The Study of Project Transfer Information to System Engineers: A Model Building

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1. INTRODUCTION

In recent years, managing a company has required the swift acquisition of information on a multiplicity of consumers, environmental needs, and one's own business. Information systems have become essential for that effort and are now a critical management resource. These systems can now be seen to be focused on four areas.

* Daily business system: Accounting, salary management, human affairs, procurement and stock, etc.
* Strategy system: BI (Business Intelligence), EC (E-Commerce) and CRM (Customer Relationship Management)
* Information system: Groupware, Application, and portal site system, etc.
* Infrastructure system: Server ware, data base and security, etc.

The results of a survey conducted in 2007 (Nikkei Business Publication, 2008) indicated that "internal controls (17.7%)," "decision-making support for management (9.6%)," "supply chain management (9.0%)," "business support (8.7%)" and "CRM (8.1%)" were viewed as more important areas for IT investment. Actual IT investments were directed mainly to the areas of "security (63.3%)," "finance and accounting (57.1%)," "CRM (49.2%)," "salary management (42.1%)" and "procurement (38.4%)." As society has become more and more information-driven, awareness of the need to strengthen protections for personal information has grown, leading companies to be keenly interested in security. They also remain highly interested in investing in systems for "finance and accounting," "sales management," and other such aspects of routine operations. Adoptions of these information systems constitute significant investments. Companies also have to show that the benefits are worth the costs. Investments in information systems, however, unlike investments in hard capital, do not yield tangible results. Furthermore, maintenance and upgrades are essential and require frequent supplemental investments. This has generally been the case for both information systems and software. And so it is important to carefully consider the management and maintenance issues to be encountered both before and after systems are introduced. This study looks at the process of introducing an information system, and discusses prior research findings and issues that remain to be addressed.

The process for introducing an information system will differ depending on company customs, the

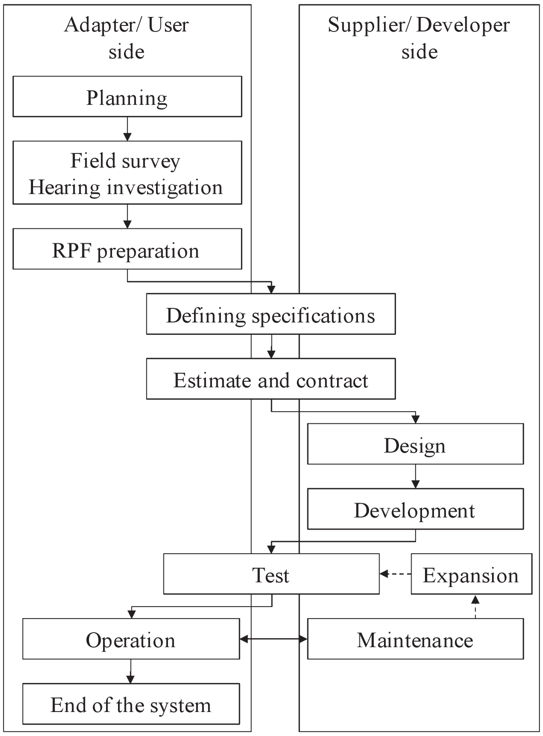

Figure 1. Introduction process of information system

approaches of suppliers, and societal circumstances, but generally follow the flow shown in Figure 1. The adopter, or "user," is the company/customer that will newly introduce and operate an information system. The supplier, or "developer," is the company that will design and develop the information system based on the user's needs, and provide maintenance services once the system is installed. This will usually be an IT company or system integrator (SI). An IT consultant may play a central role in determining system requirements and negotiating on behalf of the user when the user lacks detailed knowledge and experience with information systems. Relations between users and developers differ depending on the companies involved and the nature of the project. For this study, however, it is assumed that the user is responsible for everything from planning through RFP preparation, and operation; the developer, for design, development, and maintenance; and that both will be involved in defining specifications, developing an estimate and agreement, and testing. Individual process phases are discussed below.

In the planning phase, the user defines a clear purpose for introducing an information system and the personnel in charge of planning gather information (through interviews, surveys, etc.) to support the plan. This phase is also referred to as "requirement definition" and, depending on the user-developer agreement, can sometimes involve the developer. Requirements are laid out in the RFP (Request for Proposal). The RPF is presented to the developer and includes system requirements and conditions. After preparing the RFP, the user often obtains competitive bids and selects a developer based on considerations of cost, delivery time, and quality.

After a developer has been selected, the user and developer work together based on the details of the RFP. The developer assembles clear requirement definitions for realizing what the user has proposed and provides a formal estimate. Once the user and developer agree on how to proceed, a formal contract is entered into. The developer performs system design, development, and programming services, and tests the completed system. Testing is performed to determine whether the system meets the user's requirements and functions properly in the user environment. Both the developer and user confirm test results. After testing is completed, the system is delivered to the user for regular operation. The user and developer generally enter into a maintenance agreement in which the developer fixes defects, adds functions, and performs other such services. A system will reach the end of its useful life after a few years. This is not only because of physical durability issues but also, for example, because it becomes impossible for a dated system to use the latest upgrade of an OS or because the work for which the system was adopted has outgrown the system's capabilities.

Turning to a discussion of key considerations for each process phase and the findings of earlier research, it is critical that identification and interpretation of the system's purpose and its reflection in the system be considered in planning, information gathering, and RFP creation. Information to shed light on these issues is gathered by having user representatives interview employees engaged in the subject work. These representatives, though, find it difficult to grasp all of the relevant functions because they have other work responsibilities in addition to the subject work. However, 70–80% of the causes for problems and loss costs can be traced back to inadequate RFP preparation (Glass, R. L., 2003), so the success or failure of a system is largely determined even before planning takes place. A preceding research, for example, Nakagawa (Nakagawa T. and Kaneda S., 2001) proposed a method of introducing IE concept for the extraction of the problem demand in the definition process. Because the effect of the improvement can be quantitatively presented, it was useful and persuasive for business manager to propose the business system. Mind mapping is one approach that is gaining attention for identifying essential elements and clearly defining requirements to ensure a system fulfills its purpose (Buzan, T., 2003. Aleksander, I., 2003). They also have a variety of books as RFP making support (Porter-Roth, B., 2001. Baugh, L., 1995. Freed, R. and Romano, J., 2003).

Regarding the next step, preparation of the estimate, many methodologies have been proposed. A historically popular approach was to use the number of lines of source code (LOC) as a measure of the scale of the software to be created (Kubota, H. and Aman, H., 2008). Later, it also came into wide use that the FP (Functional Point) method which is calculated by the logic file and five kinds of I/O functions (Bundschuh, M., and Dekkers, C., 2008. Ahn, Y., et al., 2003), and WBS (Work Breakdown Structure (Hirai, C., et al., 2007)) which is divided the project detail and premeditated each worked and its cost. All of these approaches, however, rely largely on experience and intuition, so, in practice, each developer now has its own approach for developing estimates.

Moving on to design and development, studies have been performed and methodologies developed for improving efficiency. For example, structured programming and object-oriented programming language have to be conducted (Bohl, M. and Rynn, M., 2002). There are also researchers focusing on software reliability (Zahedi, F. and Ashrafi, N., 1991. Goševa-Popstojanova, K. and Trivedi, K. S., 2001. Butler, R. W. and Finelli, G. B., 1993. Dugan, J. B. and Lyu, M., 1994.), where "reliability" is a measure of the ability of a program to function without bugs or defects and maintain the specified level of performance under given time constraints and other conditions. Zahedi and Ashrafi (Zahedi, F. and Ashrafi, N., 2002) develop a reliability allocation model, which determines how reliable software modules and programs must be to maximize the user's utility, while taking into account the financial and technical constraints of the system. They provide analytic hierarchy process for integrating with the technical structure of the software and its module and program reliabilities. Butler and Finelli (1993) work affirms that the quantification of life-critical software reliability is infeasible using statistical methods, whether these methods are applied to standard software or fault-tolerant software. Its models are examined to be incapable of overcoming the need for excessive amounts of testing. It implications of the recent multiversion software experiments support the affirmation.

Operation and maintenance is the final phase. The term "expansion" as it is used in Figure 1 refers to the rectification of bugs and defects and the implementation of additional investments to meet supplemental requirements (Moran, P., et al., 1990). The cycle of expansion, testing, and implementation is performed repeatedly and one reason for the ballooning of life cycle costs in recent years (Tan, Y. and Mookerjee. V. S., 2005). Within the information system development process, maintenance costs have taken on considerable proportions and now exceed expenditures for software development. For instance, there are investigations such as "even if the bug found in the test is corrected, the bug is exceeded from its 1/5 further" and "the amount of money equal with the initial development cost will hang to the system maintenance cost in five years," too. By IT Investigation (JUAS, 2007)'s research, it is said that "if the bug is found and repaired during the test, there has been more bug in the 25% probability" and "the conservation cost takes equal amount of the initial investment. Robert (Glass, R. L., 2001) was insisted that software conservation cost will takes 40 to 80% of amount cost. It is difficult to introduce the information system without trouble or bug, and it needs to repair or expansion at the high probability. As well, 60% of the conservation are functional expansion, that is, only 17% are bug correction. Therefore, the software conservation is not only fault restore but also introducing new function to mature system. Researchers are examining ways to minimize costs and model maintenance services (Brown, D. B., 1989. Antoniol, G., et al., 2004. Bandi, R. K., et al., 2003. Banker, R., 1998). Brown (1989) makes the probabilistic model which is presented that demonstrates the optimal number of software test cases required in situations. A formula is derived by the use of calculus and is solved by approximation techniques. The model serves as a basis for further research efforts to improve the accuracy of input variable estimation.

Development and maintenance work, however, harbors a conflict directly impacting company profits. That conflict centers on the SE who is in charge of both project development and system maintenance. Being in charge of maintenance for an existing system prevents the SE from developing new systems, causing his company to miss business opportunities. SEs are given both responsibilities because of the significant overlap of development and maintenance work. Maintenance work requires a detailed understanding of the existing system. Consequently, an SE who is assigned the maintenance of a system he did not develop must learn the details of the system he is to maintain. This learning period amounts to approximately 30% of the entire time spent on maintenance work, and that is why SEs who develop systems tend to be assigned the work of maintaining them (Glass, R. L., 2003). The problem of whether to assign SEs to maintenance of existing systems or to development of new systems is a significant one.

If two issues—the degree of expansion needed and timing for the handoff of system responsibility from the development SE to the maintenance SE—are addressed ahead of time, life cycle costs can be lowered and development SEs can be reassigned to the task of creating new systems. This study focuses on the timing for handing off system maintenance responsibilities and aims to propose a model for determining the optimal time for doing so. Toward that end, the following steps were taken.

1) On-site interviews: To clearly identify maintenance issues and desired improvements.
2) Determination of hypotheses and models: To establish hypotheses and create models for the number of problem inquiries following system introduction, time necessary to address them, and expansion.
3) Model estimation: Estimation of models based on actual data.
4) Simulation and consideration: Consideration and confirmation of the appropriateness of each model.
5) Feedback on-site interviews: To gather feedback on results and verify model effectiveness.

As outlined above, problems were identified, models created, simulations performed, and a practical discussion pursued.

2. DETERMINATION OF HYPOTHESES AND MODELS

For the first step, representatives of A Co. were interviewed to identify maintenance issues. A Co. is primarily engaged in the development and maintenance of production and inventory management systems for factories. It has also installed information systems for other companies.

Interview subjects indicated that :

* There had been no cases in which newly installed systems operated free of malfunctions and that SEs in charge of development were assigned to continue working with installed systems in an ongoing cycle of expansion development, maintenance, and further expansion.
* It is difficult to properly time the reassignment of SEs to the development of new systems.
* An indicator for handoff of system responsibility from the development SE to the maintenance SE is urgently needed.

Regarding life cycle costs, it was also determined through interviews that both users and developers perceive the introduction of an information system within a predetermined budget as difficult. Both sides would like to have information on the margin for adjusting the minimum level of expansion.

In the next part of this study, data on nine large projects for which 68 expansions were performed were analyzed (Table 1).

* Projects were identified by information system installation number.
* For each project, dates spanned the period beginning with the installation date and ending with the withdrawal date.
* Data on the number of problem inquiries received by developers from users each day and the time necessary to address each one were gathered.
* Data on the dates on which decisions to expand systems were made and on which system expansion work was delivered to the user were collected.
* Data on the degrees to which systems were expanded were collected.

Table 1. A CO.'s data format

Project	Information system installation number
Date	Year/Month/Date
Inquiries number	Inquiries number received from users each day
Inquiries time	Each inquiries time
Expansion decision date	decisions date to expand systems
Delivery date	Delivery date of completed system
Expansion rate	Expansion rate of its scale

Data on the 68 expansions and from interviews were used to develop the following three hypotheses.

Hypothesis 1: The number of problem inquiries grows rapidly during the middle portion of the post-installation period and tapers off during the latter portion. It is postulated that issues users encounter during the early portion of the post-installation period are mostly simple and in regard to matters like how to interact with the user interface. Entering the middle portion of the post-installation period, users encounter fundamental system errors like incorrect inventory figures or data processing problems. These would necessitate major changes, resulting in system expansion. Once expansion work is completed, now in the latter portion of the post-installation period, problem inquiries return to relatively simple issues like resolving problems with the expansion and questions regarding usage.

Hypothesis 2: The decision to expand the system takes place during the early to middle portion of the post-installation period. The time between the point at which the decision to expand is made and budget matters are settled, and the point of expansion delivery may be affected by the number of problem inquiries received during the early portion of the post-installation period.

Hypothesis 3: There are two peaks in the time necessary to respond to problem inquiries. Once the second peak is passed, inquiries concern mainly simple matters. It would seem, therefore, that an indicator for the handing off of maintenance responsibilities could be found in the inquiry response time during the latter portion of the post-installation period.

Modeling these three hypotheses, this study attempted to estimate the timing for the handoff of maintenance responsibilities. In other words, it developed solutions for three elements :

* Expansion decision period and the length of time preceding expansion
* The expansion size in percentage terms
* An indicator for the handoff of maintenance responsibilities.

This work is premised on the following.

* Figure 2 describes a single expansion. In reality, however, expansions would be performed multiple times depending on system size and the nature of bugs, as described in Figure 3. For this study, therefore, a "project" is comprised of the period beginning with the delivery of an information system, the initial expansion of that system, and the time leading up to the next expansion. Analyses, modeling, and discussion focus on a "project" in this sense.

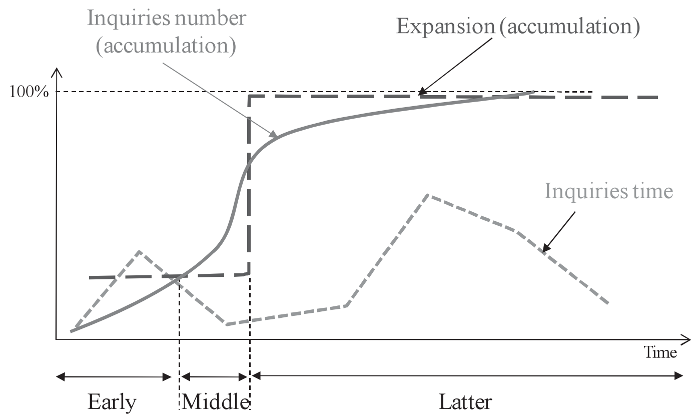

Figure 2. The relationship among inquiries number, times and expansion

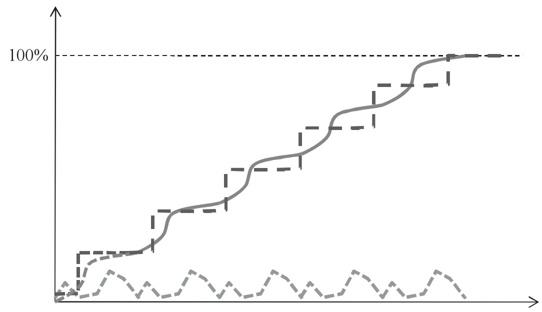

Figure 3. Transition of the inquiry relation in the original business

* The expansion decision period is the period beginning with system delivery and continuing up to the point at which the decision to expand a project is made.
* The expansion delivery date is the day on which the expanded system is turned over to the user for use.
* Through the hearing, A Co needs to know timing for the handoff of maintenance. As results, it is estimated as the time *Tt* at which handoff is indicated.

Based on the above premises, modeling and estimation were performed for: (1) Expansion decision period, (2) The period beginning with the expansion decision and ending with delivery, (3) Expansion cost, (4) The changes in time necessary to respond to post-expansion problem inquiries, and (5) The maintenance responsibility handoff indicator, in Figure 4.

2.1 Expansion decision period

The first step was determining and modeling (1) the expansion decision period. In more specific terms, this is the period beginning with the decision to expand the system, based on problem inquiries received by the developer from the user, continuing with the determination of specifications and performance of development work, and ending with delivery of the expansion. Here, the probability that inquiries are received is λ.

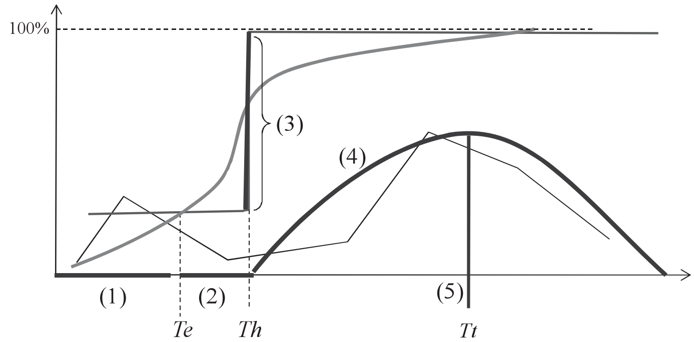

Figure 4. The presumption objects and time definition

$$\lambda = Q_i\,(t)/Ta \tag{1}$$

where,

$Q_i(t)$: Project i's accounts of inquires in term t.

Ta: Time from project start to deliver the system.

Inquires distribution takes exponent function :

$$f_0(t) = \lambda e^{-\lambda t} \tag{2}$$

It was noted that the number of inquiries declines with time. Applying this relationship to the determination of the day on which the decision to expand the system is made, it was hypothesized that the nature of inquiries will be grasped and the decision to expand the system will be made once the cumulative probability $f_0\ (t)$ equals or exceeds m. In other words, the decision period was set to change depending on when the cumulative probability reaches or exceeds m.

2.2 The period beginning with the expansion decision and ending with delivery

Modeling of (2) the period beginning with the expansion decision and ending with delivery and (3) expansion cost, is as shown in the diagram.

Interviews and data analysis yielded two reasons for this. The first is that expansion size depends on the number of inquiries, while budget constraints have an attenuating impact. The second is that delivery times grow with expansion budget size. Efforts were made to model these relationships and make it possible to produce estimates based on actual data. To make model for those considerations, it takes relationship to inquiries probability. Furthermore, it will estimate from real data (Figure 5).

$$f_1(\lambda) = Ex_i\,(t) \tag{3}$$

where,

$f_1(x)$: Function input x and output the expansion rates in t term.

$Ex_i(t)$: Project i's expansion rates in t term.

As well, it takes different delivery time by expansion

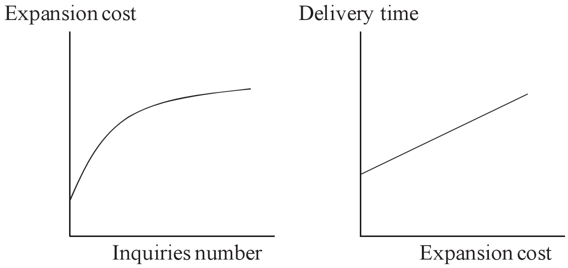

Figure 5. Model from expansion decision to delivery

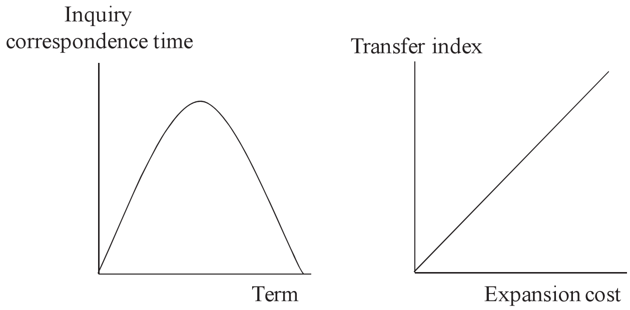

Figure 6. Model to Transfer index

time.

$$f_2\ (Ex_i(t)) = Th \tag{4}$$

where,

$f_2\ (x)$: Function input x and output Th in t term.

2.3 The maintenance responsibility handoff indicator

Regarding an indicator for the handoff of maintenance responsibilities, interview data on actual handoff conditions indicated that inquiry response times grow immediately after system delivery but decline, together with number of inquiries, to a more steady level after peaking. In this study, therefore, modeling was performed assuming that inquiry response times display a peak. That peak was estimated as (5) the maintenance responsibility handoff indicator (Figure 6).

Ultimately, the estimation of (5) the maintenance responsibility handoff indicator is critical, and a relationship was established by performing data analysis on the relationship between (4) the maximum inquiry response time and the expansion size.

$$f_4(f_3(t),\ Ex_i(t)) = Su \tag{5}$$

where,

$f_3\ (x)$: Function input x and output value according to the convex curve in t term.

$f_4\ (x, y)$: Function input x and y, and output value of the top.

Su: The value of the top.

It will make the model thorough mentioned above and estimate by real data.

3. MODEL ESTIMATION

In the next step, estimates were calculated using actual data and the models created based on this study's hypotheses in the second chapter. The object data are nine large projects for which 68 expansions were performed were analyzed.

3.1 The estimation of the inquiry probability and *Te*

This work began with estimation of the inquiry probability and time *Te* by more than *m*% of the cumulative probability (Table 2). *Te* was seen to change depending on the cumulative probability. *Te* has to change according to the *m.*

Table 2. Estimated outputs of *Te*

λ		0.143	0.136	0.140	0.182	0.459	0.259	0.091
Measurement Term		35	22	27	33	36	27	11
After delivery		22	27	33	36	27	11	158
m	90%	16.12	16.89	16.45	12.66	5.01	8.88	25.33
	80%	11.27	11.80	11.50	8.85	3.50	6.21	17.70
	70%	8.43	8.83	8.60	6.62	2.62	4.64	13.24
	60%	6.41	6.72	6.54	5.04	1.99	3.53	10.08
	50%	4.85	5.08	4.95	3.81	1.51	2.67	7.62
λ		0.095	0.713	0.677	0.632	1.182	0.955	
Measurement Term		158	87	65	38	22	67	
After delivery		87	65	38	22	67	30	
m	90%	24.25	3.23	3.40	3.65	1.95	2.41	
	80%	16.95	2.26	2.38	2.55	1.36	1.68	
	70%	12.68	1.69	1.78	1.91	1.02	1.26	
	60%	9.65	1.29	1.35	1.45	0.78	0.96	
	50%	7.30	0.97	1.02	1.10	0.59	0.73	

3.2 The estimation of the *Th* and expansion

As mentioned 2.2, the function describing the relationship between the inquiry probability and the expansion size approximates an exponential function (Figure 7).

$$y = 0.0103e^{1.1037\lambda} \tag{6}$$

The delivery time *Th* approaches linearity based on the expansion percentage (Figure 8).

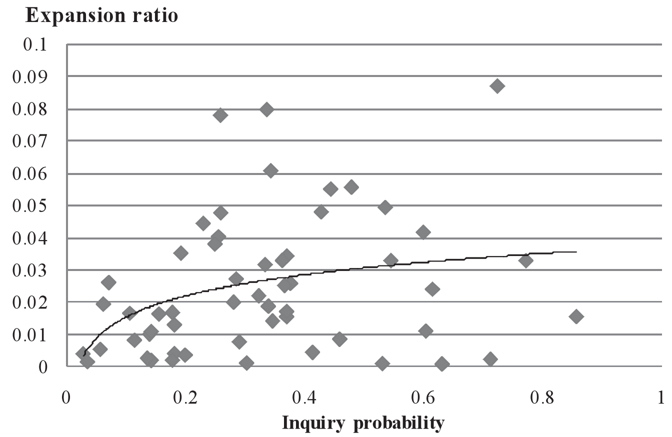

Figure 7. Estimated function between inquiry probability and expansion ratio

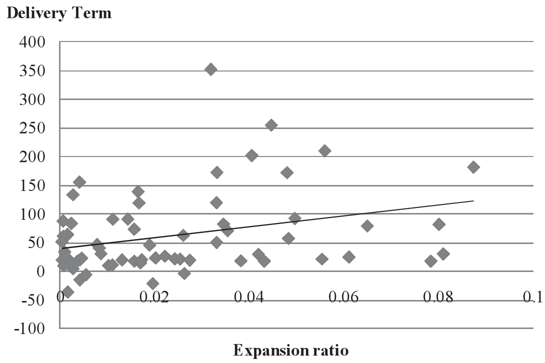

Figure 8. Relation between expansion ratio and delivery term

$$y = 89.302 * Ex_i(t) + 58.432 \quad (7)$$

3.3 The estimation of the maintenance responsibility handoff indicator

In estimating the handoff indicator, the relationship between the period prior to the inquiry response time peak estimated from actual data and the expansion percentage can be estimated linearly (Figure 9).

$$y = 566.68 * Ex_i(t) + 59.603 \quad (8)$$

In other words, the larger the expansion budget, the longer the period leading up to the inquiry response time peak.

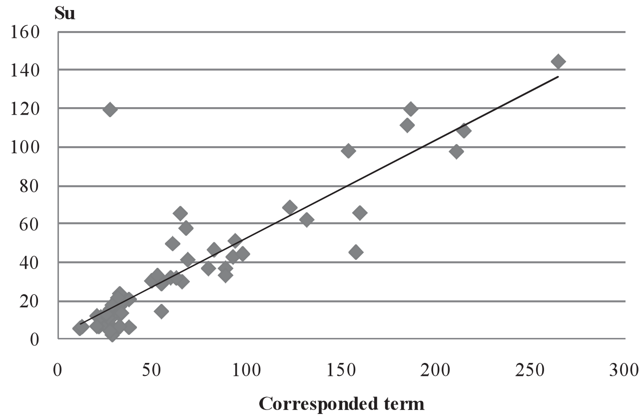

Figure 9. Estimated outputs of maintenance responsibility handoff indicator

4. SIMULATION AND ITS EXAMINATION

Using estimate results, simulations using actual data were performed. Simulation results were then used to consider the impacts of changes in inquiry probabilities and cumulative probabilities on decision-making periods, expansion percentages, and the handoff indicator (Table 3).

It is clear that changes in the inquiry probability impact the various periods and the expansion size. In particular, when the number of inquiries is large, the period leading up to a decision to expand a system is short. The same relationship was also observed in reality. It was also determined, however, that the larger the expansion size the shorter the length of time preceding the handoff of maintenance responsibilities following the delivery of a system expansion.

Table 4 shows the results of a simulation in which the cumulative probability of a decision to expand is allowed to vary while the inquiry probability is held constant. As the cumulative probability declines, *Te* also declines, but the percentage declines in *Th* and *Tt* are relatively small.

Table 3. Simulation outputs of decision making term, expansion rate and handoff indicator

λ	*Te*	*Th*	Expansion rate	*Tt*
0.05	46.05	105.46	0.01088	140.95
0.1	23.03	82.43	0.01150	117.92
0.15	15.35	74.75	0.01215	110.25
0.2	11.51	70.92	0.01284	106.41
0.25	9.21	68.61	0.01357	104.11
0.3	7.68	67.08	0.01434	102.57
0.35	6.58	65.98	0.01516	101.47
0.4	5.76	65.16	0.01602	100.65
0.45	5.12	64.52	0.01693	100.01
0.5	4.61	64.01	0.01789	99.50

Table 4. Simulation outputs depended on the cumulative probability

Cumulative probability	Te	Th	Tt
0.9	4.61	64.63	102.13
0.8	3.22	63.25	100.74
0.7	2.41	62.44	99.93
0.6	1.83	61.86	99.36
0.5	1.39	61.42	98.91
0.4	1.02	61.05	98.55
0.3	0.71	60.74	98.24
0.2	0.45	60.48	97.97
0.1	0.21	60.24	97.73

5. CONCLUSION

For this research, interviews were conducted with the cooperation of SEs and managers at A Co. Through these interviews, it was determined that an indicator for the proper time to handoff maintenance responsibilities from the development SE to the maintenance SE was needed. Interviews also indicated that users and developers both perceive that it is difficult to introduce information systems within budget and would like to have information like the margin for adjusting the minimum level of expansion. Models were developed and estimates calculated based on actual data. These models were then used to perform simulations, which made it possible to consider the time impact of inquiry probabilities.

In sum, this study succeeded in :

* Providing an additional piece of information regarding both the period leading up to the decision to expand a system and the expansion budget
* Identifying an indicator for timing the handoff of maintenance responsibilities
* Using estimated models to perform simulations and supporting future information system introductions.

Areas meriting additional research attention in the future include :

* Consideration of project types and sizes
* Further refinement of models.

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