Perceptual Congruence and Systems Development Cost Estimation

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Information systems cost estimating is an important concern for information resource management. Information systems cost estimators and non–estimators (those IS professionals not responsible for cost estimating) have different roles, responsibilities, and objectives. They might consequently be expected to have different perceptions of the estimating process. Previous research has shown that perceptual congruence— the degree to which individuals view matters similarly — is associated with favorable organizational consequences. A study of information systems cost estimators and non–estimators at 112 organizations compared and contrasted their perceptions of the cost estimating process and its success. Estimators and non–estimators did not differ substantially in their views of the uses of the estimate, the basis for estimating, the influences on the estimate, and management practices for estimating. They did differ in their perceptions of the importance of the estimate, their satisfaction with the estimating process, their estimating accuracy, and the causes of inaccurate estimates. The similarities and differences provide implications for researchers and information resource managers.

Accurate software development cost estimating is very important. Underestimated costs may convince management to develop new systems that later overrun their budgets and fail to achieve their expected payoff. Many worthwhile projects waste the resources invested in them by being canceled because of cost overruns due to poor estimates (Vacca, 1991). In fact, projects that merely begin to overrun may be canceled before completion. Overruns can thus reduce information resource management's credibility and discourage future user cooperation.

Overestimated costs may convince management not to develop potentially beneficial systems. Management generally declines to approve a project with unrealistically high estimates and thus loses its potential benefits (Emery, 1971; King and Schrems, 1978). Hence, both underestimates and overestimates can have a significant, deleterious impact (Tate and Verner, 1990) and cause lost strategic opportunities (Benjamin, Rockart, Scott Morton, and Wyman, 1984).

The impact of inaccurate estimating on business and industry has been enough to cause a discussion of it to reach the popular press. The *Wall Street Journal* (Pope, 1993) reported a Dallas–based consulting firm's estimate that 70% of its clients had major cost overruns on recent downsizing projects. The article added that a doubling of estimated costs was not unusual.

Businessweek (1988) discussed several information systems development calamities. As an example, an insurance system initially estimated at $8 million was reestimated at $100 million during development. The *Businessweek* article also reported a consulting firm's survey in which 35% of its largest clients admitted major cost overruns. Although one may question the accuracy of reports in the popular press, the problem of inaccurate estimates has clearly produced widespread attention.

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Researchers have identified many potential explanations for this inaccuracy (Brooks, 1978). They have further suggested that conflict between the participants in information systems development may exacerbate this situation (Lederer, Mirani, Neo, Pollard, Prasad, and Ramamurthy, 1990). For example, those responsible for producing estimates and those responsible for carrying them out may have different objectives and perceptions of the estimating process.

This paper describes a study of cost estimating as reported by 112 information systems development project estimators and non–estimators (those IS professionals who are not responsible for cost estimating). The study sought to better understand the perceptions of these two parties. Doing so might suggest actions for improving the accuracy of cost estimates and the management of information resources.

Background

Overview of Estimating Research

Prior research on information systems development cost estimating has largely concentrated on the study of estimating techniques. Some of this research has identified elements believed to affect information systems development and necessary to consider while cost estimating (Benbasat and Vessey, 1980; Boehm, 1984; Boehm and Papaccio, 1986; Mohanty, 1981; Subramanian and Breslawski, 1993). These diverse elements include system size and complexity, personnel capabilities and experience, hardware constraints, the use of modern software tools and practices, users' understanding of information systems technology, the volatility of their requirements, the site, and many others.

Most techniques are based on one or more such elements (Conte, Dunsmore and Shen, 1986). The estimator quantifies each based on historical data about past development projects or on intuition and experience (Aron, 1976; Mohanty, 1981). Different methods may define the same factors in different ways. For example, many methods operationalize system size in terms of the projected number of lines of executable code in the proposed system (Boehm, 1984; Conte *et al.*, 1986; Freiman and Park, 1979; Herd, Postal, Russell, and Stuart, 1977; Jensen, 1983; Nelson, 1966; Putnam, 1978; Walston and Felix, 1977; Wolverton, 1974) whereas other methods use the number of functions, modules, or program features in the system (Albrecht, 1979; Demarco, 1984; Donelson, 1976; Halstead, 1977; Jones, 1986; McCabe, 1976).

The algorithmic methods use these quantified elements to produce an estimate of the proposed system's cost. These methods vary widely in mathematical sophistication. Some use simple arithmetic formulas based on such summary statistics as means and standard deviations (Donelson, 1976) while others employ regression models (Walston and Felix, 1977) and differential equations (Putnam, 1978).

Types of Cost Estimating Research

A wide variety of types of research has appeared on cost estimating. Some researchers have used experiments to predict the cost of projects using different algorithmic techniques (Banker and Kemerer, 1989; Kusters, van Genuchten, and Heemstra, 1990; Kemerer, 1987; Kitchenham and Taylor, 1985; Miyazaki and Mori, 1985). One study evaluated the accuracy of four algorithmic methods by predicting the durations of already completed projects (Kemerer, 1987). However, it found considerable inaccuracy with error rates averaging from 85% to 772%.

In a related study, experts estimated these same projects without using formal algorithmic techniques and generally performed better than the models in the original study although mean error rates ranged from 32% to 1107% (Vicinanza, Mukhopadhyay and Prietula, 1991). A third study (using different projects) found error rates averaging 166% (Miyazaki and Mori, 1985). A fourth study (again with different projects) found similarly high error rates (Martin, 1988).

However, the projects were complete and the subjects in the studies had full knowledge of their scope at the time of estimating (knowledge generally available only in laboratory settings). Kemerer (1987) has speculated that the techniques would be even more inaccurate if the scopes were initially unknown. In any case, besides illustrating cost estimating research, these experiments confirm the inaccuracy of the estimating process.

In addition to experimental research, simulation research has considered the relationship between project management decisions on cost estimating and project completion costs (Abdel–Hamid and Madnick, 1987). In other research, the developers of methods have described their own technique and reported their own assessment of its accuracy (Donelson, 1976; Jensen, 1983; Putnam, 1978; Walston and Felix, 1977; Wolverton, 1974). In still other examples of action–oriented research, authors have used their own personal experiences to write prescriptive articles (Boehm, 1981; Demarco, 1982).

A final type of research is a case study. One such study described the cost estimating practices at a *Fortune* 200 organization's largest division (Lederer *et al.*, 1990). It distinguished the roles of systems professionals responsible for producing estimates from those responsible for implementing the systems within those estimates. It identified possible organizational pressures on the cost estimating process resulting from conflicting objectives held by those participants. For example, estimators may be very susceptible to management pressure to provide relatively low estimates so predicted costs meet budgetary constraints and projects obtain approval. On the other hand, non–estimators may prefer estimates padded sufficiently that they will not be exceeded.

Perceptual Congruence and Cost Estimating

Such different responsibilities, roles, and objectives can promote different perceptions (Schnake, Dumler, Cochran, and Barnett, 1990; Turban and Jones, 1988). Research has shown that differing job characteristics elicit a greater range of perceptions (O'Reilly, Parlette, and Bloom, 1980).

Still, evidence suggests that greater perceptual congruence —the degree to which individuals view matters similarly — has positive consequences in an organization (Wexley and Palukos, 1983). Conversely, different perceptions may be problematic. For example, the inability to agree on the estimating process might make it more difficult for estimators and non–estimators to produce estimates that are met. In fact, research has shown that the less the estimator participates in the final development of an organization's system, the less accurate the organization's estimates generally are (Lederer and Prasad, 1992).

In a similar vein, differences between users and systems professionals can delay systems development (Trip, 1991). Moreover, concerns about disagreement are consistent with the observations of the advocates of total quality management: that barriers between workers with different responsibilities can obstruct teamwork and reduce productivity (Deming, 1986).

This research seeks to determine if perceptual congruence among estimators and non–estimators exists in the cost estimating process. It examines various characteristics of cost estimating as suggested by the research described above. These characteristics are the importance of estimating, the accuracy of the estimate, satisfaction with the estimating process, the uses of the cost estimate, the basis of the estimating process, influences on the estimate, management practices followed during the estimating and implementing process, and the causes of inaccurate estimates as perceived by estimators and non–estimators.

If incongruent perceptions exist, then perhaps understanding and reducing them might facilitate the management of the estimating process and produce more accurate estimates. On the other hand, if perceptions are congruent, then other avenues for research might prove more fruitful in improving the management of the estimating process to produce more accurate estimates.

Methodology

The authors developed a questionnaire based on the software development cost estimation literature described above to determine whether estimators and non–estimators have congruent perceptions about cost estimating. It contained general questions about the importance of cost estimating, the subjects' satisfaction with the process, and the accuracy of the process. It also contained a list of uses of the cost estimate, basis of the estimating process, factors influencing the estimate, management practices, and causes of inaccurate estimates. Subjects used five–point Likert–type scales to identify:

- the importance of the estimate
- their satisfaction with the process
- the importance of each use in preparing a cost estimate
- the extent to which each basis was used in the estimating process
- the extent of the influence of each factor on the estimate and
- the extent to which each cause was responsible for inaccurate estimates.

The questionnaire asked for the percentage of large project overruns at their organization and for the percentage of projects that followed each of several management practices. A set of demographic questions also appeared in the instrument.

Subjects were asked to answer the questions in terms of what their organization defined as "large projects" to prevent them from considering trivial tasks routinely handled without formal estimating. This is because some companies – such as the one in the case study described above—consider large projects to be those estimated to exceed an arbitrary figure such as $50,000.

Subjects were permitted to augment the lists of items. For example, they could add a potential influence or cause if it was not identified in the instrument.

After a pilot test with four information systems managers and analysts followed by a revision to improve the questionnaire's clarity, the authors mailed it to 400 randomly selected members of a large, nationwide association of information systems managers and analysts. A second mailing to non-respondents yielded a total of 116 responses.

The researchers eliminated a manager of telecommunications, director of office automation, records manager and EDP auditor since they may have lacked knowledge of estimating in their firms. All of the remaining 112 participate in the development of estimates, their approval, or system development based on them. They were thus deemed knowledgeable about the questions in this study and are appropriate participants in it. It should be noted nevertheless that their responses represent the perceptions of information systems managers and analysts and these could differ considerably from those of users.

Results

Demographics

Of the 112 subjects, 71 were responsible for estimating as well as other systems management, analysis, design, and database activities. Forty–one were not responsible for estimating but did perform other systems analysis, design, and database functions. This research designated the former as estimators and the latter as non–estimators.

The subjects were a well-educated group where 87% possessed at least a 4 year college degree and 33% had at least a masters degree. They supervised an average of 12 employees

Industry	Percent
Manufacturing	33%
Insurance	17%
Banking and finance	9%
Government	5%
Utilities	5%
Retail	5%
Education	4%
Systems consulting	8%
Other	14%

Table 1: Respondents' Industries

and had 14 years of experience in information systems with eight at their current firm. On that basis, they appeared responsible, educated, and experienced professionals familiar with their current firm.

The firms varied in size and industry. Their annual sales averaged almost $2 billion. They averaged 10,797 employees while the mean number of employees in their information systems departments was 478. Annual information systems department budgets averaged $28 million. No two subjects came from the same firm. Table 1 shows the firms' industries. The sample represents a wide variety of industries and sizes. The results of the study are probably fairly generalizable.

Findings of Differences between Estimators and Non–estimators

Although both estimators and non–estimators viewed the estimate as important, estimators perceived it as more important. On a 1 to 5 scale where 1 was very unimportant and 5 was very important, estimators rated it as 4.32 while non–estimators rated it as 3.92, a difference statistically significant at the .05 level.

Not only did estimators see estimating as more important, they also viewed the estimating process as more satisfactory. On the 1 to 5 scale where 1 was very unsatisfactory and 5 was very satisfactory, estimators rated it at 3.26 while non–estimators rated it at 2.64, a difference statistically significant at the .01 level.

In absolute terms it may be observed that neither estimators nor non–estimators were particularly satisfied with cost estimating in their organization. After all, the means of both groups were fairly close to 3.00, an indifference value representing neither satisfactory nor dissatisfactory.

In addition to being more satisfied with the estimating process, estimators also were aware of relatively fewer cost overruns in their organizations than were non–estimators. Non–estimators indicated that 72.3% of all large projects overrun their estimates while estimators believed that 58.6% did, a difference statistically significant at the .05 level of confidence.

On the other hand, estimators and non–estimators revealed virtually no significant differences with regard to the uses of the cost estimate, the potential bases of the estimating process, the possible influences on the estimate, and the management of the estimating process. Thus Table 2 shows no differences in the importance of the uses of the estimate. Table 3 shows no differences in the extent to which various bases of estimating are used. Among 20 items tested, Table 4 shows one significant difference at the .05 level in the extent to which various parameters influence the estimate. However, this item (namely, the size of the system in number of lines of code) is the least important influence for estimators and the second least important one for non–estimators. Hence, little consequence is attributed to it or the influences in general.

Finally, Table 5 shows no statistically significant differences in the percentage of projects in which estimators and non–estimators felt that various management practices had been carried out. (These tables are sequenced by the magnitude of the difference between the non–estimators' and esti-

Use of Estimate	Importance of Use Rating (1-5 scale) Estimators	Non–estimators
To schedule projects	3.63	3.70
To select proposed projects for implementation	3.68	3.72
To quote the charges to users for projects	3.51	3.49
To staff projects	3.82	3.70
To audit project success	3.28	3.11
To control or monitor project implementation	3.80	3.58
To evaluate project estimators	2.99	2.74
To evaluate project developers	3.18	2.85

Table 2: The Uses of the Cost Estimate

Basis	Extensiveness of Use Rating (1 – 5 scale) Estimators	Non–estimators
A complex statistical formula (such as multiple regression, differential equations, etc.)	1.41	1.62
A software package for estimating	1.73	1.92
Guessing	2.71	2.85
Comparison to similar, past projects based on documented facts	3.40	3.43
Established standards (such as averages, standard deviations, etc.)	2.32	2.34
Intuition	3.39	3.37
A simple arithmetic formula (such as summing task durations)	3.12	3.05

Table 3: Bases of the Estimating Process

Influence	Extent of Influence Rating (1 – 5 scale)	
	Estimators	Non–estimators
The size of the system in number of lines of code	2.03	2.58*
The availability of software productivity tools (such as screen generators or code generators)	3.03	3.33
The development mode (batch or on-line)	3.00	3.27
The availability of testing aids	2.74	3.00
The number of project team members	3.21	3.45
The extent of programming or documentation standards	3.07	3.23
The complexity of the proposed application system	4.21	4.35
The complexity of the programs in the system	3.87	4.00
The capabilities of the project team members	3.59	3.70
The data management system (flat files, database, etc.)	3.35	3.46
The size of the system in number of functions	3.73	3.83
The project team's experience with the application	3.48	3.50
The particular programming language used	3.06	3.07
Computer memory and secondary storage constraints	2.66	2.64
The size of the system in number of programs	3.63	3.56
The project team's experience with the hardware	3.10	2.95
The project team's experience with the programming language	3.49	3.31
The required integration with existing systems	4.27	4.05
The anticipated frequency or extent of potential changes in requirements	3.56	3.25
The availability of test time on the hardware	2.81	2.46

* $p \leq .05$

Table 4: Influences on the Estimate

Practice	Extent of Practice By Percent Projects	
	Estimators	Non–estimators
Identity of the estimator		
Same systems analysts and programmers who eventually develop system also prepared initial cost estimate	59.93	64.03
Approval of the estimate		
User management sign-off on a cost estimate	58.48	61.15
Information systems management carefully study and approval of cost estimate	61.97	58.88
Monitoring of the estimate		
Evaluation of the development process by independent auditors	6.45	10.56
Formal monitoring of the project progress by comparing it to its project plan	73.77	64.07
Use of the estimate to evaluate personnel		
Evaluation of completion within estimate in information systems management's performance review	59.10	43.06
Evaluation of completion within estimate in user management's performance review	27.22	23.32
Evaluation of completion within the estimate in user liaisons' performance review	21.54	15.58
Evaluation of the accuracy of the estimate in the performance review of information system department estimators	45.59	33.04
Evaluation of the completion within the estimate included in the performance review of systems developers	52.78	39.50
Timing of the estimate		
Cost estimate revised to accompany changes in user requirements	59.30	68.51
Preparation or revision of a cost estimate during feasibility study	61.20	66.89
Preparation or revision of a cost estimate during systems analysis stage	49.89	53.95
Preparation or revision of a cost estimate during systems design stage	47.35	47.50
Preparation of a cost estimate during an initial project proposal stage	79.16	72.70

Table 5: Management Practices

mators' mean ratings. That is, those where the non–estimators' mean most exceeded the estimators' appear higher in the tables.)

However, estimators and non–estimators did appear to differ in their views of the causes of inaccurate estimates. Non–estimators rated 20 of the 24 items in Table 6 as higher than did estimators. Generally, the differences in the other tables were more equally distributed.

Also, differences on five items – namely, lack of project control comparing estimates and actuals, red tape, performance reviews that ignored whether estimates were met, overlooked tasks, and the lack of the setting and review of standard durations – appeared substantial. In fact, the first four of these items differed at the .01 level and the fifth differed at the .05 level.[1]

Analysis of Perceptions about Causes

While these differences may be interesting, the combined meaning of various and different items can be somewhat difficult to interpret (Kerlinger, 1986). Moreover, analysis at the item level can hide broad themes that may be buried in the data. Hence, in addition to analyzing at the item level, the authors factor analyzed the causes to see if any reasonable, broad themes emerged to further explain the different perceptions of cost estimators and non–estimators. Because the causes provided more interesting differences, their factor analysis alone is discussed.[2]

The authors chose an exploratory factor analysis rather than a confirmatory factor analysis because little theoretical basis predicts the relationship between the potential causes and particular factors. A principal component factor analysis yielded four factors. The loadings resulting from a varimax rotation were evaluated on two criteria: significance of items loadings and simplicity of factor structure. According to the first criterion, only those with loadings of at least a minimum value should be retained (Churchill, 1987). According to the second criterion, each factor should have a set of items with high loadings for that factor and low loadings for the other factors (Kim and Mueller, 1978).

As a result of these criteria, six items were dropped. Four of these items did not load at .50 or above on any factor and two of them loaded above .50 on more than one item. In addition, two more items loaded on single–item factors with low eigenvalues as shown on a scree plot and they were also dropped (Cattell, 1966). The resulting factor structure is shown in Table 7.

Causes	Extent of Responsibility Mean Rating (1 – 5 scale) Estimators	Non–estimators
Lack of project control comparing estimates and actuals	2.44	3.30**
Red tape	2.53	3.29**
Performance reviews don't consider whether estimates were met	2.22	2.95**
Overlooked tasks	3.38	3.95**
Lack of setting and review of standard durations for use in estimating	2.63	3.19*
Lack of an adequate methodology or guidelines for estimating	2.93	3.37
Lack of careful examination of the estimate by IS Department management	2.46	2.88
Lack of coordination of systems development, technical services, operations, data administration, etc. functions during development	2.92	3.33
Inability to tell where past estimates failed	2.57	2.97
Changes in Information Systems Department personnel	2.81	3.17
Lack of historical data regarding past estimates and actuals	2.71	3.05
Insufficient user-analyst communication and understanding	3.25	3.49
Reduction of project scope or quality to stay within estimate resulting in extra work later	2.66	2.87
Users' lack of understanding of their own requirements	3.54	3.73
Removal of padding from the estimate by management	2.23	2.42
Inability to anticipate skills of project team members	2.75	2.92
Poor or imprecise problem definition	3.23	3.39
Insufficient analysis when developing estimate	3.17	3.28
Lack of participation in estimating by the systems analysts and programmers who ultimately develop the system	2.58	2.63
Lack of diligence by systems analysts and programmers	2.32	2.37
Pressures from managers, users or others to increase or reduce the estimate	2.84	2.80
Insufficient time for testing	2.89	2.80
Users' lack of data processing understanding	2.80	2.70
Frequent requests for changes by users	4.01	3.68

* $p \leq .05$ ** $p \leq .01$

Table 6: Causes by Responsibility for Inaccurate Estimates

Loadings CONSTRUCT LABEL Item	F1	F2	F3	F4	F5*	F6*	Commu- nalities
F1: METHODOLOGY (α=.80)							
Lack of an adequate methodology or guidlines for estimating	.79	.07	-.11	.08	.01	-.10	.65
Inability to tell where past estimates failed	.77	.18	-.05	.26	-.02	.07	.70
Lack of setting and review of standard durations for use in estimating	.63	.23	.01	.47	.08	-.04	.68
Insufficient analysis when developing estimate	.63	-.08	.26	.07	.22	-.13	.54
*Lack of historical data regarding past estimates and actuals	.52	.28	.04	.51	-.20	.09	.66
Lack of coordination of systems development, technical services, operations, data administration, etc. functions during development	.52	.31	.04	.09	.44	-.15	.59
*Insufficient time for testing	.43	.20	.41	-.10	.22	.36	.58
F2: POLITICS (α=.78)							
Pressures from managers, users or others to increase or increase or reduce the estimate	.13	.85	.11	.02	-.09	.11	.77
Reduction of project scope or quality to stay within estimate resulting in extra work later	.14	.76	.06	.02	.23	.02	.66
Removal of padding from the estimate by management	.09	.69	.14	.27	.04	-.14	.60
Red tape	-.03	.56	.00	.23	.42	.17	.58
*Lack of participation in estimating by the systems analysts and programmers who ultimately develop the system	.10	.43	.12	.39	.21	.08	.41
F3: USER COMMUNICATION (α=.77)							
Users' lack of understanding of their own requirements	-.01	.19	.79	.01	.01	-.05	.66
Frequent requests for changes by users	-.05	.01	.75	.10	-.16	.07	.60
Users' lack of data processing understanding	-.09	.17	.74	.00	.06	-.02	.59
Poor or imprecise problem definition	.37	-.18	.64	.03	.37	-.08	.72
*Insufficient user-analyst communication and understanding	.20	.07	.43	.07	.31	.38	.48
F4: MANAGEMENT CONTROL (α=.76)							
Performance reviews don't consider whether estimates were met	.13	.20	.00	.80	.09	-.10	.72
Lack of project control comparing estimates and actuals	.44	-.10	-.12	.64	.13	.00	.65
Lack of careful examination of the estimate by Information Systems Department management	.26	.42	.19	.57	-.01	-.23	.65
*Changes in Information Systems Department personnel	-.04	.20	.14	.52	.16	.50	.60
F5: NO CONSTRUCT LABEL							
*Inability to anticipate skills of project team members	.08	.37	-.03	.11	.71	-.08	.67
*Lack of diligence by systems analysts and programmers	.13	-.23	.32	.41	.42	.14	.54
F6: NO CONSTRUCT LABEL							
*Overlooked tasks	.35	.07	.14	.21	.28	-.69	.75
Eigenvalue	6.45	2.65	2.27	1.41	1.17	1.10	
Percentage of Total Variance Explained	26.9	11.0	9.5	5.9	4.9	4.6	
Cumulative Variance Explained	26.9	37.9	47.4	53.3	58.2	62.8	

* - items/factors not selected

Table 7: Factor Analysis Results

The authors designated the names in Table 7. Factor 1, Methodology, generally contains items that focus on the procedures for establishing the estimate including tuning the standards on which it is based. Factor 2, Politics, contained items dealing with pressures to manipulate the project to stay within the estimate. Factor 3, User Communication, contained items reflecting the shortcomings of users in their work with information systems analysts; the factor is so named because these shortcomings – such as imprecise problem definition, users' lack of understanding of their requirements, their frequent change requests, and their lack of information systems understanding – are often attributed to ineffective communications. Factor 4, Management Control, contained items dealing with control issues such as performance reviews, the comparison of estimates to actuals, and management review of the estimate. The factors are thus conceptually quite reasonable.

The authors also conducted a reliability assessment using Cronbach's alpha coefficient as an indicator of the internal consistency of the items in a factor. As seen in Table 7, Cronbach's alpha substantially exceeded the coefficient alpha threshold level of .60 for exploratory research for each factor (Nunnally, 1978). The coefficients in Table 7 confirm that the items are internally related to each other in a manner expected.

For each subject, a factor score was computed as the average of the causes within each factor. A variety of ways of computing such factor scores exist. Methods vary on whether they use all or selected items as well as on whether they are unweighted or weighted; in fact, many different weighting schemes are possible (Kerlinger, 1986; Nunnally, 1978). In this study, factors were not weighted because the factor analysis was used to identify broad themes based on items that hang well together rather than the contribution of each item to each factor.

This factor score indicated the extent to which each subject perceived the constituent items collectively responsible for inaccurate estimates. Table 8 shows the means for each factor score for estimators and non–estimators. It also shows those for the items that comprise each factor.

T–tests indicate statistically significant differences between mean scores of the estimators and non–estimators for Management Control and Methodology. The non–estimators' mean rating for Management Control at 3.04 is higher than the estimators' 2.35 at the .01 level of significance. The non–estimators' mean rating of 3.24 for Methodology is higher than the estimators' mean rating of 2.86 at the .05 level of significance.[3]

Factor/Items	Mean Ratings (1-5 scale) Estimators	Non-estimators
Management Control	2.35	3.04**
Lack of project control comparing estimates and actuals	2.44	3.30**
Performance reviews don't consider whether estimates were met	2.22	2.95**
Lack of careful examination of the estimate by Information Systems Department management	2.46	2.88
Methodology	2.86	3.24*
Lack of setting and review of standard durations for use in estimating	2.63	3.19*
Lack of an adequate methodology or guidelines for estimating	2.93	3.37
Lack of coordination of systems development, technical services, operations, data administration, etc. functions during development	2.92	3.33
Inability to tell where past estimates failed	2.57	2.97
Insufficient analysis when developing estimate	3.17	3.28
Politics	2.57	2.88
Red tape	2.53	3.29**
Reduction of project scope or quality to stay within estimate resulting in extra work later	2.66	2.87
Removal of padding from the estimate by management	2.23	2.42
Pressures from managers, users or others to increase or reduce the estimate	2.84	2.80
User Communication	3.39	3.38
Users' lack of understanding of their own requirements	3.54	3.73
Poor or imprecise problem definition	3.23	3.39
Users' lack of data processing understanding	2.80	2.70
Frequent requests for changes by users	4.01	3.68

* $P \leq .05$ ** $P \leq .01$

Table 8: Causes by Responsibility for Inaccurate Estimates by Factor

Discussion

This research found examples of both perceptual congruence and incongruence.

Perceptual Congruence

Estimators' and non–estimators' perceptions often coincide. The absence of differences on the uses of the cost estimate, the potential bases of the estimating process, the possible influences on the estimate, and the management of the estimating process suggests that estimators and non–estimators may have a reasonably consistent understanding of how estimating is done.

They further agree that problems with User Communication are the most serious cause of inaccuracy (as seen in Table 8). For both groups, its mean rating was highest. For non–estimators User Communication (at 3.38) was higher than Politics (2.88) at the .01 level and higher than Management Control (3.04) at the .05 level. For estimators, it was higher than all three other factors at the .01 level of significance. In effect, both non–estimators and estimators perceive that the fickle user's lack of computer savvy – which may be beyond IS department control – is the major reason for inaccurate cost estimates. (The soundness of this perception is certainly open to question.)

Perceptual Incongruence

On the other hand, estimators indicated that the estimating process was more important than non–estimators did, that they were more satisfied with it, and that they were aware of relatively fewer inaccurate estimates. Potential explanations exist for these different perceptions.

Perhaps non–estimators are often more actively involved with a project when its inaccuracy becomes evident and thus they perceive more inaccuracy and express less satisfaction. Estimators may be less aware of estimating problems because they have moved on to estimating new projects and have less detailed knowledge on the completion of past projects. Perhaps estimators' responses reflect greater feelings of self–importance or of defensiveness because the responsibility for producing the estimate is theirs. Regardless of the explanation, estimators are clearly more sanguine about the estimating process.

In addition to incongruence about satisfaction, importance and accuracy, non–estimators perceive three factors – Management Control, Methodology, and Politics – as more serious causes of inaccurate estimates with two of them statistically significantly so. Considered together, these differences again may suggest that non–estimators are more involved with a project when its inaccuracy becomes apparent or that estimators may be less aware of estimating problems because they have proceeded to new projects.

Regardless of which reason is correct, factor differences may also be interesting when considered separately. For example, non–estimators view the lack of Management Control as a more serious cause of inaccuracy than do estimators ($p \leq .01$). Non–estimators express more concern that management does not participate in the preparation of the estimate, does not use it in the performance review of estimators or non–estimators, and does not monitor estimating inaccuracy. Per-

Key Findings

- Estimators view the estimate as more important than do non–estimators. ($p \leq .05$)
- Estimators view estimating as more satisfactory than do non–estimators. ($p \leq .01$)
- Non–estimators view Management Control ($p \leq .01$) and Methodology ($p \leq .05$) as more severe causes of inaccurate estimates than do estimators.
- Both estimators and Non–estimators view User Communication as a more serious cause of inaccurate estimates than Management Control, Methodology, and Politics. (various values of p)

Key Implications For Researchers

- Investigate the reason for the differing perceptions
- Determine if greater inaccuracy occurs when incongruent perceptions are more prevalent
- Replicate this study with a different sample
- Study the differing perceptions of managers, users, and other computer professionals in other management of information resources activities

Key Implications For Information Resource Managers

- Involve all IS professionals in the estimation process
- Define better who has responsibility for inaccurate estimates
- Better inform estimators on the outcomes of the projects which they have estimated
- Provide non–estimators with a better understanding about how estimators produced the estimate and about the design specifications for which the project was estimated.
- Facilitate agreement among project team members as to how accurate estimates actually are and why they are inaccurate
- Consider team building, role reversal, and other organizational interventions to produce a shared understanding about cost estimating and the reasons for inaccuracy

Table 9: Four Key Findings and Implications

haps by more often remaining closer to a project when its inaccuracy is discovered, they are more sensitive to a lack of Management Control over the estimating and development process. Perhaps non–estimators believe that estimators have great latitude in producing estimates with which management does not concern itself. Non–estimators may perceive that estimators are relatively free of responsibility for the inaccurate estimates for which they might be eventually asked to answer.

Non–estimators also view the Methodology as a more serious cause than do estimators ($p \leq .05$). Non–estimators perceive that inaccuracy stems more from the lack of standard durations and other weaknesses in their organization's methodology than do estimators. Perhaps non–estimators are less aware of their organization's estimating methodology or estimators are more defensive about the methodology. On the other hand, perhaps their organization lacks a substantive estimating methodology; the importance of the role of intuition and personal memory (as shown in Table 3) suggest this may be the case. (Differences in Politics are not considered because they are not statistically significant.)

Table 9 summarizes the key findings discussed in this section.

Implications

For Researchers

This research sought to determine whether estimators and non–estimators had congruent perceptions about cost estimating. It found some congruent and some incongruent perceptions. In doing so, it provides some implications for further research and for information resource managers. Table 9 summarizes these.

Researchers might investigate the reason for the differing perceptions. While this research identified some incongruent perceptions, the proposed reasons – generally that non–estimators remain closer to a project when inaccuracy is discovered and are less knowledgeable about their organization's estimating methodology – are somewhat speculative. Research might thus further attempt to determine reasons for the differences more conclusively.

Researchers might also attempt to determine if greater inaccuracy occurs when incongruent perceptions are more prevalent. To do so, they would probably use matched pairs of subjects from individual projects in specific organizations. The current research randomly selected subjects in order to control for differences across organizations. Although finding matched pairs of subjects may be more difficult, such an approach might offer different insights.

Additional insights might be gained if researchers focused on estimating accuracy. A major dimension of this research was the causes of inaccuracy. Future research could study the causes of accurate estimates.

In addition, replication of this study with a different sample might be valuable. Subjects in this study were information systems managers and professionals. Perhaps the views of general managers and users would offer a different perspective on perceptual congruence and cost estimating.

Finally for researchers, this investigation considered the potentially differing perceptions of the estimating process. It may be quite reasonable and productive to study the differing perceptions of managers, users, and other computer professionals in other activities related to the management of information resources. Indeed, understanding the differences in perceptions between users and information systems professionals might prove quite helpful to information resource managers.

For Information Resource Managers

This research also has implications for information resource managers who view inaccuracy as a problem to be rectified. Different perceptions of the causes of inaccuracy suggest that it may be worthwhile to attempt to involve all IS professionals in the estimation process. This might reduce these differences.

If that is not possible (and it may often be impossible), different perceptions of the causes of inaccuracy suggest that it may be worthwhile to define better who has responsibility for inaccurate estimates. This research suggests that estimators may feel they are producing accurate estimates which non–estimators are unable to meet. It also suggests that non–estimators may feel that estimates are not accurate and that information resource managers are not particularly concerned about this inaccuracy. Perhaps information resource managers should investigate whether subordinates in their firms share these beliefs. Perhaps they should consider whether or not they hold the estimator or the non–estimator accountable in some well–defined manner for projects which do not meet their estimates. Clearer definitions of responsibility might build commitment and thus improve accuracy.

Different perceptions of satisfaction and the extent of inaccuracy suggest it may be worthwhile to better inform estimators on the outcomes of the projects which they have estimated. It may also be worthwhile to provide non–estimators with a better understanding about how estimators produced the estimate and about the design specifications for which the project was estimated. Perhaps information resource managers should investigate how well estimators understand the outcomes of the projects which they estimated. These managers might also investigate how well non–estimators understand the estimating process.

Finally, it is probably quite valuable to facilitate agreement among project team members as to how accurate estimates actually are and why they are inaccurate. If estimators and non–estimators discussed their disagreement, they could learn more about how to collaborate better. Team building, role reversal, and other organizational interventions are alternatives that can provide a means of producing a shared understanding about cost estimating and the reasons for inaccuracy. Indeed, the fostering of increased collaboration and shared understanding is a goal whose realization would benefit not only information systems developers but also all people everywhere.

Endnotes

[1] T-tests compared these differences. Assuming items were correlated, MANOVA produced a Pillai's F statistic of .88 (p=.533), .83 (p=.578), .99 (p=.487), 0.87 (p=.624), and 1.33 (p=.188) for Tables 2, 3, 4, 5, and 6 respectively. Using this approach, the highest F suggests the greatest differences although they are not statistically significant.

[2] Besides the highest Pillai's F and most significant differences, a factor analysis of the causes had the most interesting and meaningful factors. The paper would also have grown quite long had all five factor analyses been presented and discussed.

[3] Assuming factors were correlated, MANOVA produced a Pillai's F statistic of 3.66 (p=.008) for Table 8.

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