Development of a Decision Tool for Usability Cost Justification

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Abstract

Usability investment costs are easy to measure, yet the usability benefit estimations require many critical assumptions. Slight changes in these assumptions impact the economic analysis significantly. This paper provides preliminary work and implications on how a decision tool could be developed that would optimize the usability benefit assumptions. It incorporates Meta Analysis, regression analysis, goal programming optimization, simulation, quantile regression, and economic analysis to model cost justification of usability. The key results indicated significant positive correlation between sales and traffic rate, and error rate and task time. The outcome is a decision tool for usability investments.

Keywords
Usability, cost justifying usability, modeling usability benefit assumptions

1. Introduction

Usability is defined as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” [1]. Three key characteristics of usability, as provided in this definition, are effectiveness, efficiency, and user satisfaction. Effectiveness is “the accuracy and completeness with which users achieve specified goals”, whereas efficiency is “the use of resources in relation to the accuracy and completeness with which users achieve goals” [1]. Task completion rates and error rates are widely used metrics of effectiveness. On the other hand, efficiency is generally measured by time to accomplish a task and task flow deviation metrics. The task flow deviation can be defined as: “the ratio of the optimal number of steps to complete a task to the average number of steps to complete the task” [2]. The last characteristic of usability in ISO guidelines, user satisfaction, is “the freedom from discomfort, and positive attitudes towards the use of the product” [1].

Usability investments offer internal and external benefits to organizations. The investments on usability showed a rapid increase in the dot.com bubble era, yet it has stabilized since 2001 [3]. See Table 1 for share of project budgets for usability.
The returns on investment of usability for software internally used in an organization that invests on usability are listed as: (1) increased user productivity, (2) decreased user errors, (3) decreased training costs, (4) decreased development costs, and (5) decreased user support costs [3]. Whereas, the returns on investment of usability for externally sold software are listed as: (1) increased sales, (2) decreased customer support costs, (3) savings gained from making changes earlier in the development life cycle, and (4) reduced cost of training offered through vendor organization [4].

Developing software easy to use requires focusing mainly on user needs that are feasible to implement. Understanding the user needs and projecting those needs to the development of software design stage is the duty of usability practitioners. However, usability practitioners have one more responsibility to handle; convincing decision makers to invest in usability.

As with all investments, the costs of investing on usability should be compared to the expected benefits. The results of a survey conducted on justification of user centered design showed that: 62% of people are convinced of the value of user centered design by testimonials, case stories, and demonstrated results, 23% by support from customers, management, and outside companies, and only 15% by cost-benefit analysis [5]. Although survey results revealed that cost-benefit analysis was not a preferred method to influence people of the value of user centered design, in the same survey more than half of the participants believed that cost-benefit analysis would be convincing if in-detail information about how the cost-benefit model worked and the assumptions and data used would be provided exclusively [5]. Indeed, cost-benefit analysis is the major tool used by researchers in the cost justification of usability literature [5]. Even though benefit-cost ratio is an analysis technique used for governmental organizations for public investment analysis, and should not be used for private organizations [6], it has been used extensively so far [7]. “The cost-benefit analysis is a method of analyzing projects for investment justification [8]”. It is performed to justify usability investment by estimating the costs and benefits of usability activities and comparing them against the costs of not performing those usability activities. The steps of cost-benefit analysis for usability are listed as: Selecting a usability technique, determining the proper unit of measurement, making a rational assumption about the benefit’s magnitude, and translating the estimated benefit into a monetary figure [9].

There is a declining trend in usability justification model development in the last decade [7]. Most of the establishments in last 10 years have been modifications of the primary models to different business cases. There is a need for re-focus on the cost justification of usability. Existing cost justification models are based on many critical assumptions. At present, a usability practitioner or researcher has no source or reference for finding reliable numerical ranges for these assumptions. However, it is critical to show reliable numbers to decision makers in order to promote usability investments. To be more specific about the critical assumptions, how much increase or decrease may happen in any performance measure after usability investments is not apparent. The usability practitioner or researcher has to make assumptions on the magnitude of the usability benefits. Therefore, the accuracy of these assumptions depends mainly on the consistency of usability practitioner or researcher. A crucial problem in usability testing activities is consistency [10]. For instance, a variation of 37% to 72% has been detected on within-team consistency, which indicates considerable subjectivity [10]. This paper will illustrate a decision tool being developed [11, 12, 13] for usability practitioners to understand the possible change in sales, traffic rate, error rates of users, task times, and relationships of those variables.

<table>
<thead>
<tr>
<th>Year</th>
<th>Share of Project Budget</th>
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<tbody>
<tr>
<td>1971</td>
<td>3%</td>
</tr>
<tr>
<td>1989</td>
<td>5%</td>
</tr>
<tr>
<td>1994</td>
<td>6%</td>
</tr>
<tr>
<td>2001</td>
<td>13%</td>
</tr>
<tr>
<td>2002</td>
<td>10%</td>
</tr>
<tr>
<td>2006</td>
<td>10%</td>
</tr>
<tr>
<td>2007</td>
<td>12%</td>
</tr>
</tbody>
</table>
2. Methods

The planned list of methods in order to develop a decision tool for cost justification of usability are: Meta analysis, Pareto analysis, distribution fitting, interaction modeling, spreadsheet simulation, goal programming, and quantile regression.

2.1 Meta Analysis

Meta analysis is held for data collection and statistical view of data in this research. Types of data are percentages. Meta Analysis is used to analyze and draw conclusions about other researchers’ statistical analyses. It as a useful tool when many studies have already been conducted on a particular topic and another researcher wants to convert the entire results into a mathematically concise package [14]. See Table 2 for the steps of a Meta analysis and how those steps were undertaken in this research.

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct a fairly extensive search for relevant studies: The researcher uses some systematic and far-reaching approach searching through professional journals, using online databases to identify studies addressing the topic.</td>
<td>A State-of-the-Art-Matrix for cost justification of usability was performed [7, 15, 16]. A total of 135 studies including hypothetical and real world cases were explored with a total of 385 data points.</td>
</tr>
<tr>
<td>Identify appropriate studies to include in the meta-analysis: The researcher must limit the studies to those including a specific experimental condition, or any factor that is the focus of study.</td>
<td>The studies with numerical data were filtered for further analysis.</td>
</tr>
<tr>
<td>Each study’s results are converted to a common statistical index: Previous researchers may have used different statistical procedures to analyze the data. The researcher finds a common point of the studies.</td>
<td>The studies only with percentage change data were filtered for further analysis. Hypothetical data were eliminated. Only actual data is considered in the research.</td>
</tr>
</tbody>
</table>

It was found after the Meta analysis that there were over 20 types of usability benefits mentioned in the literature with percentage change data. At this point, prioritization of goals needed to determine which usability benefits to be focused upon. In order to prioritize the goals of the research, Pareto analysis was used incorporated with the Meta analysis. See Figure 1 for the result of the Pareto analysis.
The Pareto chart shows that the usability benefits to be focused in this research are decided to be increased sales, decreased task time, decreased error rate, increase in traffic and decrease in training time. The rest of the usability benefits are saved for future research endeavor due to current data unavailability even though some of them are very important benefit categories such as reduced maintenance and support cost and reduced development time.

2.2 Distribution Fitting
The Meta Analysis provided sample data of percentage changes before and after any usability investment. These sample data for the prioritized usability benefits were analyzed with Simulation ARENA input analyzer module to determine the sample distributions. Kolmogorov-Smirnoff goodness of fit test results are preferred over Chi-Square test due to small sample sizes and the type of data being percentages.
2.3 Interaction Modeling
Usability benefits that are selected after the prioritization process were checked for correlation by Spearman’s Rho non-parametric test. The correlated variables were further analyzed by using MS Excel Data Analysis module by using the regression analysis option. Two way interaction models were found for those variables with significant interaction. Higher order interactions were ignored due to data limitations.

2.4 Spreadsheet Simulation
There is a need for simulation since the sample sizes of real data are small for each usability benefit. The sample distributions were found from real world case data, and these samples were simulated to get descriptive statistics close to population. MS Excel data table and random number function was used to simulate the samples. The number of replications are initially set to 1,000, was increased to improve power and accuracy.

2.5 Goal Programming
It is more accurate to model several decision making problems by using goals, in other terms soft constraints, rather than hard constraints [17]. Soft constraints correspond to target values that are pleasing to achieve. There can be deviations from the target value in both positive and negative direction. A critical focus point in this research is the determination of those target values for the usability benefit variables. Central limit theorem was utilized to determine acceptable target values. The correlated variables were used in the goal programming model. There are two models developed. The first model incorporates the regression model for increased sales and increased web site traffic, whereas the second model uses the regression model for decreased error rate and decreased task time.

2.6 Quantile Regression
The correlated variables were modeled by using quantile regression in order to see the distinction based upon different quantiles of the dependent variable. The first quantile regression analysis was conducted for increased sales and increased traffic rate. Increased sales was assumed to be the dependent variable, and increased traffic rate was counted as independent variable. Secondly, quantile regression was conducted for error rate and task time. Decreased error rate was counted as independent variable, whereas decrease task time was processed as the dependent variable. The reason for selecting these four variables is that they are the only correlated ones as was shown in the preliminary findings section. The findings from the methods explained so far are given in the next section.

3. Preliminary Findings
The methods employed are aimed at developing a decision tool for usability investments. Meta analysis was used for data collection and filtering in a systematic manner, which was incorporated with a Pareto analysis to prioritize goals. The prioritized goals were statistically analyzed via distribution fitting and two-way interactions in order to provide the constraints of the goal programming model. Moreover, the target values of the goal programming models were found by simulation of sample data for the prioritized goals in the Meta table with the fitting distribution. The quantile regression was a further step towards investigating possible changes in interactions based upon quantiles. Thus, the final output, which is the decision tool, is being designed with incorporation of economics, operations research, and statistics.
From the prioritized benefits, sample distributions of increased sales, decreased task time, decreased error rate, and increase in traffic were determined statistically significantly according to the Kolmogorov-Smirnov goodness-of-fit tests with high p-values. High p-values indicate failing to reject the null hypotheses in results. See Table 3 for the sample distribution results.

<table>
<thead>
<tr>
<th>Usability Benefit</th>
<th>Distribution</th>
<th>Square Error</th>
<th>Kolmogorov-Smirnov p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased sales</td>
<td>Exponential</td>
<td>0.002253</td>
<td>&gt; 0.15</td>
</tr>
<tr>
<td>Decreased task time</td>
<td>Beta</td>
<td>0.015179</td>
<td>&gt; 0.15</td>
</tr>
<tr>
<td>Decreased error rate</td>
<td>Beta</td>
<td>0.013359</td>
<td>&gt; 0.15</td>
</tr>
<tr>
<td>Increased traffic rate</td>
<td>Gamma</td>
<td>0.009704</td>
<td>&gt; 0.15</td>
</tr>
</tbody>
</table>

By using these distributions, four variables were simulated via MS Excel spreadsheet simulation. The two-way interactions were found by MS Excel spreadsheet data analysis for the variables that were detected to have
significant interaction. To detect the existence of the significant correlation, Spearman’s Rho test was utilized. See Table 4 for the results.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Model</th>
<th>R-Square</th>
<th>Significance F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased sales and increased traffic rate</td>
<td>Increased sales = -0.259746244 +5.070378837*Increased Traffic Rate</td>
<td>0.880279813</td>
<td>0.018256</td>
</tr>
<tr>
<td>Decreased task time and error rate</td>
<td>Decreased task time = 0.222958075+0.44757381*Decreased error rate</td>
<td>0.970907039</td>
<td>0.014654</td>
</tr>
</tbody>
</table>

4. Conclusion
This research is progressing towards developing a decision tool to assist cost justification of usability. The sensitivity analysis for the goal programming models, application of convergence rate of central limit theorem, and the quantile regression are under progress. The decision tool will help usability practitioners and researchers on making benefit assumptions required in all existing cost-benefit models in the usability cost justification literature. The decision tool is being developed in a way that considers different type of software companies, and provides the users of the model the prospect of assigning weights depending on company expectations. It is the first decision tool for cost justification of usability that incorporates statistics, optimization, and economic analysis.
References