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Decision Support System Impact on Conceptual Cost Estimating and Risk Analysis

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This paper summarizes the findings of a previous research project, which examined the area of decision support as it relates to the generation of real estate conceptual cost estimates (Nobe, 1996). The purpose of this research was to evaluate a prototype development cost estimating decision support system for use in the pre-development planning stage of real estate development. The system evaluated was the Real Estate Development Decision Support System (*REDDS?*), which is currently in the prototype stage of development. The system was tested on a group of real estate development and construction management students at Texas A&M University. It was hypothesized that an interdisciplinary methodology, which utilizes a decision support framework, would facilitate generation of consistent and timely analysis of real estate development cost and associated risk, and elevate the confidence of the user in the estimating decision making process. Test results indicate that the *REDDS?* system does significantly reduce conceptual cost estimating preparation time. However, it was also determined that the *REDDS?* system does not significantly change the confidence of the user in the decision making process. Finally, this research shows that the use of the *REDDS?* system provides a consistent and sophisticated framework for evaluating development cost and risk, which leads to less variation and more accurate estimates.

Key Words: Decision Support System, Conceptual Estimating, Cost Estimating, Risk Analysis, Real Estate Development

Introduction

General Problem

This study deals with decision-making in real estate development with a particular focus on conceptual cost estimating. It is the current investment decision for an uncertain future return, the reconciliation of a project's projected cost with its projected income and corresponding value, which forms the general basis of this research problem. Specifically, the cost side of the development decision equation is the focus of this study. In order to properly frame the problem, it is useful to understand the basics of the real estate development process, the characteristics, which complicate real estate investment decisions, and the market in which these decisions are made.

The real estate development process varies tremendously in the number and exact sequence of steps depending on the scope and nature of the project, but in general the process follows the four stages of pre-development, document development, product development and post development (Sharkawy, 1994). As with the process, the key participants vary, and on occasion take on multiple roles, but typically would include a developer, equity partner(s), and lenders (Sharkawy, 1994). This research will focus on the pre-development stage of the development planning process, and primarily with the developer's investment decision as it relates to the projected cost of the proposed development project. It should be noted, however, that this focus does not preclude the interests of other key participants in the development process, who are equally concerned with making wise investment decisions.

The value of all investments by definition involves the assessment of the present value of the future cash flows (Etter, Summer 1994). Real estate investment, however, has several characteristics, which complicate investment decisions. Three are of particular importance (Etter, 1989) and will be referred to as *inherent* characteristics:

- ***Physical immobility.*** Real estate cannot be easily relocated at some future date; therefore, its value is directly related to the market area in which it is constructed.
- ***Long economic life.*** It takes many years, often decades, to recover the cost of the asset through its ability to generate income.
- ***Large economic outlay.*** Cost of acquisition and/or construction is large, often requiring the use of long-term financing in addition to investor equity.

In addition to these inherent characteristics, investment in real estate is further complicated by the inefficiency of the market in which it operates (Etter, Fall 1994). An investment market is generally classified as inefficient if it possesses one or more of the following:

- ***High transaction cost.*** Investors are charged substantial fees for each individual transaction.
- ***Limited or costly information.*** Information is either difficult to obtain or cannot be obtained without undue cost.
- ***Disagreement on information.*** There is general lack of agreement on what impact this information has on prices.

The inherent characteristics of real estate outlined above are by their very definition unlikely to change. In other words, that's what makes it uniquely *real estate*. The market characteristics, and especially the *information* components, on the other hand, vary considerably, and therefore present an opportunity for research and development.

Importance of the Problem

Framed by real estate's inherent temporal and spatial restraints, initial studies must nevertheless be performed in an inefficient market. It is these studies, which form the basis for investment decisions in the short-run, that become critical to success of the development project in the long run. Despite the long-term ramifications, decisions must be made *now*, with limited, sometimes questionable information. Further complicating the situation is the fact that such decisions are generally based on limited developer resources, including time, capital and manpower. In addition, because of a narrow "window of opportunity", time is of the essence, and the stakes are generally high.

Given this, why do individuals continue to enter this complicated and risky investment environment - and more importantly, why do they do it with limited or no information? The answer, in simple economic terms, is that high risk implies a high market expectation of financial returns (Etter, Summer 1994). Therefore, any methodology, which facilitates information flow and the associated decision analysis, will reduce risk (Etter, 1988) and provide that individual investor a competitive advantage over less informed investors in the same market.

Definitions and Abbreviations

Definitions are provided as a basis of the system language employed in the built environment and decision support-system disciplines. Please note that they are in alphabetical order with no implication of relative importance.

- ***built environment:*** a comprehensive term used to encompass land and real estate development including design, construction, and/or management of existing and/or proposed projects.
- ***decision analysis:*** a rational framework which provides a structure for making multiple-objective decisions under conditions of uncertainty by breaking the problem into manageable parts (Finlay, 1994).
- ***decision support system (DSS):*** "interactive computer-based systems that help decision makers utilize data and models to solve unstructured problems" (Nagel (quoting Gorry and Scott Morton 1971), 1993, p. 145). Figure 1 graphically depicts a generic decision support system.
- ***model:*** a representation of reality or some part of the real world. Models are created to "simplify reality to some level that permits us to think rationally about our problems" (Lifson and Shaifer, Jr., 1982, p. 6).
- ***prototype:*** the first functional pattern of a future product.
- ***system:*** in computer context, refers to the joining of logic and data models (Finlay, 1994).
- ***total development cost:*** The sum of a project's hard cost, soft cost and land cost (Sharkawy, 1992, 1994). Also referred to as development cost.

Problem Statement

The purpose of this study is evaluation of a prototype development cost estimating decision support system named ***REDDS***? for use in the pre-development planning stage of real estate development.

Research Objective

The purpose of a decision support system is to ***facilitate*** cognitively complex tasks (Olson and Courtney, 1992). In this case, the *task* is projecting the total development cost of a real estate project during the pre-development planning stages of property development. As discussed earlier, investment decisions in real estate are *complicated* by the inherent characteristics of real estate as well as the inefficiency of the market in which the decisions are made. *Cognitive* refers to the process of reduction of empirical knowledge and includes both awareness and judgment. In this case, the knowledge being reduced relates to the derivation of project cost as it pertains to land, design, construction, etc. Finally, consistent with the defined purpose of decision support systems, the primary objective of this research project is *facilitation,* which among other things, means assisting the decision maker in generation of consistent and timely analysis of a project's total development cost and associated risk.

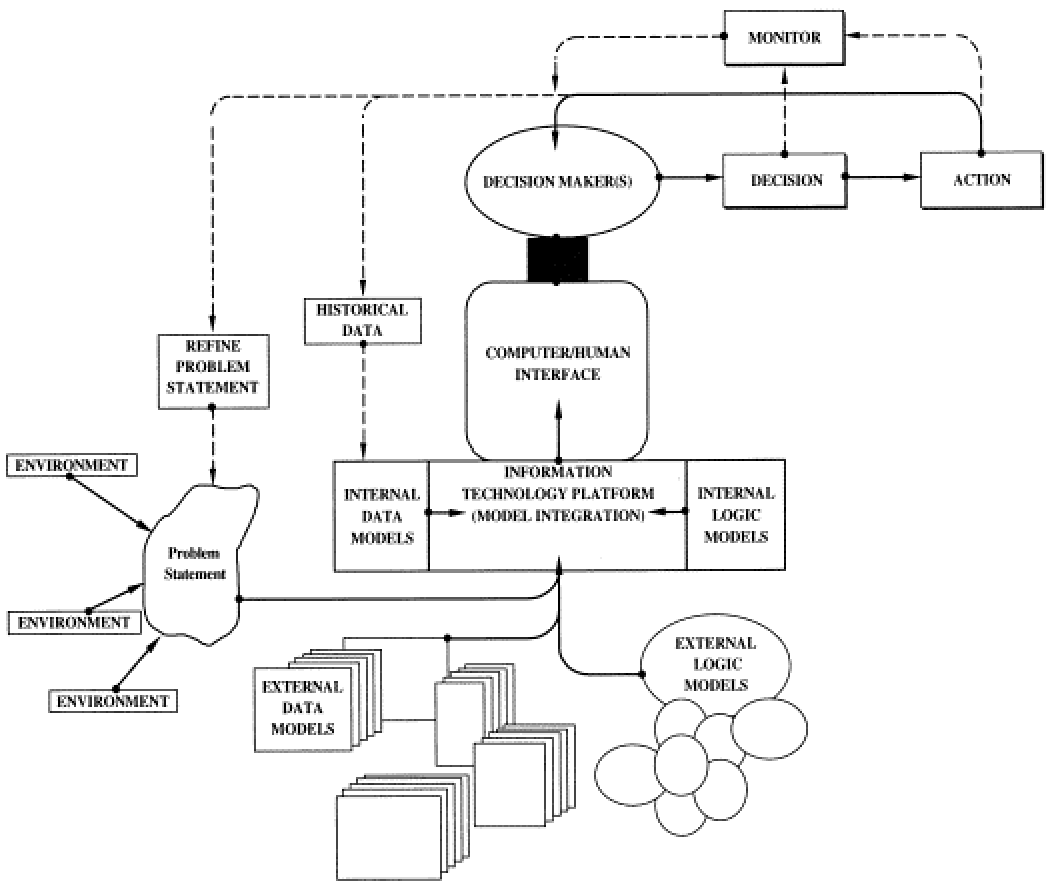

Figure 1. Generic decision support system.

Research Hypotheses

This research tests the *facilitation* objective. To this end, the following hypothesis and sub-hypotheses where tested:

General Hypothesis. Using a decision support system for derivation of total development cost in the pre-development planning stage of real estate development will facilitate the decision-making process.

Hypothesis 1. Cost analysis facilitated by the subject decision support system will take significantly less time to produce.

Hypothesis 2. Cost analysis facilitated by the subject decision support system will elevate the confidence of the user in the decision-making process.
Hypothesis 3. Cost analysis facilitated by the subject decision support system will provide a consistent framework for investigating alternatives, evaluating risk and determining critically sensitive variables.

Anticipated Benefits

The multidisciplinary theoretical base underpinning the built environment is in most cases well established. Likewise, analytical procedures in support of these theories are not only established, but often quite advanced. The data, which is necessary as inputs to these procedures, is abundant and generally readily available. And finally, the recent advances in decision support theory and computer technology are, in most cases, beyond the capabilities of the users. Despite this favorable environment, investment analysis of real estate development remains a segregated, time-consuming and expensive proposition. As Miles and Wurtzebach (1977, p. 338) note: "The complexity of the real property development process … implies the need to develop a computer simulation model designed to aid development period decision makers…" - a specialized framework unique to the development process. This research test just such a model - the ***REDDS***? decision support system prototype which facilitates answering the question; "How much will this project cost and what is the probability that it will cost that much?"

In addition, there is a benefit related to availability as a function of cost. In other words, "good" analysis is not necessarily limited by technological or theoretical restraints - given enough capital and/or time to hire a multitude of experts. Since the process of real estate analysis, and in this case the determination of project cost, is basically the same regardless of the scope of the proposed project (Sharkawy, 1994, and Sharkawy and Nobe, 1995), there are by definition economies of scale realized by those involved in larger projects. In many respects, a thorough analysis represents a fixed cost to the proposed project, and in many instances, one that cannot be overcome by smaller scale projects. "Affordable" analysis will therefore benefit many developers of small/medium-sized projects who until now may not have been able to afford it. In this case, a purely qualitative or intuitive approach would be properly supported by a quantitative decision support system.

The result: time can be spent on analysis, not data gathering and number crunching. Other resources, such as capital, can be spent to investigate the most sensitive variables (components) of the estimate instead of all of them. And finally, more projects can be evaluated, increasing the opportunity of finding a "winner". All this reduces the risk of real estate investment. In addition to the potential benefits for investors (both the developer and the equity investors), the other key participants in the development process will similarly benefit; namely, the short-term and long-term lenders who provide capital, based at least partially on the projected development cost.

Method

The purpose of this section is to provide a detailed description of the methods employed in testing of the Real Estate Decision Support (*REDDS*?) system. This study involved two separate tests. The purpose of the first test was to determine if the decision support system was capable of constantly representing the environment it was intended to model and designed to specifically address *Hypothesis 3*. This portion of the test roughly followed Finlay's (1994) recommended procedure of separately validating the logic and data models. Validation of the logic model included checks on definitions, consistency of variables and consistency of dimensions. As Finlay (1994, p. 210) notes, "validation is a process that should take place throughout the building process". Therefore, while these checks are separately addressed for purposes of this discussion, they where actually conducted simultaneously during the analysis, design and programming stages. As far as the data models are concerned, established models (i.e. historical cost, interest rates and job conditions/compression) were used and accordingly are assumed to be valid. Likewise, logic models included typical processing of data (i.e. linear regression, averaging, and simple algebraic computations). In addition to logic and data models, which were integrated to generate cost estimates, the *REDDS*? system also employed sophisticated economic and statistical models (i.e. probability and breakeven analysis) in the risk assessment portion of the analysis.

The second test was designed to address *Hypotheses 1 and 2*. Because these two hypotheses deal directly with how the DSS interacts with human subjects, evaluation research (Nagel, 1993) utilizing a survey instrument was chosen and incorporated into an untreated control group with a pretest and posttest design (Cook and Campbell, 1979). The target population was future professionals of the built environment. The initial study population was graduate-level students in the Real Estate and Land Development program at Texas A&M University, and it is assumed to have moderate external validity (generalizability). Additional testing for accuracy as discussed in the Hypothesis Three Results section also used undergraduate Construction Science majors from Texas A&M University. Although the students from these two majors don't represent the entire population of future professionals, they are nevertheless expected to enter the built environment on a professional level in the near future. The research construct (Kerlinger, p.27) of *facilitation* is operationalized with the dependent variables of time (*Hypothesis 1*) and confidence (*Hypothesis 2*). Although admittedly underrepresented, which lowers the construct validity (Kerlinger, 1986), the construct is nevertheless considered adequately represented because it is aligned with two universal management objectives (*time* and *quality*).

The second test consisted of two case studies and utilized two randomly selected student groups, one as a control and one as a test group. Random selection consisted of picking every other person seated in a row until the class was approximately evenly divided. An attempt was also made to have roughly the same number of males and females in both groups to eliminate this as a confounding variable. The groups were then directionally tested based on applying and/or removing the treatment of the ***REDDS***? system. Each group was given an identical case study (Case Study I - Mountain Lodge), which required the individual to derive total project development cost and make several assessments of the associated risk. This included a break-even analysis, sensitivity report, confidence probability assessment, and a graphical cost breakdown. Prior to distributing Case I, the entire class was given a short lecture on the fundamentals of conceptual estimating.

Based on dissemination of this information, it was assumed that both groups had knowledge and access to the same logic and data models. Prior to segregating the groups, everyone was informed that upon completion of the assignment, they would be asked to conduct a survey, and that one of the questions would specifically request the exact amount of time spent on the analysis. To increase the probability of receiving accurate information, they were further informed that all responses would be anonymous and separate from any grade they may receive from their regular instructor for completion of the assignment. Following the lecture and division of the class into the two groups, one group was taken to a computer lab and introduced to the ***REDDS***? system and asked to use the system to aid them in completing Test Case I. To assist them in organizing variable input, the ***REDDS***? input sheets were also distributed to this group. The control group conducted a manual estimate and risk analysis.

The following day, after everyone from both groups had turned in their case analysis, the class was surveyed regarding the students' individual decision-making process experience. The survey was conducted in accordance with the Belmont Report and followed Texas A&M protocol for human subjects in research.

A second case (Case II - Housing Development) was then given, and both groups were given access and asked to utilize the ***REDDS***? system; no one preformed a manual analysis. A second survey was then administered and the results statistically analyzed for direction of responses. Due to the small sample size (approximately 5 students per group), the test was pre-determined to have weak statistical conclusion validity, increasing the chance of concluding there is *no-difference* between groups (Type II error) when a difference does exist.

The survey instrument was considered a reliable test device since many of the questions were easily quantifiable (i.e., how many hours did you spend preparing the cost estimate...; how may hours did you spend researching ..., etc.) In addition, for questions which are based on the test-takers' perception (i.e., how confident are you...) a scale similar to that used for instructor evaluations was used since most students are already familiar with this type of rating scale.

Results

As described earlier in the Methodology section, the research construct *facilitation* was tested as proposed using three operational hypotheses.

Hypothesis One - Time

The study results indicate that it does take less time to produce conceptual cost and risk analysis using the ***REDDS***? system as compared to manual preparation. For the pre-test, the mean manual preparation time was 300 minutes compared to a 173 minute ***REDDS***? preparation time. Based on a sample of seven students, the post-test mean preparation times, which were entirely supported by the ***REDDS***? system, were 100 and 105 minutes respectively. This represents a 61% decrease in time going from manual to ***REDDS***? and a 33% decrease in time utilizing ***REDDS***? in both the pre-test and post-test. To determine if this decrease is statistically significant, a pooled t-test was run resulting in a t-statistic of 2.67, which is greater than the t-critical value of 2.57 for a 95% confidence interval. This indicates that the null hypothesis can be rejected meaning there is most likely a significant difference in time.

Several reasons for the decrease in time for the ***REDDS***? control group between the pre-test and post-test are plausible. First, the two cases, while intended to be comparable in the amount of work, may have been different simply because they were different projects. Second, there is an expected maturation effect due to efficiency that would produce a decrease in the control group mean preparation time. This would explain the 33% time decrease for the control group. This leaves 28% (61% - 33%) unaccounted for and potentially to the credit of the ***REDDS***? system. It is also important to note, for each case test, each participant was requested to produce a break-even analysis, sensitivity report, probability assessment, references for data and models employed and assumptions. In general, all ***REDDS***? participants produced the requested documents in the times reported above. The manual group, however, produced varying levels of the requested risk assessments, with none of them producing all of it. The time test results are graphically shown in Figure 2. The times reported for the manual estimates (control group), therefore are understated in the sense that not everything was completed; adding more creditability to the DSS time decrease findings.

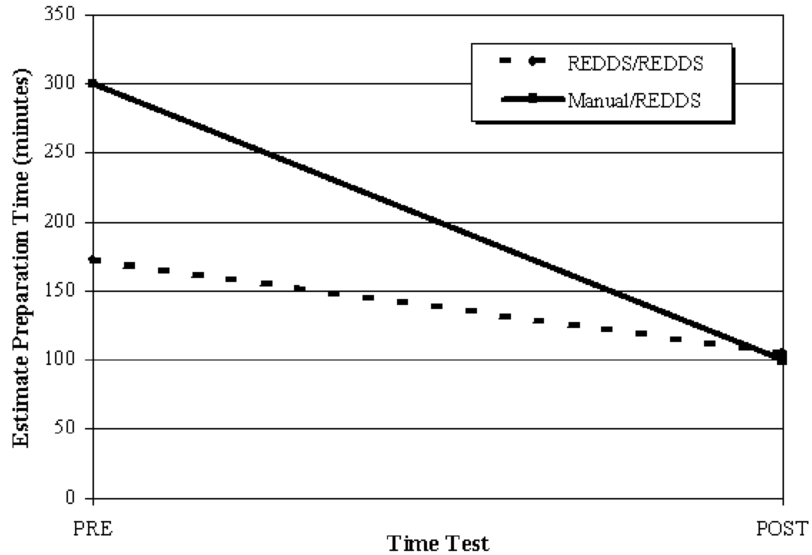

Figure 2. Time Comparison.

Hypothesis Two - Confidence

The study results indicate that use of the ***REDDS***? system compared to manual preparation does not significantly elevate the confidence of the users. For the same pre-test, post-test described above for the time hypothesis, the confidence level of the users was solicited using a rating scale of 1-5. While the ***REDDS***? users mean was higher in the pre-test (4.0 vs. 2.7); the post-test results showed similar increases in both groups (4.5 vs. 3.0). This represents a 29% increase in confidence going from manual to ***REDDS***? and a 7% increase in confidence utilizing ***REDDS***? in both the pre-test and post-test. To determine if this increase is statistically significant, a pooled t-test was run resulting in a t-statistic of 1.02, which is less than the t-critical value of 2.57 for a 95% confidence level. This indicated that the null hypothesis cannot be rejected meaning there is probably not a significant difference in confidence.

Part of the mutual increase can be explained by the same reasons outlined above in Hypothesis One. It is also plausible that because confidence was measured prior to release of the estimate results, they had no basis of comparison. In other words, had the ***REDDS***? group known that they had on average produced much closer estimates of the true cost of the project in the pre-test case (as described in hypothesis three below), they may have had higher levels of confidence in the method they utilized to achieve the estimate results, in this case ***REDDS***? **.** The confidence test is graphically shown in Figure 3.

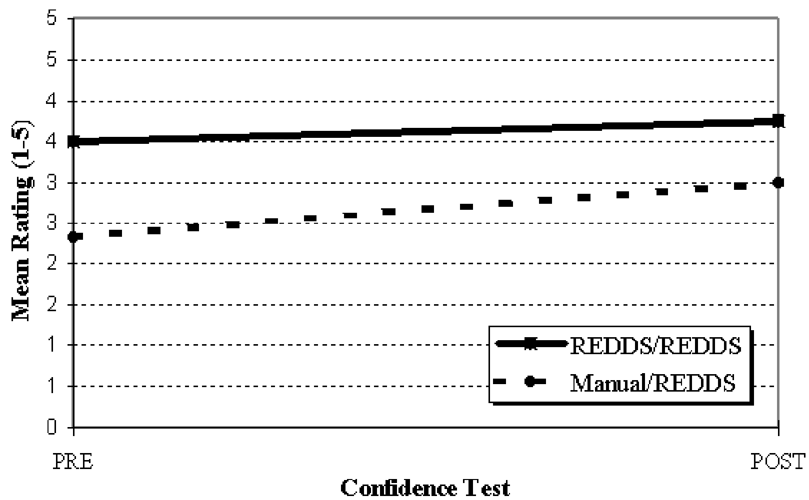

Figure 3. Confidence Comparison

Hypothesis Three - Consistency

Several tests were conducted to support the finding that cost analysis facilitated by the ***REDDS***? system does provide a consistent framework for investigating alternatives, evaluating risk and determining critically sensitive variables. This has been supported by three separate evaluations as discussed below.

As discussed, the consistency dimension of ***REDDS***? was continually tested during the design and development. This included checking for consistency in model definitions and units of analysis. This has resulted in consistent output. In addition, a set of secondary consistency tests was conducted.

Because the first case study was based on the combination of several actual projects, the actual cost could be derived. Therefore, it was decided to test project cost as a consistency dimension. For additional data, the cost estimates of 12 student projects produced from 2-3 person teams, and within a 160 minute period, where also used for comparison purposes. The test results indicate that the ***REDDS***? system users are much more consistent, and accurate in determining conceptual cost. First, variation in estimate cost was compared utilizing the coefficient of variation (standard deviation divided by the mean estimated cost). The first graduate group has a variation of estimates of 17% compared to the manual group, which had nearly a 40% variation. Both groups combined using ***REDDS***? for the second case produced estimates that varied by 27% - still considerably below the manual number. The undergraduate group effort produced 12 estimates that varied by only 15%. This is shown graphically in Figure 4.

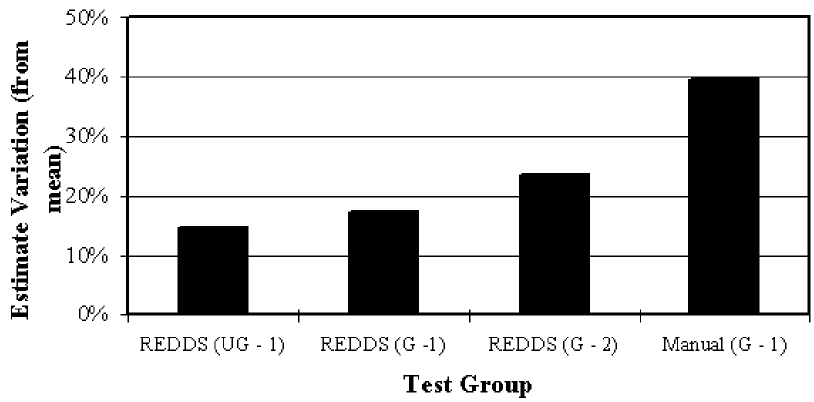

Figure 4. Estimate Variability Comparison.

Next, the mean estimated cost of each group was compared to the actual cost. Again, on average, the ***REDDS***? users produced more accurate estimates. The actual derived cost of the project was $13M. The pre-test graduates using ***REDDS***? had a mean estimate of $15.75M (121% of actual), the undergraduate ***REDDS***? users has a remarkable mean estimate of $12.30M (95% of actual), and the pre-test manual users had a mean estimate of $21.00M (162% of actual). These results are shown graphically in Figure 5.

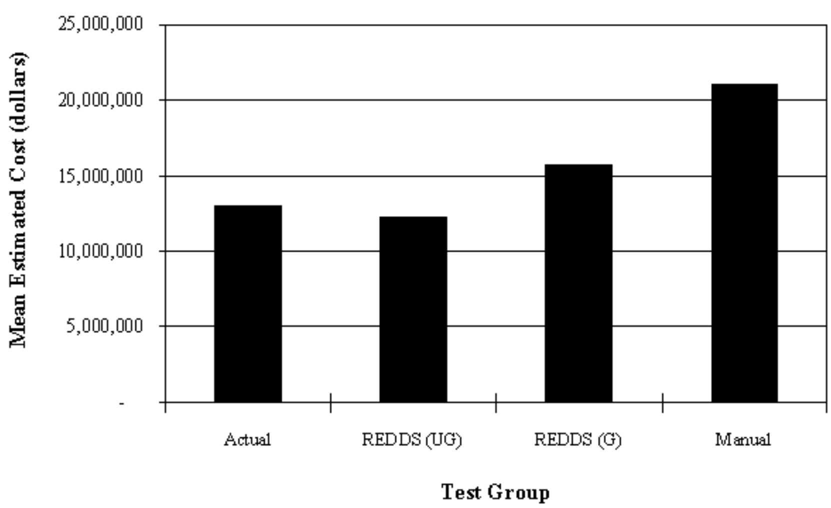

Figure 5. Estimated Cost Comparison.

Finally, visual inspection of the results of ***REDDS***? users compared to manual preparation did of course result in a more consistent format. This, does not however, indicate that the consistency necessarily means increased quality.

Discussion

Overview

The ***REDDS***? system was tested to determine if it facilitated the cost estimating decision process. The construct was tested by three operation variables of time, confidence and consistency. The results indicate that while the system does reduce estimate time, it does not necessarily contribute to the overall confidence of the user. Further, it was shown that estimates using ***REDDS***? were more consistently prepared and on average more accurate than those prepared manually.

At this early stage of development, the system is not adequate to meet the needs of most professional developers. It is anticipated, however, that with additional programming, and continued linkages, ***REDDS***? could potentially benefit real estate developers during the early stages of project development and cost estimating. A quick, reliable and consistent tool to "take a look" at potential projects may help developers better identify feasible projects. This is especially true for small developers with limited resources and/or new developers with limited experience.

A fully developed ***REDDS***? system could potentially benefit many professional in the built environment. This includes anyone who is concerned with the cost side of the development equation (i.e. lenders, appraisers, design professionals, and equity partners). In addition, the testing of ***REDDS***? inadvertently revealed another group which may also benefit, namely students of the built environment. This of course includes all those who eventually fill the professional positions listed above and includes such disciplines as construction science, architecture, land and real estate development, economics, and finance.

Strengths and Weaknesses of the Study

During the course of design and development, notes were continually recorded to assure that weaknesses would be documented. In addition, as discussed earlier, several pre-tests were conducted to begin identification of overall as well as specific strengths and weaknesses of this study.

- ***Flexibility.*** As developed, ***REDDS***? lacks flexibility in both input and output. The input is limited somewhat in the sense that there is often more than one model, which could potentially be used to evaluate a certain variable. Since the model only accesses one database and provides one decision support aid per variable, flexibility is limited. In addition, the format of the reports is fixed. In today's world of word processing, and the general accepted built in flexibility of most programs to adjust the output to the users preference, this limitation is considered serious and essential to overcome in a commercial grade edition.
- ***Linkages.*** Overall the case has been made that existing data and logic models can be linked. Automation of some of these linkages is needed, with direct access to the Internet being considered the linkage of most importance. With its expanding database, especially regarding economic and demographic data, automation of this link will

become extremely important as the analysis scope of the program is accomplished as discussed below.

- ***Scope.*** The scope of ***REDDS***? is limited both categorically and analytically. Categorically, the system is currently only capable of estimating in the conceptual stage of development planning. Although this is consistent with the delimitations set forth, given access to a building cost database, and with limited programming, the system is designed for an upgrade in this area. From an analysis standpoint, although the product of this research is consistent with the proposed scope, it nevertheless falls short of the ultimate goal of total linkage to financial feasibility analysis in the planning stage of property development. It should be noted, however, that one of the major strengths of the system is that expansion into these areas of financial analysis has been anticipated. In some cases, such as the Gross Income Multiplier Front Door Analysis, expansion has already begun.
- ***Data Sources.*** Although this study has demonstrated the potential to link multiple data bases from using a variety of medium, the primary weakness is considered to be lack of a good conceptual building square foot cost data base. Although some sources have the making of this database in the form of assemblies cost, and available in electronic medium, they have not compiled the assemblies to represent entire building costs.
- ***Speed.*** The program as developed, is slow by modern standards. Although this was overcome in the testing phase by using the latest in hardware configuration, specifically, Pentium coprocessors at 133 MHz speed, it is recognized that the average developer or other professional who may find this system of value may not have hardware with capable of this speed.

Recommendations for Further Study

Based on the conclusions, implications, strengths and weaknesses discussed above, the authors of this study make the following recommendations to others who are interested in the area of real estate decision support:

- Continued development of modules under construction
- Continued identification of data
- Continued development of decision logic models to increase analysis flexibility
- Continued development of output flexibility
- Continued development of automation of linkages
- Commercial Programming.
- Commercial Endorsement
- Commercial Documentation and Support
- Data Procurement Agreement
- Test for Accuracy/Precision

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