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ANALYTICAL MODEL FOR INCORRECT COST ESTIMATION IN LOCAL GOVERNMENTS IN JAPAN

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ABSTRACT

Bid cancellation procedures owing to incorrect cost estimation corresponding to design have been occurring in many local governments. Incorrect cost estimation has a great influence on public services. In addition, incorrect cost estimation leads to a decrease in staff motivation. Each local government has been conducting internal investigations to prevent incorrect cost estimation. However, no local government has yet developed a firm diagnosis model and preventive measures.

Medical industries have attempted to understand the cause of human error through academic studies. However, local governments have not conducted academic research to analyze the cause of incorrect cost estimation.

In this study, the authors examine precedent cases on human error analysis in other fields and construct an analytical model for incorrect cost estimation. In addition, the authors propose its application to human resource development using the incorrect cost estimation analytical model.

KEYWORDS: *Human Error, Incorrect Cost Estimation, Local Governments in Japan, V-mSELC Model, Human Resource Development*

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INTRODUCTION

Local governments frequently engage in planning, cost estimation, bidding, contracting, construction, supervision, and inspection activities for a variety of building projects. Cost estimation is a particularly important function. However, even in the new era in which the first author began working in the ordering agency at the Department for Public Works, problems with accounting and contracts caused by incorrect cost estimation often occur. The problem of incorrect cost estimation is also addressed in a number of studies 1), 2),3).

Local governments commonly move to halt bidding in the face of incorrect cost estimation, which greatly affects resident services. When public facilities that are utilized by local residents—such as libraries, parks, and school gyms—are involved, incorrect cost estimation and the consequent government response may give rise to several complaints from residents. Moreover, suspending contractor bidding because of incorrect cost estimates makes it impossible to provide stable work for local and regional construction companies. Thus, procedures to halt bidding owing to incorrect cost estimation by the local governments have significant adverse social effects. In addition, incorrect cost estimation leads to a decrease in staff motivation.

Accordingly, the authors believe that incorrect cost estimation is a critical problem that needs to be seriously addressed. Academics in the medical field have long sought answers to the question of what causes human error. A number of medical studies have analyzed the nature of the human error and suggested countermeasures to mitigate mistakes. However, local governments have little access to academic research on the causes of incorrect cost estimation.

In this study, the authors examine precedent cases on human error analysis in other fields and provide an analytical model focused on incorrect cost estimation. By conducting an analysis based on the proposed model, incorrect cost estimation can be reduced. Moreover, used properly, the proposed model should lead to the formulation and implementation of appropriate countermeasures when errors occur. In addition, the authors propose applying the incorrect cost estimation analytical model to human resource development.

HUMAN ERROR

The essence of incorrect cost estimation can be understood by grasping the concept of human error.

Concept of Human Error

Human error causes accidents across a wide range of situations and has been a serious and persistent problem since the beginning of time. Recognizing the impossibility of eliminating human error altogether, individuals and societies in virtually every part of the world have nevertheless devoted considerable time and effort to devising preventive measures. Analyzing human error is considered to be an important part of safety management.

Heinrich's Law[4),5)]

Heinrich's Law is a representative theory that provides a useful model to understand why the human error occurs. It states, "There are 29 minor accidents in the shadow of one serious accident, and, furthermore, there are 300 reserve forces behind." Collecting extensive information on incidents that may lead to accidents, analyzing the possible causes, and taking appropriate countermeasures are extremely important aspects of serious accident prevention.

Table 1 depicts the application of Heinrich's Law to cases of incorrect cost estimation. As shown, incorrect cost estimation can lead to accidents that cause local government administrations to lose credibility.

Table 1: Case of Incorrect Cost Estimation

1SeriousAccident	Incorrect cost estimation with damage to companies
29MinorAccidents	Incorrect cost estimation with little impact on public services
300MicroAccidents	Incorrect cost estimation without bid cancellation

As Heinrich's Law can be adapted to cases of incorrect cost estimation in a particular city, the authors believe that it can also be adapted generally to incorrect cost estimation. For example, in the authors' experience, when one bid was cancelled because of incorrect cost estimation in the subject city, an investigation into the items to be bid was conducted for the purpose of preventing further damage. As a result, several new incorrect cost estimations of a relatively minor nature were discovered.

Based on Heinrich's Law, the authors believe that it is necessary to investigate not only projects that have identified incorrect cost estimation, but also those that are currently being considered. In this way, it is possible to prevent further damage caused by the frequent occurrence of incorrect cost estimation.

Them-SHELL Model for Human Error[6),7),8)]

The m-SHELL model is a model considering management that is considered to be important recently. The basic model diagram is shown in Figure 1. Each component, together with the error-inducing factors, is shown in Table 2.

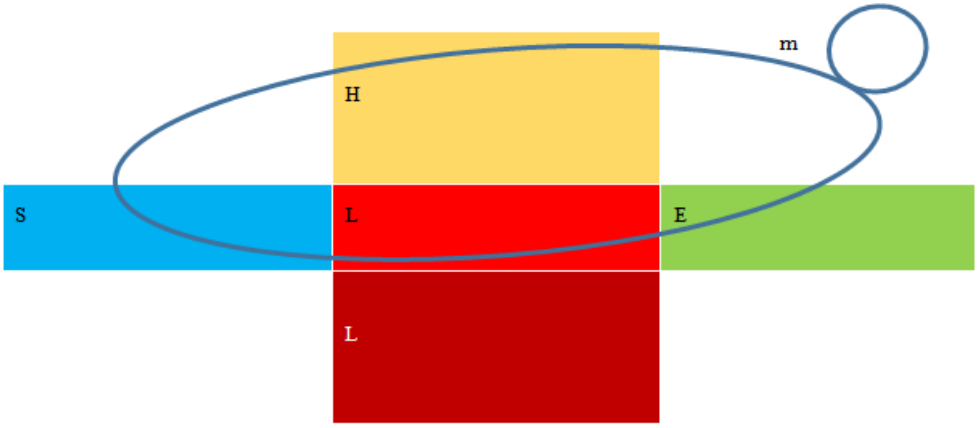

Figure 1: The m-SHELL model

Table 2: Components of the m-SHELL Model and Error-Inducing Factors

Components		Error-Inducing Factors
L	Liveware	Physical condition Psychological situation Ability
S	Software	Manual
H	Hardware	Machine operation
E	Environment	Business management Time management Emergency operation
L	Liveware	Communication Leadership Teamwork
m	Management	Organization System

The state of the "L" at the center and the surrounding S, H, E, and L changes from moment to moment. In order to prevent human errors, it is necessary to adjust the center L and the outer SHEL. For that purpose, management (m) is necessary.

An example will help explain the nature of the process. Using the analytical table (Table 3), we can identify the causes among the components and consider appropriate measures.

Table 3: Analytical Table

Incident	Relationships between Components	Factors	Measures
	L-L		
	L-S		
	L-H		
	L-E		
	L-m		

CONSTRUCTION OF AN ANALYTICAL MODEL FOR INCORRECT COST ESTIMATION

With regard to the incorrect cost estimation incident in the subject city noted earlier, the situation was analyzed and countermeasures were taken without using the analytical model introduced in Chapter 2. It is assumed that other local governments have operated similarly. This is very likely because the human error analysis model presented in Chapter 2 was created specifically for the medical industry, not as a general model dedicated to analyzing incorrect cost estimation.

In light of this, the authors believe that it is necessary to construct a human error analytical model specifically designed to address incorrect cost estimation. In a related study 9), it is stated that “to prevent human error, it is necessary to pay attention to the cause inducing it.”

In this study, the authors refer to the staff who perform cost estimation and verification as Staff (Cost estimation) and Staff (Verification), respectively.

Reason for Constructing an Original Model to Analyze Incorrect Cost Estimation

In many industries, the m-SHELL model is used to analyze accidents. Taking the medical industry as an example, a comparison of the relationship between the parties and the surrounding staff is shown in Table 4.

As indicated, the characteristics of the relationship between Staff (Verification) and Staff (Cost estimation) are different from those of the relationship between Patient and Nurse. A distinctive feature is that the knowledge relationship between Staff (Verification) and Staff (Cost estimation) is basically the same. Such a feature is believed to be special, and it is necessary to construct a proprietary model that can quickly analyze the cause of incorrect cost estimation.

Therefore, by referring to the precedent cases in specific studies10),11), the authors have constructed a V-mSELC model for incorrect cost estimation.

The V-mSELC Model

“Hardware” was excluded from the list of components of the incorrect cost estimation model since cost estimation typically does not use such advanced, complex hardware that is typically used in the aviation and medical industries. The authors simultaneously decided to add Staff (Verification) as an independent component, as the relationship between the parties is closer than with other liveware.

The basic model diagram is shown in Figure 2. Each of the components and error-inducing factors are shown in Table 4. The analysis example is the same as that shown in Table 3.

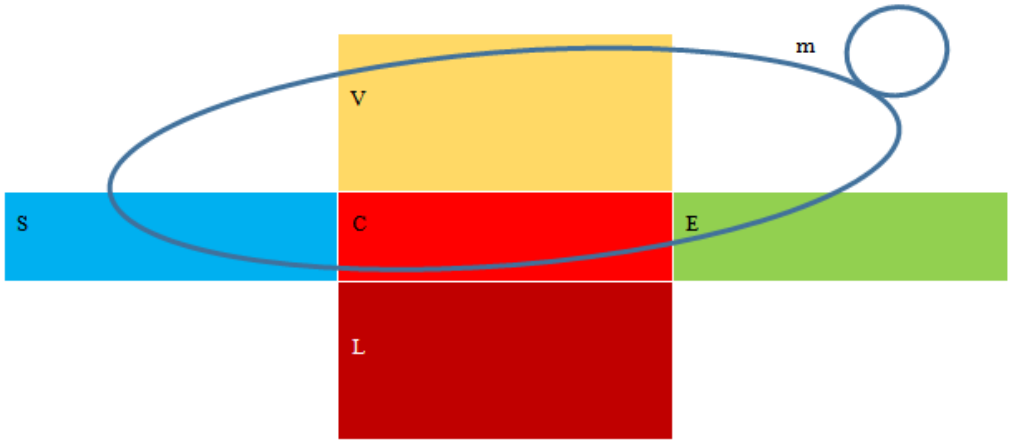

Figure 2: The V-mSELC Model

Table 4: Components of the V-mSELC Model and Error-Inducing Factors

Components		Error-Inducing Factors
C	Staff (Cost estimation)	Physical condition Psychological situation Ability
S	Software	Manual
V	Staff (Verification)	Physical condition Psychological situation Ability
E	Environment	Business environment Time environment
L	Liveware	Communication Teamwork
m	Management	Organization System

Confirmation of the Validity of the V-mSELC Model

The authors verified the effectiveness of the V-mSELC model using the virtual pattern of the case of the incorrect cost estimation in the subject city cited earlier. The results obtained by human error analysis (Table 5) using the V-mSELC model are shown in Table 6.

Clear human error-inducing factors were extracted by analyzing the relationship of the constituent elements. It was confirmed that even if there were an equal knowledge relationship between the specially added liveware and the parties, the same result as in the case of the general precedent would be obtained.

While the V-mSELC model cannot be considered a perfect analytical model for human error analysis because of the small number of cases examined, it was constructed with the aim of providing one possible analytical model to identify human error when incorrect cost estimation occurs. Regarding incorrect cost estimation in general, the authors believe that local governments should use the V-mSELC model or an appropriate alternative scientific method to analyze human errors.

Table 5: A Virtual Pattern Based on a Case of Incorrect Cost Estimation in a Certain City

Incident	Relationships between Components	Factors	Measures
Staff (Verification) is very busy and it takes time to conduct the verification. There is a tendency for few incorrect cost estimations to be caused by the unit price. Therefore, Staff (Verification) decided to omit detailed verification. However, Staff (Cost estimation) used the unit price of the last fiscal year, which caused the incorrect cost estimation.	Relationship between C and V	Staff (Cost estimation) did not check whether the inspection could be omitted if there was not adequate time.	Check whether verification items can be omitted.
	Relationship between C and S	It was not known that it was not good to hear the arguments of Staff (Verification).	Create manuals for verification.
	Relationship between C and E	When Staff (Verification) was busy, Staff (Cost estimation) was under pressure	When verifying in a short time, adjust densely. In some cases, change to other Staff.
	Relationship between C and L	Staff (Cost estimation) did not check the details on how to respond when Staff (Verification) was busy.	Create manuals for unusual cases.
	Relationship between C and m	The process of maintaining the manuals were ineffective	Clearly inform staff about the prepared manuals.

Table 6: Relationships between Components and Error-Inducing Factors

Relationships between Components	Error-Inducing Factors
Relationship between C and V	Work of both Staff (Cost estimation) and Staff (Verification) was inadequate.
Relationship between C and L	
Relationship between C and S	Manual was incomplete.
Relationship between C and m	
Relationship between C and E	Staff (Cost estimation) was in an environment where time and human pressures were prevalent.

APPLIED ADAPTATION OF THE V-mSELC MODEL TO HUMAN RESOURCE DEVELOPMENT

Human error analysis models have been used in many industries when human error occurs. However, the authors found no evidence of such models being used for human resource development. They believe that the V-mSELC model can be effective as a means of developing young staff. For example, a young staff member is more likely to contemplate the risk of a miscalculation when using the V-mSELC model. In order to avoid incorrect cost estimates owing to the combination of C and V, the correspondence of the constituent elements m, S, E, and L can be studied. By performing simulation exercises, even young staff with little experience in cost estimation can develop a viewpoint that allows them to see things objectively.

Table 7 presents an example of human resource development for young staff both using and without using the V-mSELC model for training. By using the V-mSELC model, the authors believe that it is possible to eliminate many of the cost estimation weaknesses of young staff. They also believe that the V-mSELC model is effective as a human resource development tool because it allows the clear visualization of error causes and countermeasures. In addition, the importance of visualization as an effective tool in human resource development is emphasized in the studies12),13). This type of human resource development is effective not only for young staff but also for those who are above the level of the chief clerk and who are required to manage their subordinates.

Finally, another system that the first author created has been highlighted in the studies14) pointing to the importance of human resource development.

Table 7: Example of Human Resource Development for Young Staff when using and when not using the V-mSELC Model

	When not using the V-mSELC model	When using the V-mSELC model
Physical Features	It is difficult to extract incorrect causes and prevention measures because experience with cost estimation is quite limited.	It is easy to extract incorrect causes and prevention measures because the components are given and visualized.
Psychological Features	It is difficult to determine the causes and measures for incorrect cost estimation, so young staff feel uncomfortable with cost estimation.	It is easy to understand through visualization, so young staff can feel comfortable with cost estimation.

CONCLUSIONS

The authors offer the following three conclusions:

- Based on the theory of Heinrich's Law, the authors believe that when dealing with incorrect cost estimation, it is necessary to investigate not only the projects that caused the incorrect cost estimation but also those that are currently being estimated. This makes it possible to prevent further damage caused by the frequent occurrence of incorrect cost estimation.
- When incorrect cost estimation occurs, it is necessary to properly analyze the cause and develop an appropriate response by using the proposed V-mSELC model.
- The V-mSELC model is effective not only to analyze human error but also to develop human resources.
- Finally, this paper is the result of research based on the ideas of the first author and does not stem from the idea of the local government for which the first author works.

REFERENCES

1. *Nikkei Construction: Actual situation of frequent occurrence of the incorrect cost estimation, Nikkei Business Publications, No.501, pp.37-40,2010.*
2. *2)Nikkei Construction:The incorrect cost estimation does not disappear, Nikkei Business Publications, No.572, pp.44-47, 2013.*
3. *Nikkei Construction: Pitfalls of the cost estimation, Nikkei Business Publications, 2013.*
4. *Komatsubara, Akinori.: Human Error (second edition), Maruzen Publishing, 2008.*
5. *5)Ohzeki, Chikashi.: All of the safety management of the new era, Japan Industrial Safety and Health Association, 2014.*
6. *6)Kawano, Ryutaro.: Idea of human error reduction technique・procedure of error proof, The Society for Industrial Plant Human Factors of Japan, Vol. 4, No. 2, pp.121-130,1999.*
7. *7)Miyachi, Yumeko., Takada, Noboru., Matsumoto, Jun. :Efforts for Human Factor Analysis in Space Development・Efforts to Reduce Defects Due to Human Error (Part 1), 13th Reliability Symposium, Reliability Engineering Association of Japan, pp.7-10, 2000.*
8. *8)Japan Aerospace Exploration Agency: Human Factor Analysis Handbook, NASDA-HDBK-10, 2000.*

9. *9)Miyachi, Yumeko.: The point of human factor theory and model practical uses, Reliability Engineering Association of Japan, Vol.31, No.8, pp.603-605, 2009.*
10. *10)Kawano, Ryutaro. :Human error in medical treatment, Igaku-Shoin,2014.*
11. *Kawano, Ryutaro.: Human Factors Approach to Medical Safety, Japanese Standards Association, 2010.*
12. *12)Ishikawa, Hiroshi.: Howto visualize human resources development･The key to getting ahead of the competition,Kadokawa Corporation, 2010.*
13. *Shoko Research Institute:Human resources strategy for small and medium-sized manufacturing industry, pp. 1-35, 2009.*
14. *Nikkei Construction: Mechanism to prevent mistakes young people, Nikkei Business Publications, No. 706, pp.44-45, 2019.*