Economic Evaluation of IT Investments for Emergency Management : A Cost-centric Control Model

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Abstract

In an emergency management case, evaluating the economic value of information technology investments is a challenging problem due to the effects of decision making, uncertainty of disasters, and difficulty of measurements. Risk assessment and recovery process, one of the major functions in emergency management, consists of (1) measurement of damages or losses, (2) recovery planning, (3) reporting and approving budgets, (4) auctioning off recovery projects to constructors, and (5) construction for the recovery. Specifically and of our interest, measurement of damages or losses is often a costly and time-consuming process because the wide range of field surveys should be performed by a limited pool of trained agents. Managers, therefore, have to balance accuracy of the field survey against the total time to complete the survey. Using information technologies to support field survey and reporting has great potential to reduce errors and lowers the cost of the process. However, existing cost benefit analysis framework may be problematic to evaluate and justify the IT investment because the cost benefit analysis often include the long-run benefit of IT that is difficult to quantify and overlook the impact of managerial control upon the investment outcomes. Therefore, we present an alternative cost-centric control model that conservatively quantifies all cost savings to replace benefits in cost benefit analysis and incorporate the managerial control. The model provides a framework to examine how managerial decision making and uncertainty of disaster affect the economic value of IT investments. The current project in Emergency Agency in South Korea is introduced as a case to apply the cost-centric control model. Our work helps managers to better evaluate and justify IT-related investment alternatives in emergency management.

Keywords : IT investment, Emergency Management, Cost Benefit Analysis, Cost-centric Control Model

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1. Introduction

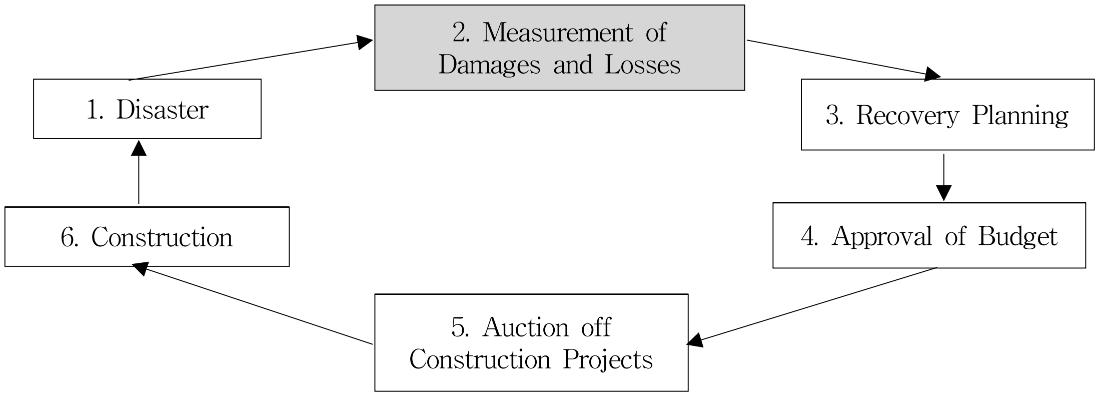
Natural disasters, such as typhoons, earthquakes, forest fires, oil spills, tsunamis, flood, and so forth, tend to repeat over the years. Although continuous efforts have been devoted to prevent them, the amount of losses and damages has been drastically increased over recent years because the rate of land utilization goes high as the economy grows.

Risk assessment and recovery processes, as is illustrated in <Figure 1>, are one of the major functions in emergency management. In these processes, (1) trained agents are dispatched to survey damages or losses in the disaster fields, (2) agents report the amount of damages or losses and the authorities at federal, state, county levels examine the amount of it and approve the budgets for the recovery of damages, and (3) once the budgets are finalized, then the agency auctions off a variety of recovery projects to constructors.

It is critical for all parties involved to measure damages or losses quickly and accurately in order to recover in a cost-efficient way and in a timely manner, so that they can prepare for the upcoming disasters. However, measuring damages or losses and investigating the source of damages are often costly and time-consuming process because a limited pool of trained agents should perform the wide range of field-surveys in a short time frame. When these agents are dispatched, their tasks additionally include (1) task coordination, (2) emergency recovery, (3) disaster relief, (4) response to resident needs, and (5) response to media. Since these agents should perform excessive amount of tasks and do not have a standardized way of tasks, their responses are prone to be ad-hoc and ineffective and the measurements are often subjective and exaggerated for local governments.[1)] <Table 1> takes examples from 2003 Report by National Institute for Disaster Prevention of Korea (NIDPK). This table shows a great disparity between measurement amount and actual amount needed identified from investigation. It is hard to generalize from this fragmental information but contractors seems to have better information for the actual amount when these contracts are auctioned off when we compare the amount paid to contractors and actual amount from investigation. Overpayment is not a desirable appropriation of the tax and could be used for better disaster recovery and prevention.

Recent surveys reported by NIDPK in 2003 asked these agents how they can improve the disaster measurement process in various objects (road, river, sewer system, and building) and find out they want (1) more agents (25～30% for each object), (2) more time for measurement (30～45%), and (3) Improvement of measurement instructions and requirements (20～40%). They also pointed out to improve the report system, improve the process so

1) Korean government supports 1/2 of total recovery cost. U.S. and Japanese governments support 3/4 and 2/3 respectively. Actual cost for recovery does not fully reflect its inflation. Based on these facts, we expect the fiscal exaggeration may come from the incentive to secure enough recovery budgets for local governments (state or municipal).



〈Figure 1〉 Disaster Measurement and Recovery Process

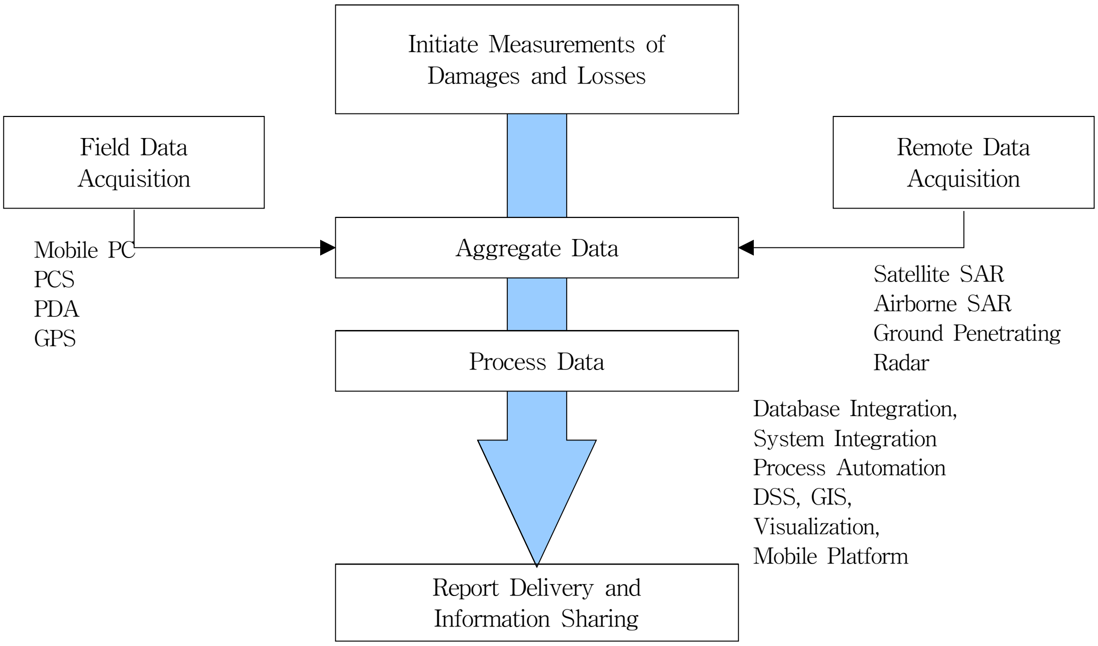
〈Table 1〉 Two Cases of Measurement Errors Reported by National Institute for Disaster Prevention of Korea (NIDPK)

	River A	River B
(1) Measurement Amount by Agents	$ 8.38 M	$ 8.98 M
(2) Amount Paid to Contractors	$ 4.58 M	$ 6.51 M
(3) Actual Amount from Investigation	$ 1.76 M	$ 4.45 M
Measurement Error (1)~(3)	$ 6.62 M	$ 4.53 M
Overpayment (2)~(3)	$ 2.82 M	$ 2.06 M

that it can allow agents to add omitted measurements later.

Managers, therefore, have to balance accuracy of the field survey against the total duration allowed to complete the survey. Inaccurate surveys lead to overpayment or underpayment of actual recovery cost; both are undesirable for the society. Lengthy survey for accurate measurements may reduce the social cost of inaccurate survey but require excessive survey cost and delay the actual recovery.

In the disaster measurement and reporting context, information technologies have a great potential to expedite the process by automating some part of the process and exploiting wide range remote sensing tools (See <Figure 2>). Satellite synthetic aperture radar (SAR) can be applied to monitor disasters such as forest fire, floods, volcanic eruptions, and oil spills. Geographic information systems (GIS) can be used to gather, transform, manipulate, analyze, and produce information related to the surface of the Earth. Portable computer equipped with Global positioning system (GPS) can shorten the time spent for identifying the locations and areas of the disaster. Mobile Computing allows agents to measure and send the survey data to the central server without delay. Development and integration of software programs such as Workflow, Enterprise Resource Planning, Data Warehouse and Data Mining Tools can replace manual labor with automated survey data processing, disaster



〈Figure 2〉 Measurement Process and Information Technologies

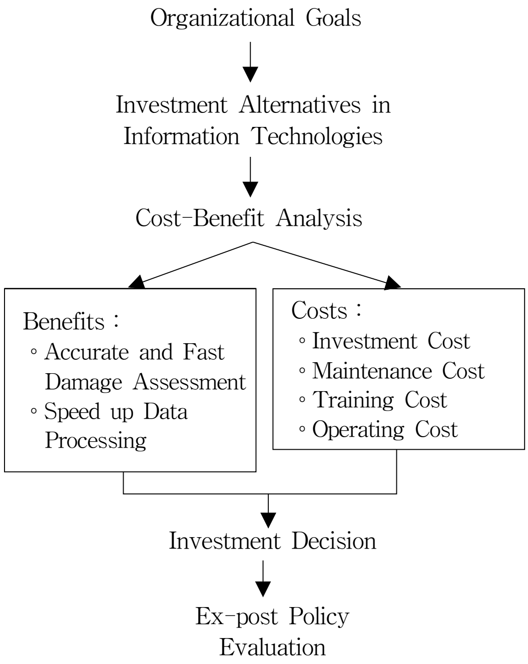
amount calculation, and database query. More valuable outcomes can be expected from managerial decision support utilizing measurement technologies and data warehouse/mining such as disaster prediction, effective reaction to the disaster, better allocation of measurement accuracy, and the like.

As shown in <Figure 2>, Information Technologies can provide novel solutions for the government agencies to better cope with these disasters. However, it is difficult for managers to evaluate IT investment alternatives. Especially in the context of an emergency management setting, it is complicated : (1) managers make decisions how to allocate the amount of resources in a variety of activities related to emergency management, which will affect the final outcomes of the IT investments, (2) disasters by nature are uncertain about when they would arrive and how much amount of damages they would cause, (3) Often the benefits of the investments are subjective and difficult to quantify.

We briefly discuss potential problems of cost benefit analysis and introduce an alternative cost-centric control model in section 2. Then, we introduce an economic model of cost-centric control in section 3. The application of the model applied to emergency management case of South Korea is explained in section 4. Section 5 concludes our work.

2. Comparison of Cost Benefit Analysis (CBA) and Cost-centric Control Model (CCM)

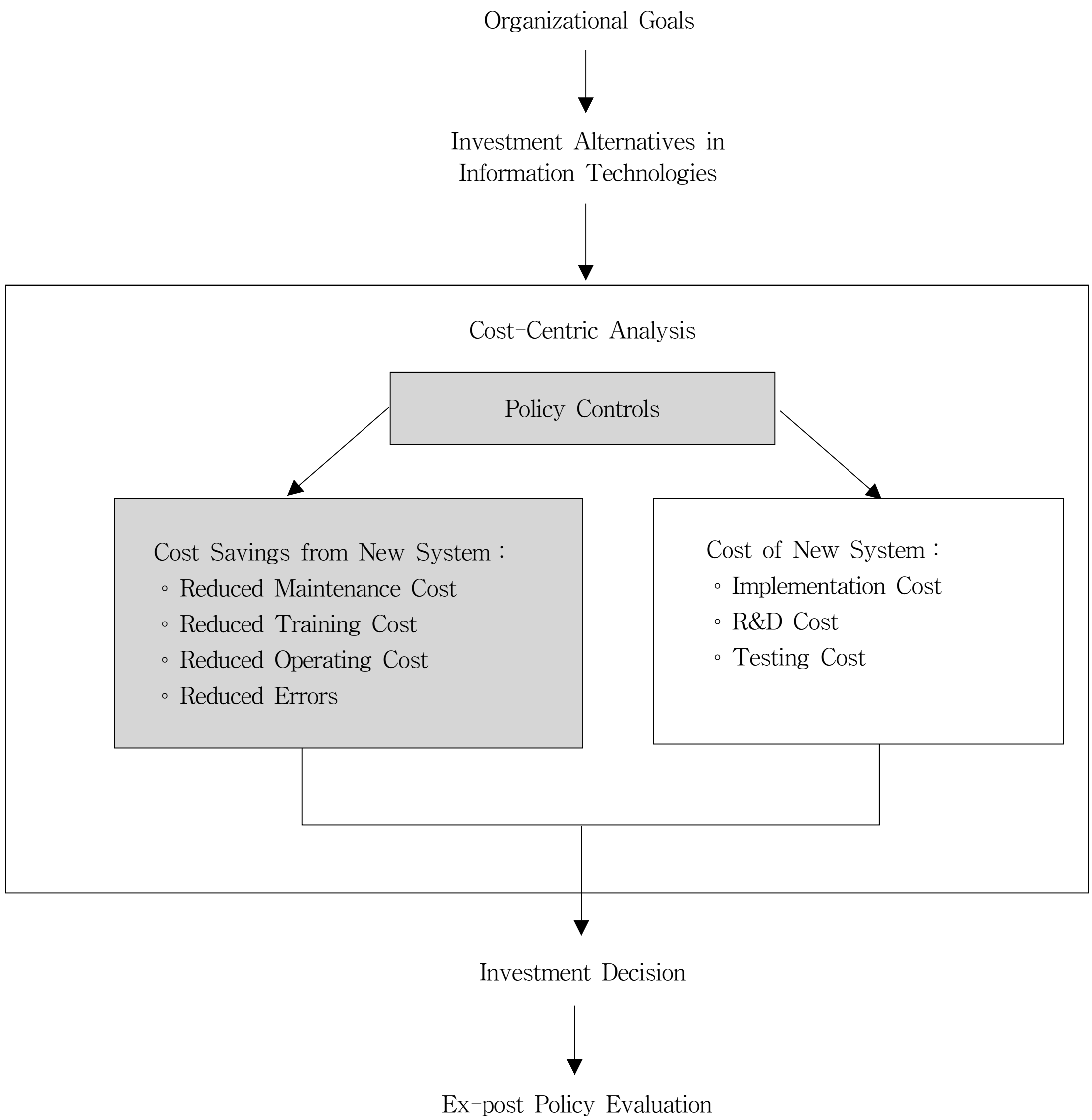
In general, CBA consists of (1) choosing an investment alternative, (2) quantifying the benefits of the alternative, (3) quantifying the costs of the alternative, (4) calculate net benefit/cost, and (5) make an investment decision (see <Figure 3>)



〈Figure 3〉 Cost-Benefit Analysis

However, existing CBA framework is not well fitting to evaluate and justify the IT investments. Using CBA, cost of IT investment is easy to quantify but benefit of IT is difficult to quantify because benefits in CBA include not only economic benefits but also behavioral, social and cultural benefits. In order to validate these economic and non-economic benefits for CBA, analysts have to ask beneficiaries to prioritize each item and assess how much each item affects their wealth. This empirical procedure may be costly and delay the analysis. Even in many business practices, *managers often add on enough intangible benefits such as better decision-making to justify the investment when they want to develop an application but they cannot show benefits that exceed costs* [Lucas 1999]. Moreover, the existing CBA overlooks the impact of manager's decision making, which may drastically change the outcomes of the analysis. In the emergency management setting, information technologies may cut the cost and time of disaster assessment and recovery. Managers should now compare several options and choose better outcome : (i) getting the benefit of reduced cost and time, (ii) diverting the resources from reduced cost and time to more accurate assessment, or (iii) even spend more cost and time with better technologies to achieve more precise assessment. This exemplary managerial decision making may result in quite different investment outcomes, which is hard to capture by the existing CBA.

Therefore, we present a cost-centric control model (CCM) that examines how manager's decision making and uncertainty of disaster affect the economic value of IT investments (See <Figure 4>). CCM can explicitly quantify and measure costs of the new system and cost savings enabled by the new system under the proposed policy control of the new system. CCM is more conservative approach than CBA in that CCM avoids quantifying or measuring long-term behavioral, social, cultural benefits that are subjective and hard to quantify. Furthermore, CCM also allows managers to compare and examine how their decisions should change under a new investment



〈Figure 4〉 Cost-Centric Control Model

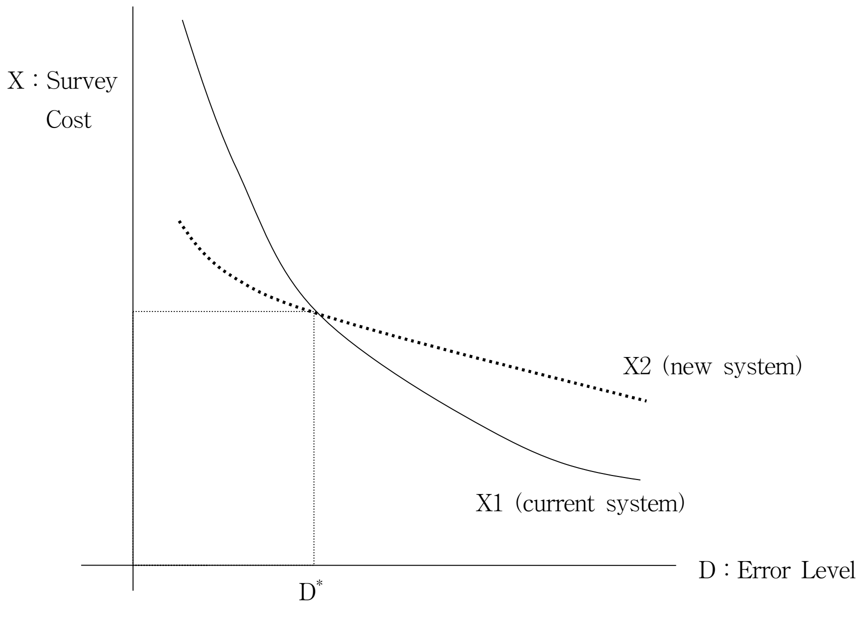
alternative for better investment outcomes. In contrast, CBA often assumes that the outcomes will be the aggregate of benefit and cost holding all other variables including managerial control constant, which does not truly reflect the reality of many investment cases in the emergency management setting.

3. Economic Model of Cost-centric Control

Suppose a new disaster measurement system is implemented as one of IT investment and managers should decide whether to invest or not in an IT related investment project.

The project includes conducting R&D, integrating systems, and maintaining the system. The new system is expected to increase the precision of damage assessments and speed up the process of data processing and reporting the recovery amount.

Suppose there are N_t places that suffered disasters in a year t. As the area of disaster goes wide or the number of disasters increases, N_t increases. The cost of each survey based on current field survey system is x_{1i} and $i \in \{1 \cdots N_t\}$, which includes labor, devices, and maintenance cost. Then, the total cost of survey is $X_1 = \sum_{i=1}^{N_t} x_{1i}$. The cost of each disaster is y_1 and the total amount to be reported for the recovery is $Y_1 = \sum_{i=1}^{N_t} y_{1i}$. We can define that the cost of each survey using the new system is x_{2i} and total cost is $X_2 = \sum_{i=1}^{N_t} x_{2i}$. Total amount for the recovery is $Y_2 = \sum_{i=1}^{N_t} y_{2i}$. If we define the actual amount required for the recovery as $Y_k = \sum_{i=1}^{N_t} y_{ki}$, then the errors of the survey for both survey methods can be calculated as $D_1 = \sum_{i=1}^{N_t} |y_{1i} - y_{ki}| = |Y_1 - Y_k|$ and $D_2 = \sum_{i=1}^{N_t} |y_{2i} - y_{ki}| = |Y_2 - Y_k|$. We think that the survey cost is increasing as the error level D and duration of the survey T set by the managers decreases such that the survey cost function $X_{i \in \{1,2\}} = f_i(D, T)$ and its first derivative are negative with respect to D and T, i.e. $\frac{\partial}{\partial D} f_i(D,T) < 0$ & $\frac{\partial}{\partial T} f_i(D,T) < 0$. As the error level decreases, survey cost using the

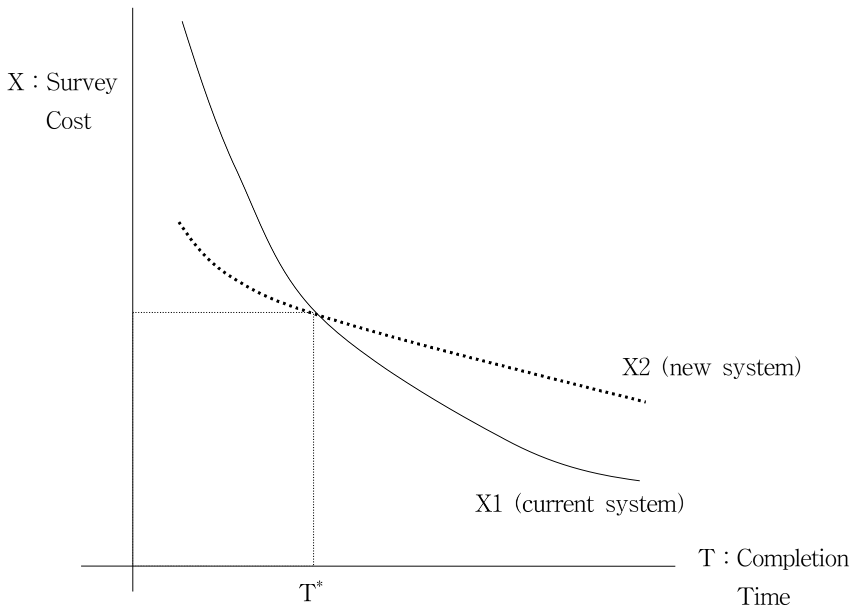


<Figure 5> The impact of Error Level on Survey Cost

new system will increase less than the current system such that $\frac{\partial}{\partial D} f_1 < \frac{\partial}{\partial D} f_2 < 0$. <Figure 5> illustrates the relationship between error level and survey cost. The second derivatives of the cost are positive reflecting the fact that survey cost increases at an increasing rate as the error level decreases. We can observe D^*, a threshold error level, at which the survey costs of new and current system are equal. If the error level is greater than the threshold, then current system costs less than the new system. In the opposite case, the new system is less costly than the current system.

Similarly when we compare the impact of survey duration T, the same order of the first derivatives applies such that $\frac{\partial}{\partial T} f_2 < \frac{\partial}{\partial D} f_1 < 0$ (see <Figure 6>). As the completion time decreases, the survey cost increases at an increasing rate. T^* is the threshold at which the survey costs are the same between current and new system. If the duration is less than T^*, the new system is more efficient than the current system.

In a cost-centric control model, the benefit is conservatively defined as the cost reduction and the cost is defined as initial investment and maintenance cost. Both CBA and CCM take the same NPV template but the subjective benefit in CBA is replaced by the narrowly defined measurable cost reduction in CCM. It is also notable that error level and duration are assumed same in CBA while these variables are controllable by the manager in CCM. Moreover, the recovery amount overestimated/underestimated is also captured as cost/benefit in CCM. The net present val-



〈Figure 6〉 The impact of Duration on Survey Cost ue in CCM can be calculated as following.

(1) If the policy is setting Error Level and Duration constant for current system and new system ($D_1 = D_2$ and $T_1 = T_2$), then net present value of the new system is :

$$NPV_A = -INV + \frac{X_1(D_1,T_1) - X_2(D_1,T_1)}{(1+i)^1} + \frac{X_1(D_1,T_1) - X_2(D_1,T_1)}{(1+i)^2} \cdots + \frac{X_1(D_1,T_1) - X_2(D_1,T_1)}{(1+i)^L},$$

(2) If the policy is setting Error Level and Duration is lowered down for the new system ($D_1 > D_2$ and $T_1 > T_2$) than the current system, then net present value of the new system is :

$$NPV_B = -INV + \frac{X_1(D_2,T_2) - X_2(D_2,T_2) + D_1 - D_2}{(1+i)^1} + \frac{X_1(D_2,T_2) - X_2(D_2,T_2) + D_1 - D_2}{(1+i)^2} \cdots + \frac{X_1(D_2,T_2) - X_2(D_2,T_2) + D_1 - D_2}{(1+i)^L},$$

where INV is initial investment, i is interest rate, and L is system life cycle. In the second equation, $X_1(D_2,T_2) - X_2(D_2,T_2)$ is the difference of measurement costs between current and new systems; $D_1 - D_2$is the gap of measurement errors between two systems. If the new system offers less measurement errors than the current system, the difference is counted for the benefit. In the first equation, the gap is zero because the error levels are same.

If the net present value is positive, then alternative system is worth economically. This net present value (NPV) in CCM can be viewed as a function of decision and parametric variables such that $NPV(X(D,T), L, i, INV)$. Among these parameters of NPV, *error level (D) and survey duration (T) are decision variable* of the manager or policy maker; and system life cycle (L) and interest rate (i) are explicitly given exogenously; and number of places to survey (N), i.e. the range of disaster is stochastic.

Comparing NPV_A and NPV_B provides us a framework to analyze the impact of decision variables (error level and duration) upon the value of new system investment. We consider a few cases regarding the setting of decision variables before and after new system implementation.

(1) [Case 1] both error levels and durations are less than D^* and T^* in <Figure 5> and <Figure 6> and policy is setting the decision variables constant after new system implementation ($D_1 = D_2 < D^*$ and $T_1 = T_2 < T^*$) : In this case we need to assess NPV_A. All terms in NPV_A other than INV are positive because measurement cost reduction $X_1(D_2, T_2) - X_2(D_2, T_2)$ is positive. Managers should compare INV and future flow of cost reduction to measure the net present value of the new system investment.

(2) [Case 2] both error levels and durations

are greater than D* and T* and policy is setting the decision variables constant after new system implementation ($D_1 = D_2 > D^*$ and $T_1 = T_2 > T^*$) : NPV_A is the equation we need to assess. All terms in NPV_A are negative in the case because measurement cost reduction $X_1(D_2, T_2) - X_2(D_2, T_2)$ is even negative. Because policy setting of the decision variables does not fully exploits the merit of new system implantation, the investment alternative is not worth investing. If the error level and duration are set same with current system setting by the managers and they are above the threshold levels of decision variables, IT investments simply increase overall cost but do not improve any performance in reducing the survey cost and lowering the error level.

(3) [Case 3] both error levels and durations are lowered after the investments and both of them are lower than D* and T* ($D_2 < D_1$ & $D_2 < D^*$ and $T_2 > T_1$ & $T_2 < T^*$) : We need to evaluate this case using NPV_B equation. The changes of error level and duration have accelerated impacts on the value because (i) it increases the amount of cost reduction : $X_1(D_1, T_1) - X_2(D_1, T_1) < X_1(D_2, T_2) - X_2(D_2, T_2)$ and (ii) it increases the benefits from reduced measurement errors : $D_2 < D_1$. As a result the net present value of this case is greater than Case 1, i.e. $NPV_B > NPV_A$. When the managers want to improve the performance by reducing errors and shortening the duration, the new system alternative becomes more attractive.

(4) [Case 4] both error levels and durations are lowered after the investments but both of them are still greater than D* and T* ($D_2 < D_1$ & $D_2 > D^*$ and $T_2 > T_1$ & $T_2 > T^*$) : We need to evaluate this case using NPV_B equation. The changes of error level and duration are still greater than the threshold levels, such that the cost reduction from measurement is negative. However, it increases the benefits from reduced measurement error s : $D_2 < D_1$. As a result the net present value of this case is greater than Case 2, i.e. $NPV_B > NPV_A$ and less than Case 3. In this case, the managers try to improve the performance by reducing errors and shortening the duration but the attractiveness of the investment alternative mainly depends on the magnitude of the benefits from reduced measurement errors compared to the increase of measurement cost.

4. A Case Study

National Institute for Disaster Prevention of Korea (NIDPK) currently considers an investment alternative in automating disaster assessment process. The investment aims at shortening the overall process time and increasing the accuracy of disaster assessment. Since this investment alternative expects the policy intervention in order to increase the accuracy of the measurement, we applied Cost- centric Control Model to assess how the combination of policy control and new investment alternative can affect investment outcomes. It will take 4 years to complete and the overall amount of investment is approximately $15.4 M and the details of the subprojects are listed in <Table 2>. The new system will be in operation from the first year with limited capabilities and will be fully operational after 4th year.

Based on <Table 1>, total investment (INV) can be calculated as following :

$$INV = 2.4 + \frac{4.6}{(1+i)} + \frac{4.4}{(1+i)^2} + \frac{4.0}{(1+i)^3}$$

in million dollars.

The total amounts of disasters in the past fiscal years are listed in <Table 3>. The overall amount of yearly disaster, in general, has been increasing over time and shows a sharp increase since 1998. It can be attributed to economic growth as well as increasing land utilization. We can also note that though there are a couple years of exception, disasters seem to happen almost every year.

〈Table 3〉 Disaster Amounts during 1987~2003

Year	Damages ($)	Year	Damages ($)
1987	630 M	1994	153 M
1988	95 M	1995	601 M
1989	228 M	1996	483 M
1990	323 M	1997	190 M
1991	341 M	1998	1,582 M
1992	24 M	2002	6,115 M
1993	197 M	2003	4,408 M

In order to estimate the amounts of damages Y_1 using current system in future, we assume that the amount follows a probability distribution function $Y_1 \in g(Y_1)$ with mean μ and variance σ^2. If we assume the distribution follows a uniform distribution between 4,408M (Yr 2003) and 6,115M (Yr 2002), then the expected amount of disaster measured by the current system is 5261.5M and the standard deviation σ is 492.77M.

If we assume the amount of disaster is the

〈Table 2〉 Investment Details (approximate dollar amount)

Projects	Y1	Y2	Y3	Y4	Total
Damage Assessment and Data Processing	0.4 M	0.5M	0.5M	0.3M	1.7 M
Economic Analysis of R&D	0.2M	0.4M	0.4M	0.4M	1.4 M
Standardization of Mobile Equipment	0.4M	0.7M	0.6M	0.6M	2.3 M
System Integration (Software and Hardware Development)	1.4M	3.0M	2.9M	2.7M	10.0 M
Total	2.4M	4.6M	4.4M	4.0M	15.4 M

mean (5261.5M), the differences between two measurements are shown in <Table 4>.

〈Table 4〉 The difference of disaster measurements (in Million Dollars)

% Difference	Y_1 (current system)	Y_2 (new system)	$Y_1 - Y_2$
0%	5261.5	5261.5	0
1%	5261.5	5208.89	52.615
2%	5261.5	5156.27	105.23
3%	5261.5	5103.66	157.845
4%	5261.5	5051.04	210.46
5%	5261.5	4998.43	263.075

Then the impact of measurement errors is :

$$\begin{aligned} D_1 - D_2 &= |Y_1 - Y_K| - |Y_2 - Y_K| = Y_2 - Y_1 \\ &= \frac{Y_1 - Y_2}{(1+i)} + \frac{Y_1 - Y_2}{(1+i)^2} \cdots + \frac{Y_1 - Y_2}{(1+i)^{L+1}} \\ &= (Y_1 - Y_2)\frac{(1+i)[(1+i)^L - 1]}{i(1+i)^L} \end{aligned}$$

if $Y_1 \geq Y_2 \geq Y_k$.

If the measurement cost of new system is 5% less than that of current system, then the above equation can be calculated as

$$D_1 - D_2 = 263.1 \times \frac{(1+i)[(1+i)^L - 0]}{i(1+i)^L}$$

in million dollars.

The survey cost using current system is 850K per year. So the cost reduction of the survey enabled by the new system is less than a million dollar a year, which is insignificant in our analysis and allows us to focus only on the effect of measurement error reduction. Additional cost by setting less time to complete the survey should be also negligible based on the magnitude of the overall survey cost. The exclusion of the measurement cost would only strengthen our comparison.

The net present value using CCM would be

$$NPV_B = -(2.4 + \frac{4.6}{(1+i)} + \frac{4.4}{(1+i)^2}\frac{+4.0}{(1+i)^3}) + 263 \times \frac{(1+i)[(1+i)^L - 1]}{i(1+i)^L}.$$

Assuming interest rate as 10% and system life as 5 years, the net present value is 1084 million dollars. <Table 5> summarizes NPVs when we vary both % difference and amount of disaster. As a result, we can conclude that the new system is worthwhile investment when it can reduce the damage assessment errors even only by 0.2%.

〈Table 5〉 Impact of error reduction and disaster amount on NPV (sd stands for standard deviation)

Disaster Amount	3783.19	5261.5	6739.81
% Difference	Mean - 3sd	Mean	Mean + 3sd
0.0%	-13.22	-13.22	-13.22
0.2%	18.32	30.65	42.98
0.4%	49.87	74.53	99.19
0.6%	81.42	118.41	155.40
0.8%	112.98	162.29	211.60
1.0%	144.53	206.17	267.81

As such, CCM provides a useful framework to capture the impact of policy or managerial control upon the net present value of an investment alternative. In this case, managers may realize that the part of value chain to which IT investment most contributes is reducing the damage assessment errors, i.e. $D_1 - D_2$. The suggestion may be counter-intuitive since most IT investment in common sense is often believed to be efficient in cost reduction by the new system implementation. In the case, the effective reduction of reported amount plays a crucial role. Using conventional CBA, analysts often overlook the impact of the control and deliver less justification of the investment by adding subjective benefits.

5. Conclusion

Our work provides a cost-centric control model framework in order to better evaluate the economic value of information technology investments in an emergency management setting, specifically for measuring damages and losses caused by natural disasters. Information technologies have great potential in reducing time and cost for the measurement process. However, maximizing the reduction of measurement cost and time may not lead to best outcomes of the IT investment since spending more cost for more accurate measurement of recovery amount even after the technology implementation may bring about greater benefit that can offset the increased measurement cost and sometimes all investment cost. Therefore, managers should realign their policy controls in accordance with the new system in order to get the best of their investment.

Existing cost benefit analysis framework overlooks this role of managers and bears the difficulty of measuring often long-term non-economic benefits. Therefore, we develop an alternative cost-centric control model that conservatively quantifies all cost savings to replace subjective benefits in cost benefit analysis. The model provides a framework to examine how manager's decision making and uncertainty of disaster affect the economic value of IT investments. We apply the cost-centric control model to the case of Emergency Agency in South Korea and find out that the cost reduction of the disaster survey is minor while the error reduction in measuring the amount for recovery plays a crucial role in justifying the investment. However, it should be noted again that the amount of error deduction is controlled by the manager. In other words, the validity of the investment heavily depends on the role of managers. Our work provides an integrated framework for the managers or policy makers to understand how to effectively invest in and manage information technologies in order to improve the overall performance of their critical processes.

Reference

[1] Alaska SAR Facility, http://www.asf.alaska.edu/3_1.html.

[2] Brealey, R. and Myers, S., Principles of

Corporate Finance, McGraw-Hill, New York, 1981.

[3] GeoAnalytics, "A Cost/Benefit Investment Analysis of an Enterprise Geographic Information System for Scott County, Iowa", Report prepared for Scott County, Iowa, March 2003.

[4] Lucas, H. C., *Information Technology and the Productivity Paradox*, Oxford University Press, 1999.

[5] National Institute for Disaster Prevention of Korea, "Examination Report on the Improvement of Disaster Measurement Structure", 2003.

[6] Rick Kazman, Jay Asundi, and Mark Klein, "Quantifying the Cost and Benefit of Architectural Decisions", *Proceedings of the 23rd International Conference on Software Engineering (ICSE 23)*, (Toronto, Canada), May 2001, pp. 297-306.

[7] Rob Trickel, "North Carolina Forest Damage Appraisal-Hurricane Isabel", Report, September 2003.

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