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***Sustainable Technology
and Innovation:
Opportunities and
Challenges***

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PREFACE

WELCOME NOTE FROM INCITE 2017 ORGANIZING COMMITTEE CHAIRMAN

Rector of University of Surabaya: Prof. Dr. Joniarto Parung,
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Fellow Participants, Distinguished Guests, Ladies and Gentlemen:

First of all, welcome to Bali, Indonesia, and welcome to the first International Conference on Informatics, Technology and Engineering (InCITE) 2017!

It is still vivid in my memory, one and a half year ago, when some colleagues and officials of our Faculty of Engineering discussed the possibility of organizing an international event, to substitute national seminars that some of our study programs held annually or bi-annually. The call for an international event is a necessity given 30 years of Faculty of Engineering's existence, and the dawn of University of Surabaya's Silver Anniversary next year. Such a level of maturity prompts us to contribute more to a larger scale. An international event will have greater exposure to international community, and consequently greater impact to us all.

The following process, however, was far from easy. We were inexperienced, but we were faithful to our mission. It took us some time until we were able to formulate the conference theme, found prominent scholars in the selected theme, and negotiated with them. We are very grateful that all four speakers whom we approached are here with us today, to deliver their insights on opportunities and challenges in sustainable technology and innovation. Let's give our big hands to them!

Sessions beyond those with our invited speakers will deliver four sub-themes, namely: *sustainable design & innovation*, *sustainable manufacturing & processes*, *sustainable energy & earth resources*, and *the role of IT in sustainable enterprise*. We are glad to inform you that our conference has attracted 67 papers from the first round of acceptance. After careful selection by a panel that consists of high-profile international reviewers around the world, we passed 50 papers. We are thankful to our international reviewers who worked very hard providing feedback to the submitted papers. We are indebted to such great service that they have given.

I sincerely hope that the exchange of knowledge throughout this event, be it from within the substance of academic papers or during the conference time, will enhance our professional network and benefit us in the long run. Thank you to all our speakers, reviewers, participants, and most of all my committee members who have been hand-in-hand with me in this long journey! You all have made our dream come true!

We hope you will have a wonderful conference and memorable stay in Bali thisweek. We are looking forward to seeing you again in the next two years!

Assoc. Prof. Eric Wibisono, Ph.D.

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The conference organisers would like to thank the following names who will serve as the:

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Survival analysis for customer satisfaction: a case study

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Abstract. Mostly, customer satisfaction survey conducted periodically to track the dynamically of it. One of the goals of this survey is to evaluate the service design by recognizing the trend of satisfaction score. Many researchers recommend re-designing the service when the satisfaction scores were being decreased, so that the service life cycle could be predicted qualitatively. However, these scores usually set in likert scale and have quantitative properties, then should be analysed in quantitative model as well so that the predicted service life cycle would be done by applying the survival analysis. This paper will discuss a starting point for customer satisfaction survival analysis with a case study in healthcare service.

Keywords: satisfaction scores; survival analysis; satisfaction life cycle; service re-design predicting

1. Introduction

Many researchers proposed to conduct the customer satisfaction survey periodically to capture the behavior of this dynamic satisfaction scores [1]. The questionnaire for this survey consists of items interested by customers that influencing their satisfaction level. Qualitatively, some researchers decide to re-design the service when there are some indications that the scores being decreased [2]. It means that there are some limitations in predicting when the re-design process should be conducted. One needs to expert judge the re-design time base on past experiences.

However, quantitative approach in designing questionnaire for measuring customer satisfaction should be considered. Items in questionnaire for this survey usually scaled in likert items, so that the scores have some quantitative property [3]. Once the survey was conducted and satisfaction score was calculated, the quantitative analysis could be done and gives stronger interpretation in predicting the service life cycle.

As in modeling the reliability of an electric product, the similar survival analysis would be fitted for the customer satisfaction scores. Idea for choosing the product reliability models in this paper was based on [4] and [5] who has successfully models the customer lifetime value using survival approach. The satisfaction scores were measured time by time to capture the dynamic behavior of what customers have perceived. Theoretically, once the new service design deployed to customers, then the satisfaction would increase due to the new service innovations. At some levels, the satisfactions scores reach the maximum level, and then decreased as the perceived service started to be unsatisfied. In this point, new service design should be made and deployed soon to maintain the customer satisfaction level.

The survival analysis helps the management to predict the time where new service design should be deployed, by constructing the probability that the scores less than certain levels of satisfaction. Started by control charting the satisfaction scores over time and capture its dynamic, then continued by fit the best probability distribution and followed by calculating the probability of satisfaction survival. Smaller survival probability of certain level of satisfaction represents the need of service re-design.

2. Literature review

2.1. Parasuraman's Satisfaction scores

Parasuraman[6] mention that satisfaction of customer is the gaps measurement between expected and perceived service received by customers, defined as customer gaps. Moreover, another gaps also measured for mining the causes of customer gaps, and all those integrated gaps are summarized as the well-known method called SERVQUAL, stand for service quality.

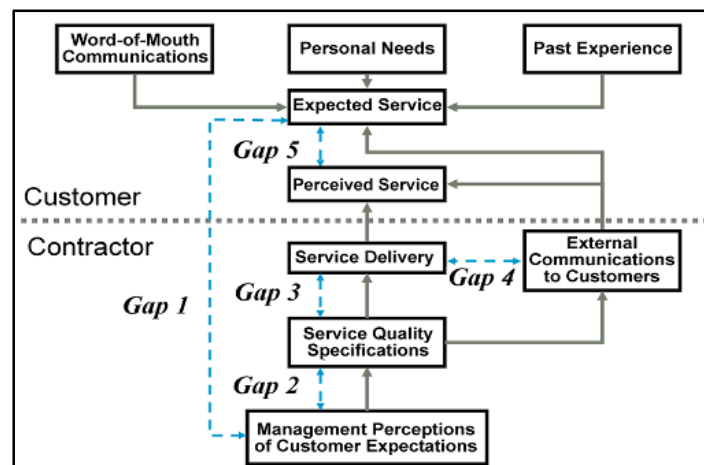


Figure 1. SERVQUAL gaps (taken from [6])

Common questionnaire for measuring these customer gaps consist of at least 20 likert scale questions. All items are generated based on 5 dimensions i.e. tangibles, empathy, reliability, responsiveness, and assurance. Overall satisfaction score of a customer is calculated as the average of each item scores. Scores from all customers that measured over time form a dataset to be modeled with survival analysis. In this paper, all satisfaction scores converted to positive value, low positive mean unsatisfied while high one means satisfied.

2.2. Survival analysis

Similar to the calculation of product reliability, the survival analysis in this paper is based on [7] applied to satisfaction dataset. Steps in survival analysis for product reliability follows points below:

- Measure the reliability data t (age of component, or satisfaction scores),
- Fit the dataset with some probability density function (PDF) $f(t)$, this function could be a product of two or more probability distribution regard to its dynamically behavior.
- Use the fitted PDF to calculate the reliability of component or satisfaction. Fitted probability distribution could be calculated by using simulated Bayesian approach due to its multimodality.

$$\text{Reliability function } R(t) = P(t > T) = 1 - F(t), \quad (1)$$

$$\text{Where } F(t) = P(t < T) = \int_{-\infty}^T f(t)dt$$

- Predict the probability that a component or satisfaction will decreased at a certain level

The PDF used in this paper refer to common survival analysis, for example, like weibull, exponential, gamma, and similar distribution covered in normal family distribution, multiplied by similar distribution as well so that $f(t)$ could be interpreted.

3. Research framework and methodology

This paper is part of preliminary research in modeling customer satisfaction data and predicting the service life cycle. The main framework includes the integration of two probability distribution fitted by Bayesian approach. Satisfaction PDF called $f(x)$, and how long customers have been using service denoted by $s(t)$.



Figure 2.research framework

Product PDF as multiplication of $f(x)$ and $s(t)$ done by simulating those prior distribution so that the posterior PDF obtained. Mathematically, the posterior PDF (product PDF) for modeling satisfaction reliability survival function written as follows:

$$L(xt) = \int f(x)s(t) dxdt, \quad x \geq 0, t \geq 0 \quad (2)$$

4. Result and discussion

Case study in this paper was taken from [8], there are 155 data recorded from survey conducted for evaluating a hospital patients perception about its services. The dataset consists of two variables, patient satisfaction scores (on scale of 1-7) and how long they have been treated and staying in hospital (in days). First, the behavior of those two variables captured by using multivariate control chart, as in [9] and refers to [10].

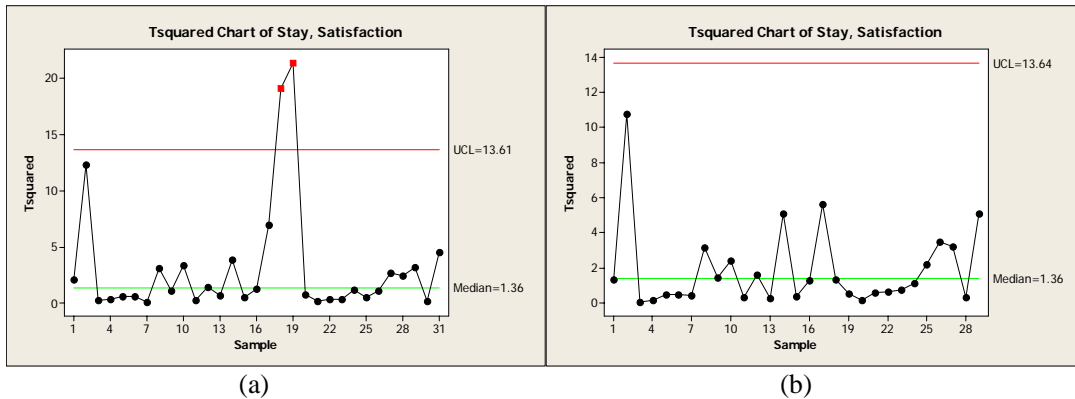


Figure 3. Multivariate control chart. (a) Before omitting unusual observations, and (b) After removing unusual observations

Two points are out of control; indicate that at certain time some special cases should be investigated. If there are some causes then the two points should be removed from analysis. Therefore, PDF fitting process for those two variables could be held.

Based on parametric survival analysis using MINTAB software, fitting process for $f(x)$ and $s(t)$ has done. PDF $f(x)$ was well fitted by weibull distribution, and $s(t)$ was assumed to follow exponential distribution.

Goodness-of-Fit for Satisfaction

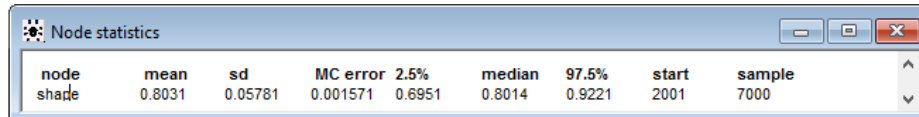
Distribution	Anderson-Darling (adj)	Correlation Coefficient
Weibull	2.212	0.981
Lognormal	6.213	0.919
Exponential	73.699	*
Loglogistic	6.117	0.920
3-Parameter Lognormal	2.072	0.976
2-Parameter Exponential	57.498	*
3-Parameter Loglogistic	2.706	0.966
Smallest Extreme Value	1.734	0.985
Normal	2.062	0.976
Logistic	2.693	0.966

Figure 4. Minitab output; probability distribution fitting for satisfaction data

The multiplication process in (2) could not be solved analytically, so that Bayesian Markov Chain Monte Carlo [10] simulation was used to fit the PDF $L(xt)$ as the Bayesian posterior distribution. Bayesian structure for likelihood function $f(t)$, prior distribution $s(t)$ and posterior $L(xt)$ defined as:

$$\begin{aligned}
 L(xt|\alpha, \mu) &= \int f(x)s(t) dxdt \\
 f(x|t, \alpha, \mu) &\sim \text{weibull}(\alpha, s(t)) \\
 s(t) &\sim \text{exponential}(\mu)
 \end{aligned}
 \tag{3}$$

The Markov Chain Monte Carlo simulation was conducted by using WINBUGS (Bayesian Using Gibbs Sampler) software [11].



node	mean	sd	MC error	2.5%	median	97.5%	start	sample
shade	0.8031	0.05781	0.001571	0.6951	0.8014	0.9221	2001	7000

Figure 5. WINBUGS Markov Chain Monte Carlo Result for posterior PDF

Figure 5 shows that the estimated α was 0.803, using similar way the estimation of other parameters has obtained. Next, this value would be used to predict the probability of satisfaction survival. Table 1 represents the trends of survival probability.

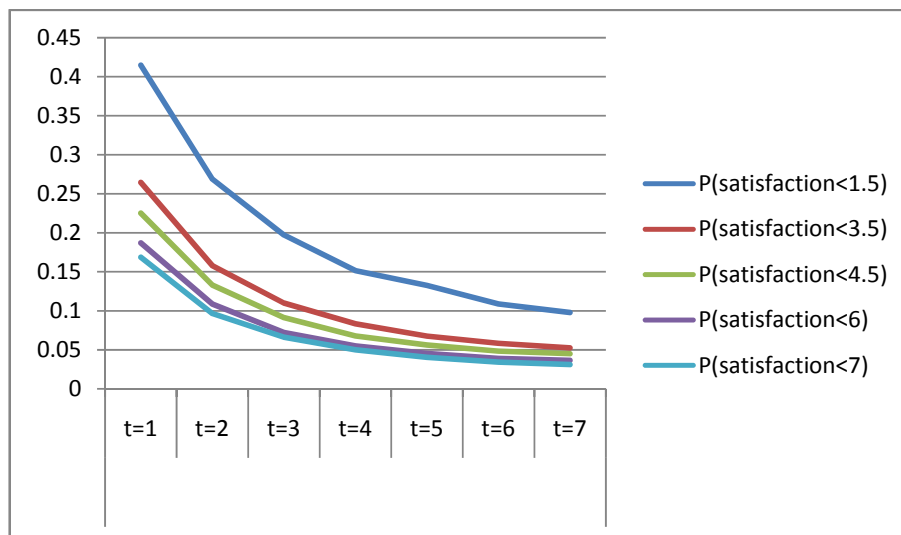


Figure 6. Survival probability over time (satisfaction likert scale of 1-7)

The survival probability decreased over time; moreover the probability at same time t for high satisfaction level gives higher probability than lower ones. Figure 6 gives interpretation that at until $t=7$, the satisfaction of customer becomes higher. At first day in hospital, patient feels uncomforted because of inadaptable conditions, but after few days the patient perceived more satisfy and got more complete service.

5. Concluding remarks

This is an initial research for mathematically modeling customer satisfaction due to service quality of a nonmanufacturing company or public service. The level of satisfaction was being dynamic and interested to study. Development of this research leads to the innovation of robust service design.

Acknowledgement

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