIS flexibility, its evaluation and the development of methodology for its enhancement. This paper aims to present a comparative evaluation via *POC* (penalty of change) analysis of system alternatives involving a case of new technology implementation. To start with, we will define the concept of MIS flexibility. We will then describe the actual technology implementation and define the problem it involved and go on to illustrate the evaluation of MIS flexibility via *POC* analysis, enumerating project risks accompanying the technology implementation.

Definition of MIS Flexibility

For the present purpose, let us draw on the definition of MIS flexibility and the scheme for its evaluation that we proposed in literature [1] and [2].

(1) POC as a Substitute Index of MIS Flexibility

Let us postulate MIS flexibility as an ability to absorb future change demands on an MIS, and let us express it formulaically with (1):

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$$Flex = \frac{Const}{g(C,T)} = \frac{1}{POC} \quad (1),$$

where *C* and *T* stand for cost and time, respectively.

Formula (1) suggests that *POC* can serve as a substitute index for quantitative evaluation of the flexibility of an MIS. It also obviously shows the following relationship between MIS flexibility and *POC*:

- If MIS flexibility is low, *POC* is high.
- If MIS flexibility is high, *POC* is low.

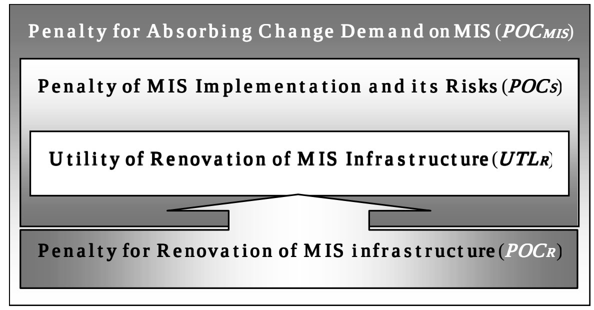


Figure 1. Structure of MIS Flexibility

POC can serve as an index for measurement of the ability to absorb future demands for MIS change and can be accounted for in terms of cost and time.

(2) Structure of MIS Flexibility

As detailed in a relevant section in literature [2], a moderate renovation of MIS infrastructure can contribute to greater ease and efficiency of MIS modification [utility of renovation].

We know from experience that modification of an MIS is liable to expose it to system risks of some sorts or other, and that these risks are most to blame for impairment of MIS efficiency. However, if we moderately renovate IT infrastructure by building into it some preemptive risk-evasion strategies by anticipation, these strategies can be expected to reduce system risks that future MIS modification would almost inevitably entail. But implementation of such a renovation incurs a *POC* of its own [*POC* of renovation]. Therefore let us represent MIS flexibility in terms of the substitute index of *POC* as in Figure 1. This figure suggests that the *POC* [POC_R] paid for a moderate renovation of MIS infrastructure can generate the benefit [UTL_R] of reducing the *POC* (POC_S) that processing of demands for system change would incur in future [utility of renovation] (Hereafter let us use the term “renovation of MIS infrastructure” to refer to the application of IT to an existing MIS for enhancement of its flexibility).

All this allows us to represent the *POC* of a whole MIS change (POC_{MIS}) with formula (2):

$$POC_{MIS} = POC_S + \left(POC_R - UTL_R\right) \quad (2)$$

A Case of Downsizing as an Implementation of New Technology

Attempts Made by Company X

Printing paper container manufacturer X had used on a mainframe a fairly sophisticated system for the scheduling and control of production targeted at printing and subsequent processes.

In 1994, with its stocks due to go public the next year (an organizational crisis), the manufacturer decided to build a sales management system. At that time downsizing was the fashion of the day in Japan. Jumping on the bandwagon, this company decided to remodel the management system on client/server architecture, which was an utterly new technology discontinuous with the technology hitherto used. The system development, accompanied by a purchase of PCs for development work was outsourced to a vendor. (Incidentally, on completion of the system development, the PCs were to be used in their routine work.) The development of the system on this basis took far less time than it would have on the mainframe.

Adopting a prototyping-like development approach and using a relational DBMS (data base management system), they got a user-friendly application system completed one year later.

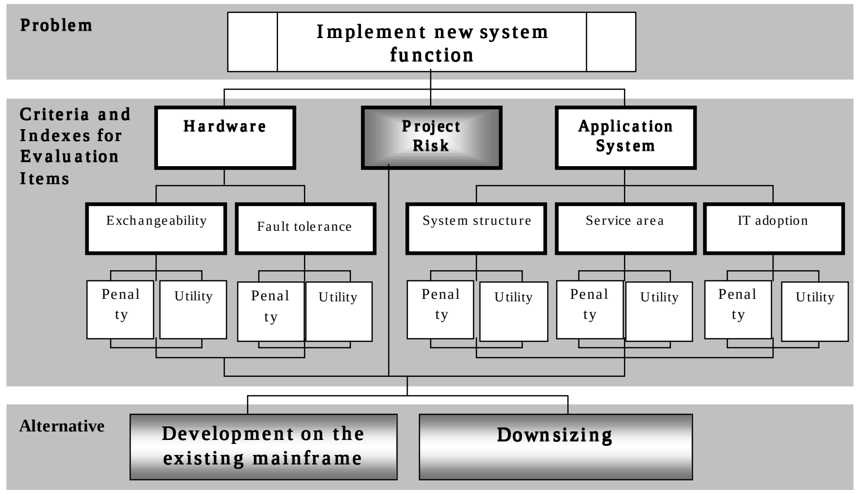


Figure 2. Definition of the Problem via AHP

Unfortunately, however, they found that the capacity of the one-year-old PCs was less than sufficient to let this system work. This obliged them to replace these PCs with the latest high-end ones at extra cost. They also had to upgrade to a new OS for the PCs, which for lack of upper compatibility burdened them with a great deal more extra cost. 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 they would have with a mainframe-based system.

Several years later, they undertook another change, this time around in the system for data communication with customers. Adoption of this technology was the trend of the times. The change, however, took far more time and labor than they had expected due to deficiency in documentation. Besides, the heterogeneity of the technology that they had newly adopted continued to make fun of the engineers for quite a long

Category		Index for Evaluation				
		Viewpoint	Penalty		Utility	
			Cost	Time	Cost	Time
Hardware	Exchangeability	Enhancement of Connection interchangeability, Enhancement of upper compatibility (open protocol, open system)	Human resource (Man-month)	Time distance (exchange speed)	Reduction of cost	Shortening of exchange time,
	Fault tolerance	Availability	Opportunity loss, Recovery cost	MTBF, MTTR	Reduction of opportunity loss and recovery cost	Reduction of recovery time
Application system	System structure	Structuring of system and program	Cost for change demand, Cost of structuring	Time for change demand, Time for structuring	Reduction of cost of design	Reduction of time for design
		Degree of database (Number of access paths from application programs to data, Number of programs and data that should be changed, Rate of entity implemented in database, Tendency of backlog volume on the time axis	Cost for change demand, Cost of database development	Time for change demand, Time for database development	Reduction of cost of design	Reduction of time of design
	Service area	Rate of BP and entity given a service	Cost of processing change demand, Cost of new service	Cost for change demand, Cost of new service	Reduction of cost of design	Reduction of time for design
	IT adoption	Technical continuity and degree of experience	Cost for change demand, Cost incurred depending on proficiency level	Time for change demand, Time required depending on proficiency level	Reduction of cost of learning Reduction of cost incurred depending on proficiency level	Reduction of time of learning Reduction of time required depending on proficiency level

Table 1. Indexes for Evaluation of Internal Factors

time. Now, however, the heterogeneous monster, in a manner of speaking, has been tamed and become relatively obedient. In other words, new technology has come to acquire greater flexibility.

Definition of the Problem via AHP

Figure 2 shows the structure of the decision problem confronting the company, defined via AHP (analytic hierarchy process). The target of the problem is "to implement a new system function by the due date", and the alternatives to be evaluated are "development on the existing mainframe" on the one hand and "downsizing: *i.e.* development on client/server architecture" on the other. The difficulty with the problem,

(1) Hardware

			Evaluation
POC	Cost	Cost of hardware implementation for downsizing	30%
	Time	Time for hardware implementation for downsizing	150% (because of the large number of machines (or PCs))

Exchangeability

Hardware exchange		Different protocols for one PC and another, and for PC and mainframe	
		Good or poor affinity at the time of parts change	
Basic software		Not guaranteed high-order compatibility at the time of version-up	
Utility	Index	Manpower for exchange	Faster
		Speed for exchange	Faster
	Cost	Cost of future exchange	Will be low
	Time	Time for future exchange	Will be short

Fault tolerance

Basic software		System is unstable and operation rate low, compared with the use of mainframe	
Application system		Insufficient tool for system management	
Operation		More frequent system-down by operating-error, compared with the use of mainframe	
Utility	Index	Opportunity loss	Risk reduction by distributed system
		Cost of recovery	Risk reduction by distributed system
		MTBF (mean time between failure)	Longer
		MTTR (mean time to repair)	Shorter
	Cost	Cost of future exchange	Will be low
	Time	Time for future exchange	Will be short

(2) Application system

			Evaluation
POC	Cost	Cost of application system implementation for downsizing	65%
	Time	Time for application system implementation for downsizing	80%

System structure

Ratio of structured program		Structuralization only of access parts to DB	
Ratio of structured system		Complicated system interfaces	
Ratio of DB		Incompleteness of normalization	
Utility	Index	Number of access paths from application program to data	150%
		Number of programs that should be modified to cope with system demand	120%
		Number of data items that should be modified to cope with system demand	150%
		Ratio of entity implemented into database	Higher by 30%
	Cost	Cost of processing new demand for change	Extra cost of outsourcing
	Time	Time for processing new demand for change	Longer than before

Service area

Ratio of supported BP		Addition of sales management system and its interface with production management system	
Ratio of supported Entity		Same as above	
Utility	Cost	Cost of new domain or new service area	Cost reduction in sales management
	Time	Time for offering new domain or new service area	Same as above

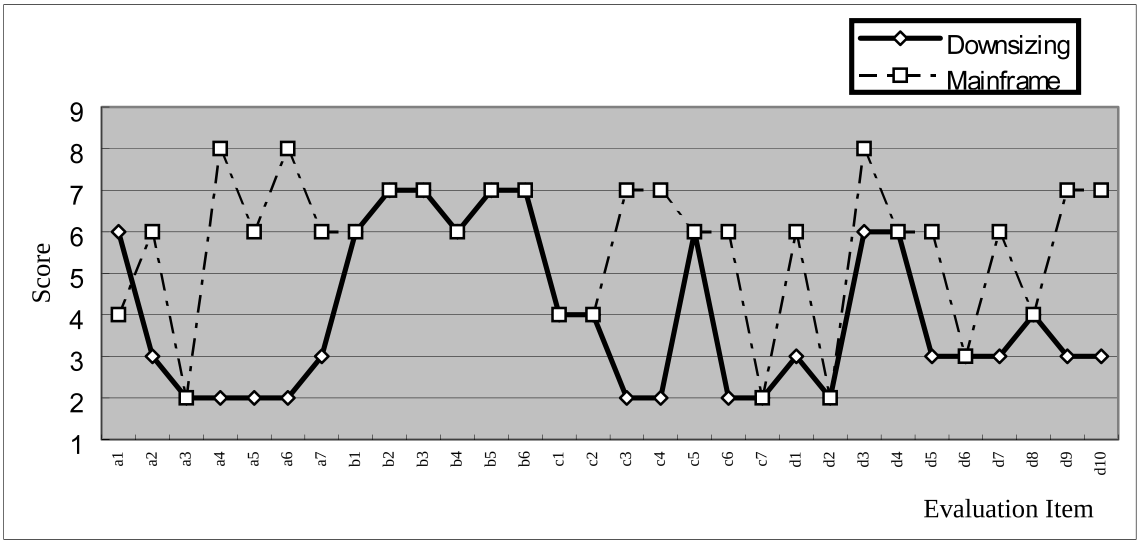
IT adoption

Technological continuity		Extra dependence on skillful outside engineers for lack of technological continuity	
Degree of experience		One year or more of learning	
Utility	Cost	Cost of offering service by means of new technology and technique	Decrease with increasing experience
	Time	Time for offering service by means of new technology and technique	Same as above

Table 2. Evaluation of Downsizing (as compared with use of the mainframe**)**

it should be noted, comes from "project risks" that use of unfamiliar technology for downsizing tends to entail. Hence the need for inclusion of the factor of "project risks" in the criteria for the analysis of the problem (See Figure 2). The analysis criteria for the problem also need to be broken down into different levels of abstraction ranging from the abstract to the detailed as shown in Table 1.

Table 2 shows the evaluation of downsizing as compared with development on the mainframe with regard to the indexes listed. The result of the evaluation indicates that development on the mainframe is prefer-



a1	The system to be implemented in the project is small in scale.
a2	The system requirements are simple enough and well defined, and there is no likelihood of a need for their change.
a3	The user has experienced similar system implementations before and thus is well aware of the possible impact of the new system implementation on the organizational structure, the work group and human behavior.
a4	The project team has had experience of success in other projects of the same scale.
a5	The user is sufficiently knowledgeable about business and experienced in IT use.
a6	The system designers are sufficiently knowledgeable about business and experienced in IT use.
a7	There are well-prepared measures available for supplementing project staff's possible deficiency in knowledge and experience.
b1	The project team has been given support and authorization from every echelon of the management.
b2	The project can secure sufficient resources required for the system implementation.
b3	The director of the project is well qualified as a leader of organizational change.
b4	The user organization has been reacting favorably to the system implementation to date.
b5	The user organization has shown a favorable attitude toward the present project.
b6	There is no serious enough communication gap between the user and the system designer.
c1	The officers concerned provide the project with sufficient understanding and support.
c2	The project could be administered on a user-led basis or with otherwise appropriate user participation.
c3	There are reliable methods available for estimating resource requirements for this project.
c4	There are reliable standards available for estimating resource requirements for this project.
c5	There is no likelihood that the project team will add extra engineers to cope with the possibility of failure to complete the system implementation by the due date.
c6	The project team has appropriate support tools (software) available for planning and administration.
c7	There is no likelihood that a delay in the system implementation will be dealt with by the shortening of the user-training period.
d1	The beneficiary (user) has enough resources available for continuous use of the system.
d2	It is easy to execute change of business roles to be necessitated by implementation of the new system.
d3	There is an adequate system (for recovery from system trouble) that will enable stable information provision.
d4	It is easy to execute relocation of personnel to be necessitated by implementation of the new system.
d5	It is easy to execute shift of power to be necessitated by implementation of the new system.
d6	Adequate training will be planned and provided to get the user organization used to the new system function.
d7	There is adequate preparedness for continuous system renewal.
d8	There is adequate support of key persons to get the user organization used to the SOP change.
d9	There is no problem in the system maintenance after reshuffle of development personnel.
d10	There is adequate preparedness for expansion of the utility of the system.

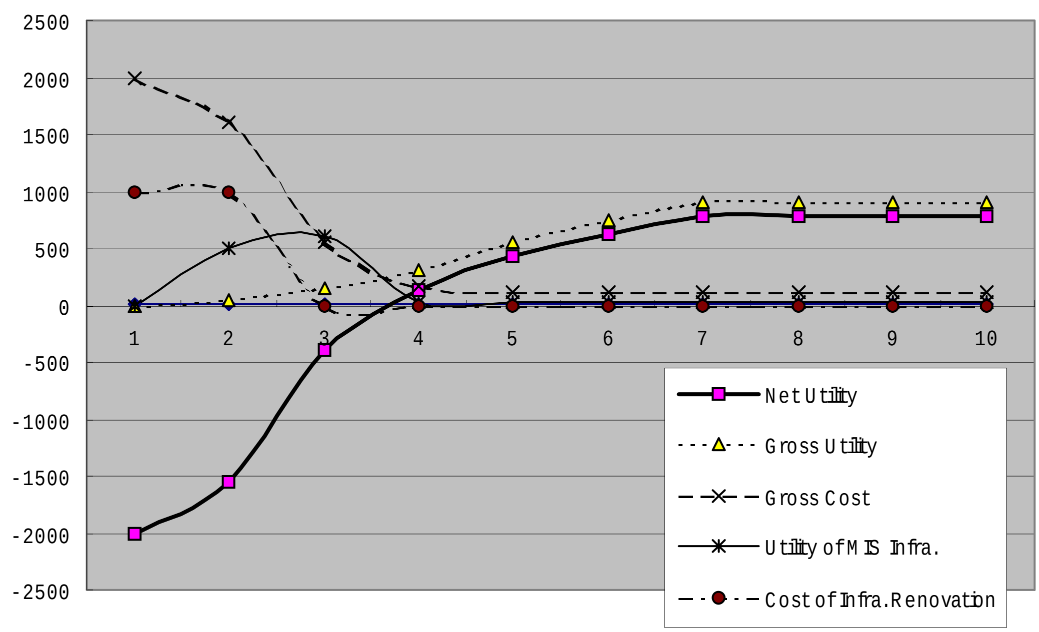
Figure 3. Evaluation of Project Risks

able to downsizing after all, since the former is found to be less vulnerable to project risks than the latter.

Project Risks

In solving this sort of problem, as noted above, project risks inevitably accompanying technology implementation are a crucial factor we must not fail to take into account. Target evaluation items listed in Figure 3 are excerpts from "System Success and Failure: Implementation" in literature [3], and a higher score in this figure means a smaller risk.

For company X, downsizing via implementation of client/server technology is an unexperienced and unfamiliar project. This is why the evaluation scores indicate that "downsizing" is riskier than the development of the system on the existing mainframe. The unfortunate choice made by this company is not so surprising. We often hear of cases of MIS implementation that have met with troubles such as failure to deliver by the due date, excess over the estimates, productivity deterioration (increase of backlogs), malfunctioning (activity inability, operational inability, increase of bugs), system failure (failure of a system to be used as intended).



Fiscal Year	Net Utility	Gross Utility	Utility			Gross Cost	Cost			Utility of MIS Infra.	Cost of Infra. Renovation
			MIS1	MIS2	MIS3		MIS1	MIS2	MIS3		
1	-2000	0	0	0	0	2000	1000	0	0	0	1000
2	-1550	50	50	0	0	1600	100	1000	0	500	1000
3	-400	150	100	50	0	550	50	100	1000	600	0
4	130	300	150	100	50	170	50	50	100	30	0
5	430	550	300	150	100	120	50	50	50	30	0
6	630	750	300	300	150	120	50	50	50	30	0
7	780	900	300	300	300	120	50	50	50	30	0
8	780	900	300	300	300	120	50	50	50	30	0
9	780	900	300	300	300	120	50	50	50	30	0
10	780	900	300	300	300	120	50	50	50	30	0
Total	360	5400	2100	1800	1500	5040	1500	1450	1400	1310	2000

Figure 4. Net Utility of MIS on the Time Axis

Consideration

Generally implementation of new technology will expose a system to the high risk of system failures (*i.e.* an information system that either won't perform as expected, fails to be operational at a specified time, or cannot be used in the way it is intended to be). Moreover, successful implementation does not mean an immediate realization of effectiveness since it takes considerable time for the users to acquire expertise and proficiency in the use of the new system. System trouble obstructs flexible use of an MIS. A project like the present one whose due date is critical requires a high degree of MIS flexibility.

In this case, to obtain the same MIS function, it would have been more advantageous if they had modified the existing MIS working on the mainframe since it would have incurred a far smaller *POC* than did the implementation of new technology.

Now, however, we know that new technology has come to be flexibly and effectively used thanks to the accumulation of engineers' bitter experiences, their efforts to tame intractable technology and technological progress in general in recent years. As Figure 4 graphically shows, all this is good enough proof that in general MIS evaluation needs to be executed longitudinally on the time axis.

Future-oriented POC Analysis

In this section, let us attempt to expand and generalize the *POC* analysis we proposed in literature [1].

Enhancement of MIS flexibility cannot be realized unless the possibility of system risks is reduced by means of moderate strategic renovation of MIS infrastructure. This infrastructure renovation actually means applying preemptive risk-evasion strategies in anticipation of future MIS modification. What we should consider in this connection is how to evaluate what combination of system alternatives would incur the least *POC* (cost and time). For this purpose, it is necessary to enumerate a possible set of risk-evasion strategies we should provide for application to the combination of system alternatives, and evaluate both the penalty of change the very provision of these strategies would incur and the utility that their application would also generate (*i.e.* their utility in reducing penalty that we would otherwise have to pay when addressing change demands in future).

Since anticipatory provision of evasion strategies for possible future system changes, by its very nature, involves predictive uncertainty, it should be dealt with as a probabilistic event. Therefore, before going on into our detailed discussion, let us refer to a related idea involving a probabilistic event in the form of formula (3), an idea proposed by Chryssolouris, G. et al [4] in the context of the evaluation of flexible manufacturing system:

$$POC = \sum_{s=1}^{n} Pe(X_s)\Pr(X_s) \qquad (3),$$

where

X_s = the state after change $s(1, 2, \ldots, S)$

$Pe(X_s)$ = the penalty for change s,

$\Pr(X_s)$ = the occurrence probability of change s.

The calculation of *POC* can be viewed as an application of single-attribute decision-making under conditions of uncer-

Change Demand *k* (*l*=3)				**Set of Risk Evasion Strategies**		**Occurrence Probability of Change *X***
p (*q*=8)	**Combination of Alternatives** (Al_{jp})					
	k=1, *j*= 2	*k*=2, *j*=2	*k*=3, *j*= 2	St_{ip} *i*=*n*(*p*)		$\Pr(X_{ip})$
1	Al_{11}	Al_{12}	Al_{13}	*i*=5	St_{11}	$\Pr_{11}$
					St_{21}	$\Pr_{21}$
					St_{31}	$\Pr_{31}$
					St_{41}	$\Pr_{41}$
					St_{51}	$\Pr_{51}$
2	Al_{11}	Al_{12}	Al_{23}	=2	St_{12}	$\Pr_{12}$
					St_{22}	$\Pr_{22}$
3	Al_{11}	Al_{22}	Al_{13}	=2	St_{13}	$\Pr_{13}$
					St_{23}	$\Pr_{23}$
4	Al_{11}	Al_{22}	Al_{23}	=3	St_{14}	$\Pr_{14}$
					St_{24}	$\Pr_{24}$
					St_{34}	$\Pr_{34}$
5	Al_{21}	Al_{12}	Al_{13}	=2	St_{15}	$\Pr_{15}$
					St_{25}	$\Pr_{25}$
6	Al_{21}	Al_{12}	Al_{23}	=2	St_{16}	$\Pr_{16}$
					St_{26}	$\Pr_{26}$
7	Al_{21}	Al_{22}	Al_{13}	=3	St_{17}	$\Pr_{17}$
					St_{27}	$\Pr_{27}$
					St_{37}	$\Pr_{37}$
8	Al_{21}	Al_{22}	Al_{23}	=3	St_{18}	$\Pr_{18}$
					St_{28}	$\Pr_{28}$
					St_{38}	$\Pr_{38}$

Table 3. Factors for *POC* Calculation

tainty (*i.e.*, the decision problem of selecting a combination of system alternatives for the enhancement of MIS flexibility); X_s is a possible future scenario (*i.e.*, the state brought about by the implementation of the *s*th system change); $Pe(X_s)$ is the attribute value for the future scenario (*i.e.*, required management resources for the *s*th change); and $\Pr(X_s)$ is the probability of the possible occurrence of the future scenario; the numerical value of *POC* is the expected value of the penalty payable for the system change leading to the possible future scenario.

Here, let us represent a change demand as $k(1 \le k \le l)$, a system alternative for a change demand *k* as $j(1 \le j \le m(k))$ and a combination of system alternatives for a change demand as $p(1 \le p \le q)$. Where the number of change demands is *l*, the number (represented as *q*) of combinations of system alternatives for processing all change demands can be represented as $q = n(1) \times n(2) \times \ldots \times n(l)$ (*q*=8 in Table 3.). On the other hand, let us represent a set of risk-evasion strategies for *p* as $i(1 \le i \le n(p))$ and enumerate a set of risk-evasion strategies(*i*) to be applied to each *p* of *q* combinations of system alternatives and let us give the notation of $\Pr(X_{ip})$ to the probability of the occurrence of the state of affairs where a set of risk-evasion strategies (*i*) will be applied. Then, the expected value of POC_p (*POC* payable for execution of each *p* of the *q* combinations of system alternatives) can be represented with formula (4) after the fashion of Chryssolouris, G. et al [4].

$$POC_p = \sum_{i=1}^{n(p)} Pe(X_{ip}) \Pr(X_{ip}) \qquad (4)$$

In order to process all (=*l*) change demands, we must execute *q* combinations of system alternatives for them. And each of these combinations of system alternatives is supposed to have been provided with a set of risk-evasion strategies in advance. An aim of this paper is to establish the methodology for selecting a system plan comprised of combinations of system alternatives and sets of risk-evasion strategies, which will best serve the purpose of MIS flexibility enhancement. A combination of system alternatives that will show the lowest value of *POC* (POC_{min}) can be represented with formula (5).

$$POC_{\min} = \sum_{p=1}^{q} \min POC_p \qquad (5)$$

As the structure of MIS flexibility in Figure 1 visually shows, enhancement of MIS flexibility can only be realized by reduction of system risks via renovation of IT infrastructure. In order to evaluate a system plan, therefore, we must enumerate all sets of risk-evasion strategies to be applied to combinations of system alternatives, and then we must estimate both the penalty for the provision of the strategies and the application of the alternatives (POC_R, POC_S,) and the utility (UTL_R) that the application of the strategies will generate in the enhancement of MIS flexibility.

The following formula (6) represents the effect of the application of a set of risk-evasion strategies to a combination of system change alternatives in future. This formula means that a combination of system alternatives that will incur the lowest penalty (POC_{min}) can be identified through close scrutiny of what set of risk-evasion strategies will be the best one to be applied to a combination of system alternatives for processing all change demands. There can be no doubt about the validity of this idea, since it closely reflects the fact that one and the same IT infrastructure is shared by all possible application systems.

$$Pe(X_{ip}) = POC_S(p) + POC_R(ip) - UTL_R(ip) \qquad (6),$$

where

$POC_S(p)$ = the penalty for applying a combination of system alternatives *p* to all change demands (without applying a set of risk-evasion strategies),

POC_R (*ip*) = the penalty for providing a set of risk-evasion strategies *i* for a combination of system alternatives *p*,

UTL_R (*ip*) = the utility of applying a set of risk-evasion strategies *i* to a combination of system alternatives *p*.

Conclusion and Challenges for Us

In this paper we have considered MIS flexibility with respect to a case of downsizing. What we have learned from this consideration is that project risks are a crucial factor that should be included in the evaluation of MIS flexibility and that evaluation must be executed longitudinally on the time axis.

The challenges still facing us are the integration of project risk analysis and *POC* calculation. For this purpose, we must find a workable method of estimating future system risks and utility accruing from new technology implementation.

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Biography

Masaru Furukawa is a faculty member of TOYAMA University in Japan, where he teaches management information systems. He has ten years of practical experience as a manager of MIS division in a large enterprise and eight years of teaching experience as a Professor.

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