

Louis E. Freund  
Wojciech Cellary *Editors*

# Advances in The Human Side of Service Engineering

Proceedings of the AHFE 2017  
International Conference on The  
Human Side of Service Engineering,  
July 17–21, 2017, The Westin  
Bonaventure Hotel, Los Angeles,  
California, USA

# **Advances in Intelligent Systems and Computing**

Volume 601

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Louis E. Freund · Wojciech Cellary  
Editors

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ISSN 2194-5357

ISSN 2194-5365 (electronic)

Advances in Intelligent Systems and Computing

ISBN 978-3-319-60485-5

ISBN 978-3-319-60486-2 (eBook)

DOI 10.1007/978-3-319-60486-2

Library of Congress Control Number: 2017943054

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Printed on acid-free paper

This Springer imprint is published by Springer Nature

The registered company is Springer International Publishing AG

The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Advances in Human Factors and Ergonomics 2017



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*Proceedings of the AHFE 2017 International Conference on the Human Side  
of Service Engineering, July 17–21, 2017, The Westin Bonaventure Hotel,  
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# Preface

The 5th International Conference on the Human Side of Service Engineering (HSSE 2017) held at The Westin Bonaventure Hotel, Los Angeles, California, USA, from July 17 to 21, 2017. The conference was organized within the framework of the International Conference on Applied Human Factors and Ergonomics (AHFE) as an Affiliated Conference. If there is any one element to the engineering of service systems that is unique, it is the extent to which the suitability of the system for human use, human service, and for providing an excellent human experience has been and must always be considered. This conference included over 60 presentations during the three-day event in sessions including Gamification in Service Engineering, Advances in Health Care Facilities Design and Quality and Safety Practices, Shaping the Human Side of T-Shaped Professionals, Industry 4.0 and the Smart Service World, and Service Science and User Experience Design.

While many of the presentations were contributed as slides only, 21 of the presenters also submitted full papers that were reviewed and accepted by the co-editors for publication in this Proceedings. The book is divided into five major sections as follows:

- Section 1: Gamification in Service Engineering
- Section 2: Innovations in Quality and Safety Practices in Health Care Systems
- Section 3: Smart Service World
- Section 4: Service Science Education and T-Shaped Professionals
- Section 5: Worker and Consumer Factors in Service Engineering

A major area of expansion in this conference is in Gamification in Service Engineering, led by Freimut Bodendorf and Christian Zagel, which appears as the first section of this Proceedings. As service systems look for new ways to engage participants, gamification has become a fruitful strategy for research. New applications of the concepts are reported in five full papers in this section.

New to the conference this year were two sessions led by Jim Spohrer focusing on the topic of the T-Shaped Professional. This has been a subject of substantial



interest in the areas of personnel development and education in recent years. The concepts of “depth in a discipline or system” and breadth across fields of study, cultures, organizational responsibilities, and other experiences contributing to managerial, empathy, communications, teamwork and similar skills have been leading topics in discussions about educating service systems professionals. Of the 11 presentations in these sessions, we are pleased to have two representative papers included in this Proceedings. We intend to expand our content in this field in the future.

Other major areas of discussions at this meeting were in the fields of service design and improvement in the healthcare sector, led by Lukasz Mazur, Kendra Johnson, Alison Amos, Gregg Tracton, and Carolyn Brown, and service innovations in industry (referred to as Industry 4.0) led by Walter Ganz. Other session chairs included Aura Matias, Regiane Romano, Shrikant Parikh, and Debra Satterfield. We are deeply indebted to all session chairs for their contributions to HSSE 2017. We hope that you find this volume useful and interesting, and invite all to join us for next year’s meeting. Information is available at [www.ahfe-hsse.org](http://www.ahfe-hsse.org).

Our sincere thanks and appreciation go to the Board members listed below for their contribution to the high scientific standard maintained in developing this book.

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Caio Márcio Almeida e Silva, Brazil  
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Carolyn Brown, USA  
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July 2017

Louis E. Freund  
Wojciech Cellary

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# The Consequences of Lean Six Sigma on Banking Improvement: A Study at a Front-Line Unit of a Bank Company in Indonesia

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**Abstract.** The purpose of this paper is to present research about how lean Six Sigma delivers recommendations to minimize the seven wastes which is strongly associated with human aspects in banking sector. The research was performed using Define, Measure, Analyze, Improve (DMAI) method, whereas the seven wastes are identified and will be minimized by using different tools. A research questionnaire delivered the sigma level of the defects in services that performed by teller, customer service, and security person are 3.01, 2.91, and 3.89 respectively. Lists of actual activities of delay/waiting and unnecessary movements is delivered by using Closed Circuit Television (CCTV) records and Pro Time Estimation software. The wastes of duplication and over processing, unclear communication, incorrect inventory, and lost opportunity are found using brainstorming. There are six recommendations of improvement obtained from brainstorming within the 5-Whys, FMEA, and improve phases. The bank can achieve significant efficiency without extorting employees' energy with low cost operations and flexibility.

**Keywords:** Banking sector · Brainstorming · Lean six sigma · Pro time estimation SERVQUAL · Sigma level · Waste

## 1 Introduction

### 1.1 Lean

The term “Lean thinking” was first proposed by Womack, et al. (1990) [1] and it encompasses a set of lean practices. The lean philosophy were developed by Toyota which is known as *Toyota Production System* in the mid 50 s and is nowadays world-wide used by companies. Lean Thinking book by Womack and Jones (1996) [2] commented: “Lean thinking can be summarized in five principles: precisely specify value by specific product (value specification), identify the value stream for each product (value stream mapping), make value flow without interruptions (flow optimization), let the customer pull value from the producer, and pursue perfection or continuous

improvement". The fundamental principle behind lean is the elimination of waste from a process to promote using the least amount of capital or other investments to produce the most amount of gain.

Lean is focusing on eliminating "muda" which is a Japanese word for waste. Lean focused on only seven types of waste. There are seven wastes in the manufacturing sector such as defective units, inappropriate processing, unnecessary motions, excessive transportation, over production, waiting, and excessive inventory [3].

Earlier applications of lean concept only focused on manufacturing companies. There is a movement to apply these very same concepts to the service industry in places like hospitals, office buildings, and even banking sector. The manufacturing industry has some differences with service industry, so there are some revisions of the seven wastes concept for service industry. The seven wastes of the service industry are [4]: Delay/Waiting; Duplication and over processing; Unnecessary movement; Unclear communication; Incorrect inventory; Lost opportunity; and Defects in service.

## 1.2 Six Sigma

Introduction of the Six Sigma concept for the manufacturing industry on 1980 by Motorola brought about a revolution of the scope and use of quality systems in this era. The goal of Six Sigma is to "reduce variation in organization processes by using improvement specialists, a structured method, and performance metric with the aim of achieving strategic objectives [5]. As a Metric, when a process is operating at Six Sigma level, it will produce nonconformance (i.e. defects or errors) at a rate of not more than 3.4 defects per one million opportunities. As a methodology and quality management philosophy, Six Sigma leads to improve business process by focusing on managing customer requirements. It is also a statistical term used to measure process variations, i.e., how far a given process deviates from perfection, which causes defects.

There are two methods to improve the six sigma target, such as: (1) Six sigma DMAIC (Define, Measure, Analyze, Improve, Control) dan (2) Design For Six sigma DMADV (Define, Measure, Analyze, Design, Verify). DMAIC is used to improve current business process, whereas DMADV is used to design the process of new product to deliver zero defects performance [6].

## 1.3 Lean Six Sigma

Lean six sigma is an application which combined methodology of lean in six sigma methodology. In other words, techniques in lean integrated within DMAIC or DMADV methodology [7]. There are a lot of scientific publications which discussed the application of lean six sigma in manufacturing sector. Bubshait, et al. (2014) [8], Hassan (2013) [9], Enoch (2013) [10], Mandahawi, et al. (2012) [11], and Panat, et al. (2014) [12] concluded that the lean six sigma as a powerful tool to improve the efficiency and effectiveness of the manufacturing system. Scientific publications which discussed the applications of lean six sigma in services sector is also growing but with different subconcepts. Service sector is very different from manufacture sector, where the

definition of “defects” is very dynamic and the way to measure the “defects” is abstract. One of the types of services that is complex to implementing the lean six sigma method is banking or financial service. The benefits of implementing lean Six Sigma in Banking or financial service are highly dependent on the human aspect for example in reducing internal and external customer complaints, increasing customer satisfaction, improving process efficiency, and reducing cycle time. This paper presents a case study of Lean Six Sigma application at a front-line unit of a bank company in Indonesia.

## 2 Method

The purpose of this paper is to deliver the improvement recommendations for banking sector by using Lean Six Sigma. A preliminary questionnaire based on SERVQUAL model was used to identify gap between customer perception and customer expectations. The dimensions are tangibles, responsiveness, reliability, assurance, and empathy. The dimension was explored to the respondent by using 21 attributes. The respondent was asked to give the rating scale between “Strongly disagree” until “Strongly agree” of service dimension for customer perceptions and customer expectations. The preliminary study was done by distributing the questionnaire into 30 respondents. The result of rating scale is tested by validity, reliability, and significance test. An interview with branch vice manager was done to strengthen the *gap* that was identified.

Additionally, a research questionnaire was designed to explore the response of the customers for the services. The purpose of this questionnaire was to measure DPMO and the sigma level of Critical to Quality (CTQ) of the research objects. There were total 16 CTQ’s across the three services i.e. bank teller, bank security, and bank customer service. The respondent was asked to give the rating scale between “very bad” until “very good” of the current services of the company. The questionnaire used a 5 level Likert scale. Scale 5 and 4 are expressions of the desired value, so that the Lower Specification Limit (LSL) is the scale 4. Scale 1, 2, and 3 are expressed as a defects. The sample size was set to 30 respondents as the baseline. If none of the 30 sampling are found the defects value, then the sampling should be continued until at least 1 defects found. This questionnaire system describe by the tabulation sheet as shown in Table 1. The result scale also tested by validity and reliability test.

**Table 1.** The tabulation sheet of customer’s perception of teller’s CTQ

Respondents	Stand up and raise right hand when mentioning the queue number	Say greetings and asking the customers’ needs	Serve the needs of customers well	Asks again whether there could be assisted	Say thanks	Defect or Not
R1	4	5	4	4	5	-
R2	3	5	4	4	4	√
...	...	...	...	...	...	...
Total of defects						...



Other instruments are Pro Time Estimation software and CCTV records that used to identify waste by type of delay/waiting and unnecessary movement in bank unit. The actual activity of waste in the company can be detected easier by using CCTV records. CCTV records used two days with seven hours of service each day. There are four research objects (respondents) i.e. functional teller, two customer services and security. It is important that the observations can describe the actual conditions and illustrated at least 90% of the population then validation was done by doing brainstorming section with two experienced managers representing the bank. Brainstorming with the branch vice manager is also done when practice 5-Whys, Failure Mode and Effect Analysis (FMEA), and formulating the recommendations for improvement. The entire instruments are blended in a DMAI methodology.

### 3 Results

Table 2 shown results of testing the questionnaire which included validity, reliability and significance test. The test showed the gap of each quality attributes are significant at 96.6% significance level. The bank can know that the customer is still not satisfied in every dimension of services. Quality gap of responsiveness dimension is the lowest with a value of -0.78 and gap of empathy dimension also has a very low value that is -0.63. Based on the results, it can be concluded that the depth investigation was needed to carry out in terms of non value added activities or defects (wastes) occurred in bank front-line unit.

The investigation of defects in services conducted through research questionnaire which design to measure Defects per Million Opportunity (DPMO) and sigma level. DPMO and sigma level is used to describe performance baseline of Critical to Quality (CTQ). DPMO and sigma level of teller services obtain by calculating using the equation below:

$$\begin{aligned}
 \text{DPMO} &= \frac{1,000,000 \times \text{number of defects}}{\text{number of units} \times \text{number of opportunities per unit}} \\
 &= \frac{1,000,000 \times 10}{30 \text{ sample} \times 5 \text{ CTQ}} = 66,666.67
 \end{aligned}
 \tag{1}$$

$$\begin{aligned}
 \sigma_{\text{level}} &= 0.8406 + \sqrt{29.37 - 2.221 \times \ln(\text{dpmo})} \\
 &= 0.8406 + \sqrt{29.37 - 2.221 \times \ln(66,666.67)} = 3.01
 \end{aligned}
 \tag{2}$$

Based on customer perceptions, the bank can find out how much the performance baseline of their employees with values of 66,666.67 Defects per Million Opportunity (DPMO) or sigma level of 3.01 to a teller’s services.

It should be noted that the value of DPMO and sigma level are presented in accordance with the value issued by Motorola which has shifted 1.5 sigma. Based on the same way, the bank knew the position of customer service performance at 80,952.38 dpmo or 2.91 sigma and security of 8,333.33 dpmo or 3.89 sigma.

**Table 2.** The gap between customer perceptions and customer expectations on service dimension of the bank’s front-line unit

Dimension	Attribute	Mean of perception	Mean of expectation	Attribute gap	<i>RUz</i> mean hypothesis test	Significance ( $\alpha = 3,4\%$ )	Dimension gap
Responsiveness	X10	4,2	4,90	-0,70	-3,80	Significant	-0,78
	X11	3,93	4,93	-1,00	-6,05		
	X12	4,3 7	4,97	-0,60	-4,43		
	X13	4,10	4,93	-0,83	-4,77		
Tangibles	X1	4,20	4,93	-0,73	-5,30	Significant	-0,76
	X2	3,87	4,87	-1,00	-4,85		
	X3	4,50	4,90	-0,40	-3,38		
	X4	4,00	4,90	-0,90	-4,96		
Reliability	X5	4,03	4,90	-0,87	-5,76	Significant	-0,73
	X6	4,03	4,93	-0,90	-4,63		
	X7	4,47	4,97	-0,50	-2,87		
	X8	3,93	4,97	-1,03	-6,38		
	X9	4,60	4,97	-0,37	-2,87		
Empathy	X17	4,20	4,83	-0,63	-2,92	Significant	-0,63
	X18	4,17	4,90	-0,73	-4,98		
	X19	4,30	4,93	-0,63	-4,38		
	X20	4,33	4,90	-0,57	-3,62		
	X21	4,40	4,97	-0,57	-3,40		
Assurance	X14	4,53	4,97	-0,43	-3,62	Significant	-0,36
	X15	4,73	4,93	-0,20	-2,12		
	X16	4,50	4,93	-0,43	-3,07		

The bank knew that the customers is still not satisfied in every dimension of services, and knew the amount of defects in their services, the bank also can find out how much the waste existed manifold by delay/waiting and unnecessary movement confiscated employee’s work hours. The investigation was obtained after observing the CCTV records that assisted by Pro Time Estimation software. The results obtained shows that there are two types of activities which caused teller’s job delayed or should waiting. Delay/waiting confiscated 1.05% of teller working hours. Waste type of unnecessary movement divided into five types of activities which confiscated 3.51% of teller working hours. Ten types of activities as shown in Table 3 confiscated 11.51% of customer service 1 working hours. Twelve types of activities confiscated 15.79% of customer service 2 working hours plus 9.41% of customer service 2 works done in locations that are not supposed to. Seventeen types of activities as shown in Table 4 confiscated 35.66% of security working hours.

**Table 3.** Observations result on unnecessary movements of customer services 1

No.	Unnecessary movement	NVA/SVA	Frequency	Average time (s)	Total time (s)	Percentage to work hours
1	Chatting with other employee	NVA	1	94,82	94,82	0,22%
Total time of NVA					94,82	0,22%
2	Pick up the documents from storage or from account officer	SVA	4	282,23	1128,9	2,61%
3	Move to discuss the customer documents with customer service 2		1	10,69	10,69	0,02%
4	Move to discuss the customer documents with teller		3	285,28	855,83	1,98%
5	Move towards printer		5	26,02	130,09	0,30%
6	Move towards account officer's room		2	362,16	724,31	1,68%
7	Pick up the documents from teller desk		2	52,43	104,86	0,24%
8	Deliver and pick up the documents from storage or from account officer		5	206,39	1031,96	2,39%
9	Deliver the documents from storage or from account officer		1	190,42	190,42	0,44%
10	Move to ask something to teller		2	21,81	43,62	0,10%
Total time of SVA					4220,68	9,77%
Individual needs					658,56	1,52%
Total					4974,06	11,51%

Another four types of waste is difficult to identify. So, an alternative is identified by brainstorming and measured directly with a risk priority number. Two experienced managements who participated in a brainstorming has stated waste manifold by duplication/over processing existed were “waste of paper on the account registration form and not have a tax ID number letter” and “twice queuing of customers who open new accounts”. Waste of unclear communication types existed as “interruptions from other customers” and “cancel the transaction because lack of transaction requirement”. Waste of incorrect inventory type existed as “the files piled up on the service table when customer service serving the customers” and “storing documents should be made less”. Waste of lost opportunity existed as “customer lamented, even cancel the transaction because queuing in teller took a long time”, “more than one customer in a service by customer service” and “uncertainty for customers who wait for customer service”.

**Table 4.** Observations result on unnecessary movements of security

No.	Unnecessary movement	NVA/SVA	Frequency	Average time (s)	Total time (s)	Percentage to work hours
1	Chatting with customer service 1	NVA	6	204,30	1225,77	2,84%
2	Chatting with customer service 1 and 2		1	146,77	146,77	0,34%
3	Chatting with customer service 2		6	60,93	365,55	0,85%
4	Chatting with customer service 2 and teller		1	278,02	278,02	0,64%
5	Chatting with customer in customer service 2 desk		3	108,87	326,60	0,76%
6	Chatting with customer in teller desk		1	192,56	192,56	0,45%
7	Chatting with other employee in teller desk		1	72,97	72,97	0,17%
8	Chatting with customer who queuing		1	67,11	67,11	0,16%
9	Chatting with teller		1	90,71	90,71	0,21%
10	Chatting with other three employees		1	245,50	245,50	0,57%
11	Sitting on waiting chairs		2	86,51	173,01	0,40%
12	Sitting on customer service 1 chair		2	1480,94	2961,88	6,86%
13	Sitting on customer service 2 chair		2	668,03	1336,06	3,09%
14	Out from office		4	528,83	2115,32	4,90%
Total time of NVA					9597,83	22,22%
15	Individual needs	SVA	18	309,73	5575,16	12,91%
16	Perform customer service 1 activities		1	104,45	104,45	0,24%
17	Fetching other employee's documents		1	127,49	127,49	0,30%
Total time of SVA					5807,10	13,44%
Total					15404,93	35,66%

An analysis was done by approaching 5-Whys and FMEA. Companies can find out the root of the problem (failure mode) that existed in the front-line unit and how much each failure mode should get attention as shown in Table 5.

As the most important result, there are six improvement recommendations for upgrade the bank's unit efficiency. Recommendations were obtained from brainstorming in improve phase are:

### 3.1 Using *Smart IP Camera* to Evaluate the Employees Performance

Use of Smart IP camera to evaluate the performance of employees is the proposed solution to overcome the failure mode "Inadequate tools used in evaluating defects of

**Table 5.** Results of analyze phase

Failure mode obtain from approaching 5 why	RPN obtain from approaching FMEA
Inadequate tools used in evaluating defects of services	486
Space and content of the registration form is not optimal	432
Still using the numbering queueing system	405
Customer Service is also doing other work while serving customers	315
The layout is not optimal	245
Customer Services desk capacity is not optimal	243
Security stand too long and doing repetitive work	216
Services at customer service desk does not use a queue number but do not have queue line	216
Do not use a queuing system which customer’s lined up	216
Lack of notice to prepare the document before customers arrived in teller	144
Customers who open new accounts have to sit down again when the file is in the process from customer services to teller	144
The lack of visual aid	144

services” and “customer service is also doing other work while serving customers”. Recommended Smart IP camera is capable of storing CCTV records nonstop for several days, recording sound and should still give a good and futuristic impression if used at the office. CCTV can be installed respectively near teller, customer service and security. CCTV records can be used as an employee performance evaluation by the management of the bank unit. The next CTQ performance baseline calculations quite done by observing the CCTV records, so that it will becoming an alternatives besides the questionnaire explained. The employees evaluation results can be briefed periodically in the morning or evening. Smart IP camera is the right choice to be used because the cost is around Rp. 1,500,000 or USD 111.23 for the four cameras as very cheap compared to the benefit that is much higher. The benefit is a vision to achieve defect-free services (the good image of the eyes of ±75,000 customers/3 years) through services sigma periodically evaluation using CCTV records.

**3.2 Reducing Paper of New Account Registration for Customer Who Doesn’t Have Tax ID Number**

Failure modes “space and content of the registration form is not optimal” can be overcome by reducing some space in the account registration form and insert the certificate of lack of tax ID number contents. This recommendation can provide enormous benefit because it can reduce the cost of making the form from two sheets into one sheet of ±Rp. 135,000/year or USD 10.01/year only from one unit of the bank, reduce holding costs of the letter of does not have tax ID number which must saved for 30 years, and reduces the registration time ±1 min/customer.

### **3.3 Using Small Table as the Temporary Place of Customer Service's Documents**

Job specification of customer service indeed requires customer service does some work on office documents when they are not serving the customers. Human-machine systems of customer service working area is not optimal, caused failure mode "customer service is also doing other work while serving customers" and "customer service desk capacity is not optimal". Besides add smart IP camera for evaluating the performance of customer service, wisely the bank should be able to provide job satisfaction to customer service. Good reversible reaction between the company and its employees will make the company better.

The bank can using small table as the temporary place of customer service's documents to add more function of an existing table. So, when customers are coming, customer service can put a work-in-processes file at the small table and then stood to greet customers and so on. It can be helpful for customer service to concentrating when serving customers. Customers also gain comfort with the customer service desk when it was neat and they will feel privileged with that empathetic treatment. If the bank issuing about Rp. 1,000,000 or USD 74.16 for two tables, then the benefit is customer and employees comfortable that have an impact on customer satisfaction and bank productivities where the value is greater than the cost.

### **3.4 Changes the Layout and Queuing System**

Changes to the layout and queuing system can be used to overcome many failure modes specifically "still using the numbering queuing system", "the layout is not optimal", "services at the customer service desk does not use a queue number but do not have the queue line", "do not use a queuing system which customer's lined up", "customers who open new accounts have to sit down again when the file is in the process from customer service to teller". Queuing system which expected to provide positive change is accompanied with queue barrier rope so that customers can line up neatly. However, parallel to the barrier rope need put a minimalist chairs so that when long queues or existed a bad communication network of the bank, customers who do not want to stand can sit and remain in the queue.

Layout changes design created by activity relationship chart and change the concept of "push" to "pull" and create a more efficient flow of value. Changes to the layout and the queuing system can provide enormous benefit in terms of bank productivity and customer conveniences with cost incurred only form of activities to change the layout by unit managements mutual cooperation or contracted and the cost of a queue barrier procurement around Rp. 6.4 million or USD 474.6.

### **3.5 Using Chair for Security**

Failure mode "Security stand too long and doing repetitive work" can be overcome by allowing security to sit while no customers coming with an height adjustable chair. It is intended that security can perform duties that are repetitive standing and sitting

comfortably. This recommendation can provide benefits that is employees convenience where impact on productivity and customer satisfaction is more valuable than the cost is around 500,000 or USD 37.08 for a single chair.

### 3.6 Using Visual Aid

Failure mode “lack of notice to prepare the document before customers arrived in teller” and “the lack of visual aid” can be overcome by actively using the visual aid. Visual aid was needed is an appeal for customers to prepare the documents prior to teller desk installed at the site will be queued. In addition, the requirements of transactions should be displayed visually in the location that is often seen by customers. One of the locations is around the transaction attribute table.

## 4 Conclusion and Discussion

The six recommendations cost which can used for more than three years is around Rp. 11,000,000 or USD 815.72 with currency exchange rate Rp. 13,485 equal USD 1. That cost is around 0.036% of the bank unit net profit for three years of Rp. 30,548,294,741 or USD 2,265,353.71. The value of 0.036% can give a vision to achieve defect-free services without reducing job satisfaction of employees, USD 10.01/unit of the bank/year saving form convert two sheets into one sheet, reduce the certificate of lack of tax ID number holding costs which a certificate must keep for 30 years, reduces the registration time  $\pm 1$  min/customer, the convenience of customer service employees and their customers, increasing security job satisfaction, and significantly increasing system efficiency and customer loyalty. So, lean six sigma is the pursuit of system perfection which not merely about extort more employees sweat, but work with them to make continuous innovations and improvements so that the balance between the two parties obtained not at high cost but at a cost that may be very cheap.

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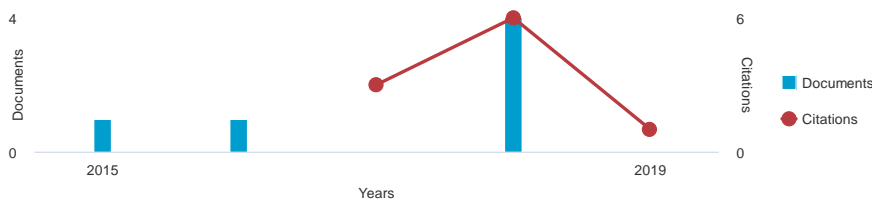
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