A Business Performance Measurement Model for Mobile User Interface

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Abstract. In this paper, we present a new framework for measuring business performance of mobile user interfaces (UIs). Until now, the performance measurement of mobile UI was mainly to assess usability performance. Yet, as mobile phones are increasingly replacing wired devices, stakeholders in mobile phones began to invest a lot of time and money to mobile UI development. As a result, it is desirable that the business performance of mobile UI has to be measured qualitatively as well as quantitatively. This paper develops a measurement model for business performance of mobile UI based on BSC (Balanced Score Card). The proposed model contains "Financial", "Customer", "Internal Business Processes", and "Learning & Growth" perspectives. We applied the presented measurement model in a real world mobile UI design project. Finally, we demonstrate the benefit of applying the proposed model to quantitatively measure the business performance.

Keywords: User Interface, Mobile Phone, Business Performance, BSC (Balanced Score Card).

1 Introduction

User Interface (UI) plays an important role in traditional software development processes since UI can improves software usability performance and reduce potential maintenance work. In order to model UI's desired business benefits, there have been many quantitative and qualitative approaches proposed in software engineering field. However, due to the relatively short lifetime of a mobile phone, there have not been many attempts for measuring the business performance in the context of mobile UI. Furthermore, as mobile phones are being adopted as direct replacements of wired devices, they have suddenly become platforms for entertainment and commerce as well as tools for information management and media consumption [8]. As a result, stakeholders in mobile phone industry are investing a lot of time and money in mobile UI. Before and after development stage of mobile phone and service, it is necessary to estimate ROI (Return on Investment) for mobile UI.

This paper develops a measurement model for business performance of mobile UI based on BSC (Balanced Score Card) [4]. The primary reason to employ BSC is that the business performance of mobile UI has to be assessed both qualitatively and quantitatively. By using measurement model, we can utilize them as data for verification

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before a development stage, and in case of multiple projects, we can prioritize the projects according to the measurement value to see if there's anything we need to develop now, or delay later.

In this paper, we analyze some relevant work in software engineering and related areas, and develop a framework for measuring the business performance of mobile UI. In order to demonstrate the advantages of the proposed measurement model, we applied the model to a real world project that estimates monetary value of mobile UI in a commercial service stage.

The organization of this paper is as follows. Section 2 describes some related work. Section 3 defines details of the proposed framework. In section 4, we estimate monetary value when we apply the proposed measurement model to a real mobile service project. Finally the conclusions and some remarks are given in section 5.

2 Research Reviews

In 1988, Mantei and Teorey [9] described cost-benefit analysis when human factors methods are applied in software development and classified tangible and intangible factors for costs and benefits. They calculated costs and benefits of general examples for tangible factors and listed conceptions for intangible factors. Since then, many quantitative and qualitative methods for demonstrating UI's desired business benefits have been proposed by calculating costs and benefits of UI in the actual development projects. In particular, Cost-Justifying Usability [2] of Randolph G. Bias and Deborah J. Mayhew, Presentation material [12] of Deborah J. Mayhew and others [5, 10, 11] showed that UI played an important role in traditional software development process and website development process through costs and benefits analysis. That is, UI contributed to better usability, increased productivity, and reduced cost of development and service.

Unfortunately, most existing research results in mobile UI were mainly to develop new UI techniques or evaluate usability performance of a new technique in the laboratory environment [6]. In addition, since mobile device has a small screen size compared to that of a computer, there have been many research results for improving user experience in order to overcome the hardware limits of mobile phones.

One of widely used methods for measuring business performance is cost-benefit analysis which measures financial benefit of projects quantitatively. In the 1990s, Robert S. Kaplan and David P. Norton publicized BSC concept for performance planning and measurement framework. By focusing not only on financial outcomes but also on the human issues, BSC helps provide a more comprehensive view of a business so that managers focus on performance metrics while balancing financial objectives with customer, internal process, and employee perspectives [1].

3 Measurements Model

In this section, we propose a measurement model for business performance based on BSC. BSC consists of four perspectives that are labeled "Financial", "Customer", "Internal Business Processes", and "Learning & Growth". Evaluating business performance based on BSC requires a few good measures for each perspective. For financial perspective, increased sales volume, ROI, payback period and EVA are generally used. Main measure of customer perspective is customer satisfaction. The measures selected for internal process perspective include process for operations management and customer management. Finally, learning & growth perspectives contain internal skills and capabilities that are required to support the internal process.

In this paper, we use sales volumes for financial perspective, increased ARPU (Average Revenue per User) for customer perspective, experience curve effects [3, 14] for internal process and learning and growth perspectives since experience curve effects can be applied in most situations [3]. In order to calculate sales volume of a mobile UI project, we multiply the number of original service subscribers right before starting mobile UI project for the original service by the increased ARPU during payback period in the service. The reason to use this number is because it is difficult to justify that mobile UI project efforts actually have resulted in the increased number of subscribers via positive word-of-mouth. Upgraded mobile UI can contribute to the increased number of subscribers and we propose the conservative measurement model. Therefore, instead of using the increased number of subscribers in the service with upgraded mobile UI, we use the increased ARPU since improved mobile UI leads to increased perceived quality, customer satisfaction as well as increased ARPU [13]. More formally, we define the following notations.

- N : payback period of project
- t : order number of project
- α : coefficient of decreased cost, $1 \le \alpha \le 2$
- Z_t : total revenue of t^{th} project, $t = 1,2,\cdots$
- a_t : number of original service subscriber right before t^{th} project, $t = 1,2,\cdots$
- x_t^i : increased ARPU of t^{th} project at time i, $t = 1,2,\cdots$, $i = 1,\cdots,N$
- y_t : cost of t^{th} project
- y_t^1 : cost of t^{th} project when we produce it as 1^{st} project by experience curve effects

The following assumption is made in this paper:

(A) Only the mobile UI projects for UI revision of existing mobile services are considered.

That is, we don't consider new mobile service project with new UI.

By using the above notations, we obtain a measurement model for the business performance of mobile UI as follows.

$$\textbf{(M)} \quad Z_t = \sum_{i=1}^{N} \left(a_t \times x_t^i \right) + \alpha \times \left(y_t^1 - y_t \right) \tag{1}$$

(M), total revenue of mobile UI project consists of original sales volume and decreased costs by experience curve effects. **(M)** provides business performance after payback period of mobile UI project and evaluates real cost-benefit analysis. We utilize **(M)** as data for verification before development stage begins. In order to use **(M)** before the development stage, we formulate the measurement model with statistics. Since we already have done several mobile UI projects which need costs and lead to benefits such as revenue, we were able to utilize several numerical data consisting of a dependent variable such as revenue and an independent variable such as cost. The revenue in the regression equation can then be modeled as a function of the cost, corresponding parameters and an error term. Using regression analysis, we can obtain the statistical measurements model **(M_s)** of **(M)**.

$$\textbf{(M}_s\textbf{)}\ \ Z_t = \beta_0 + \beta_1 y_t + \alpha \times \left(y_t^1 - y_t\right),\ \ \beta_0, \beta_1 : \text{parameters} \qquad (2)$$

where $w_t = \beta_0 + \beta_1 y_t$

(M_s) corresponds the case of linear regression. We now obtain a solution for the model **(M)** solving **(M_s)** before the development stage of a project. After payback period of the project, we can compare **(M)** with **(M_s)** for difference between estimation and actual value.

4 Results

We apply the proposed measurement model to estimate business performance of mobile UI in a real mobile service. For this purpose, we define the following procedure.

<u>Step 1</u> : Calculate **(M_s)**.
<u>Step 2</u> : Calculate the mediated **(M_s)** considering only UI.
<u>Step 3</u> : Compare **(M)** with the mediated **(M_s)** using actual value and recalculate the mediated **(M_s)**.
<u>Step 4</u> : Analyze BCR (Benefit-Cost Ratio) using **(M_s)**.

For step 1, we first construct a regression model using data which consider revenue as a dependent variable and cost as an independent variable, and obtain parameters for regression equation of **(M_s)**. That is, we fix β_0, β_1 parameters of **(M_s)** using regression analysis. In this study, 31 service cases in the mobile service provider were analyzed. Each service case is defined as the previous service with renewal UI. The regression equation about cost of renewal UI and revenue in 31 service cases is as follows :

$$w_t = 12.31\, y_t - 186{,}411{,}568,\ R^2 = 0.8595,\ \ Adj.R^2 = 0.8545 \qquad (3)$$

Table 1. Regression Diagnostics(Coefficients)

	B	Std. Error	T	Sig.
Constant	-186,411,568	120,685,939.0394	-1.5446	0.1337
X	12.3062	0.9401	13.0899	0.0000

Table 2. Regression Diagnostics(ANOVA)

	df	Sum of Squares	Mean Squares	F	Sig.
Regression	1	3.04229E+19	3.04E+19	171.3465	0.0000
Residual	28	4.97146E+18	1.78E+17		
Total	29	3.53944E+19			

For regression diagnostics, we can confirm the goodness of fit of the model since R^2=0.8595. Statistical significance can be confirmed by an F-test of the overall fit, followed by t-tests of individual parameters. Then, we estimate y_t^1 with y_t by experience curve effects [3]. We use NASA's learning curve calculator [7]. The learning percent is usually determined by statistical analysis of actual cost data for similar products. That information is not available, we use the following industry guideline [7]: 1. Aerospace 85%, 2. Shipbuilding 80~85%, 3. Complex machine tools for new models 75~85%, 4. Repetitive electronics manufacturing 90~95%, 5. Repetitive machining or punch-press operations 90~95%, 6. Repetitive electrical operations 75~85%, 7. Repetitive welding operations 90%, 8. Raw material 93~96%, 9. Purchased parts 85~88%. Among them we use 96% learning percent which is guideline for raw material because UI design and development is not repetitive operations but creative operations. Because the decreasing costs by experience curve effects between **(M)** and **(M_s)** are the same, we apply the decreasing costs when we calculate the cost-benefit analysis in step 4.

For step 2, we calculate the mediated by considering only UI. We can classify several effects for increasing the service revenue. The effects for increasing the service revenue are as follows: service rate, UI, word of mouth, advertising, etc. In general, most effects for increasing the mobile service revenue come from marketing promotion such as advertising, service rate. But we assume that mobile UI project is defined as the previous mobile service with renewal UI in this paper and each effect has the same effect. And then, we calculate the mediated **(M_s)** by multiplying w_t of **(M_s)** by UI effect value (25%).

In step 3, we compare **(M)** with the mediated **(M_s)** using actual value. During the time horizon of one year, we collect actual values for a specific project for calculating the first term of **(M)**. And we apply the cost of specific project to (3) for calculating the first term of **(M_s)**. Because the second term of **(M)** and **(M_s)** is the same, we don't consider the second term for comparing **(M)** with **(M_s)**. The number of original service subscriber right before 32nd UI project is 11,506 and the following (4) includes the increasing ARPU of 32nd project for 1 year. The UI expenditure of 32nd project is 100,000,000 won.

The first term of **(M)** :

$$11{,}506 * (403 + 450 + 487 + 642 + 688 + 865 + 983 + 1{,}128 + 1{,}724 + 1{,}711 + 2{,}629 + 3{,}438) = 174{,}281{,}382 \text{ won} \quad (4)$$

The first term of $(\mathbf{M_s})$:

$$(12.31 * 100{,}000{,}000 - 186{,}411{,}568) * 0.25 = 261{,}147{,}108 \text{ won} \quad (5)$$

Through comparing **(M)** with the mediated $(\mathbf{M_s})$ using actual value, we find that the first term value of $(\mathbf{M_s})$ is greater than the first term value of **(M)** since all the effects for increasing the mobile service revenue are included. UI effect value has to be decreased for using the statistical measurements model $(\mathbf{M_s})$ of **(M)**. We can get 16~17% as UI effect value in order to revise the mediated $(\mathbf{M_s})$ in comparison to **(M)**. We recommend that the UI effect value is less than 20%.

In step 4, we calculate the projected BCR. Assuming the time horizon of one year, the UI expenditure of the 32nd project is 100,000,000 won (Korean money unit). We estimate $(\mathbf{M_s})$ of the 32nd project using 16% as UI effect value and 0.3 as α and estimating y_t^1 with y_t by experience curve effects with 96% learning percent.

$$(\mathbf{M_s})\ 0.16 * (12.31 * 100{,}000{,}000 - 186{,}411{,}568) + 0.3 * (130{,}197{,}071 - 100{,}000{,}000) = 176{,}193{,}270 \quad (6)$$

Therefore, the projected BCR for this project is

$$\text{BCR} = 176{,}193{,}270/100{,}000{,}000 = 1.762 \quad (7)$$

A 1.762 is a very healthy return. This makes it possible for the investment in mobile UI to be considered alongside other investments the firm might make, rather than merely being considered a cost.

5 Conclusions

In this paper, we presented a new framework for measuring the business performance of mobile UI. Until recently, performance measurement in mobile UI was mainly carried out to assess the usability performance, and the investment to mobile UI was considered a cost. However, as mobile phones are increasingly replacing wired devices, stakeholders in mobile industry began to invest a lot of time and money to mobile UI development. Therefore, it becomes necessary that the business performance of mobile user interface is considered qualitatively as well as quantitatively. This paper developed a measurement model for business performance based on BSC (Balanced Score Card). We proposed two models, **(M)** total revenue model of mobile UI project, and $(\mathbf{M_s})$ statistical measurements model of **(M)**. In the proposed model, we considered "Financial", "Customer", "Internal Business Processes", and "Learning & Growth" perspectives. We obtained a solution for the model **(M)** solving $(\mathbf{M_s})$ using real mobile UI project data. Through comparing **(M)** with $(\mathbf{M_s})$, we were able to compute UI's effect quantitatively among all the effects for increased mobile service revenue. In contrast to the existing approaches, the presented method considers mobile UI development efforts as investment and it also emphasizes that these efforts must be financially accountable.

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